MACHINE DRAWING

(M–SCHEME)

N. IYANARAPPAN, M.E., M.I.S.T.E.

Principal
Sri Renugambal Polytechnic College,
Polur – 606 907.

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கல் பதிப்பகம்
வேலூர்- 632 011

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PART - A

Unit – I

SECTIONAL VIEWS

1.1 Review of orthographic projection

If straight lines are drawn from various points on the contour of an object to meet a plane, the object is said to be projected on the plane. The figure formed by joining the points at which these lines meet the plane, is called a *projection* of that object. The lines drawn from the object to the plane are called *projectors*.

1.2 Orthographic projection

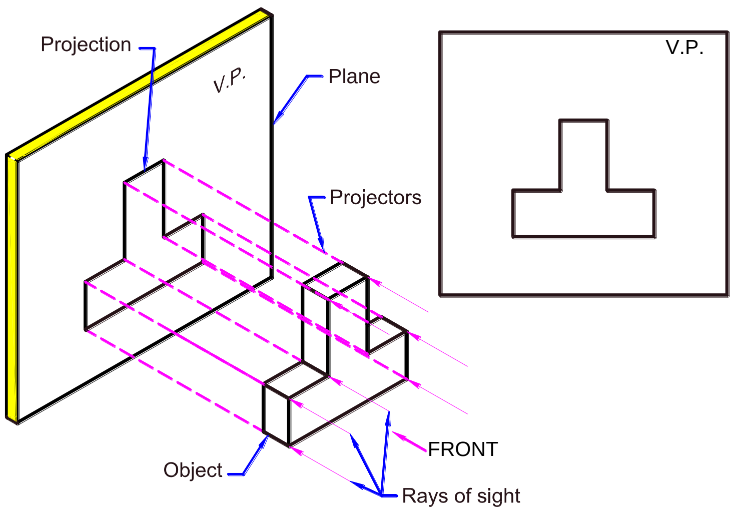


Fig.1.1 Orthographic projection

When the projectors are parallel to each other and also perpendicular to the plane, then the projection is called an *orthographic projection*.

1.3 Planes of projection

- ✦ The picture planes used for obtaining orthographic projection are called *reference planes or principal planes of projection*. They meet each other at right angles.
- ✦ The plane in front of the observer is the *vertical plane of projection* or the *frontal plane*. It is usually denoted by the letters V.P.
- ✦ The other plane which is horizontal but perpendicular to the V.P. is the *horizontal plane*. It is denoted by the letters H.P.
- ✦ A plane perpendicular to both V.P. and H.P. is known as *auxiliary vertical plane* and is denoted by A.V.P.
- ✦ The line of intersection of V.P. and H.P. is known as the *reference line* and is usually denoted by the letters X–Y.

1.4 Systems of orthographic projection

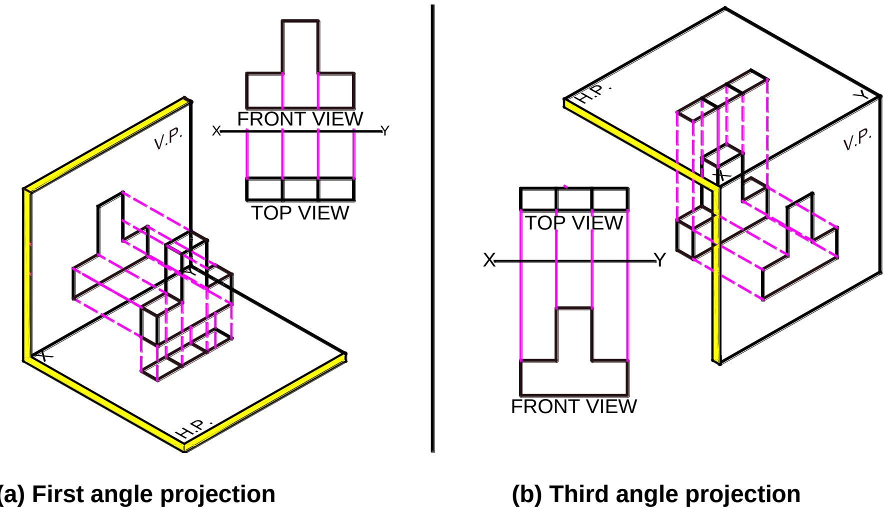


Fig.1.2 Systems of orthographic projection

Orthographic views can be obtained by the following two methods.

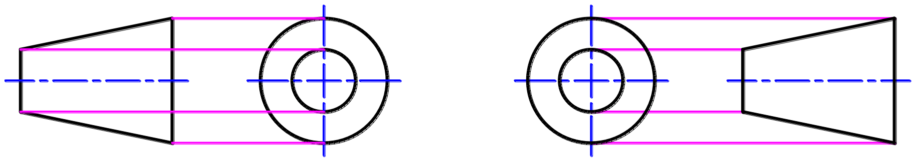
a) First angle projection

b) Third angle projection

The comparison of these two methods of orthographic projection is shown in the following table.

	First angle projection	Third angle projection
1.	The object is assumed to be kept in first quadrant, i.e. in front of VP and above HP.	The object is assumed to be kept in third quadrant, i.e. behind VP and below HP.
2.	The object lies between the observer and the plane of projection.	The plane of projection lies between the observer and the object.
3.	The plane of projection is assumed to be non–transparent.	The plane of projection is assumed to be transparent.
4.	In this method, the top view comes below the front view.	In this method, the top view comes above the front view.
5.	The left side view of the object is drawn to the right of the front view.	The left side view of the object is drawn to the left of front view.

1.5 Symbols of orthographic projection



(a) First angle projection **(b) Third angle projection**

Fig.1.3 Symbols of orthographic projection

For every drawing it is essential to indicate the method of projection adopted. This is done by means of a symbolic figure drawn within the title block on the drawing sheet. The symbols recommended by BIS for first angle projection and third angle projection are shown in the Fig.1.3. The symbol represents the views of a frustum of cone with its axis horizontal.

1.6 General procedure for drawing orthographic views

1) Determine the overall dimension of the required view. Select a suitable scale so that the views are conveniently accommodated in the drawing sheet.
2) Prepare a sheet layout. Draw rectangles for each view, keeping sufficient space between them and from the borders of the sheet.
3) Draw centre lines in all the views for circles and arcs.
4) Draw details simultaneously in all the views in the following order:
   - ✦ Circles and arcs of circles.
   - ✦ Straight lines for the general shape of the object.
   - ✦ Straight lines, small curves, etc. for minor details.
5) Check whether all the hidden features are shown in the drawing by dotted lines.
6) Erase all unnecessary lines completely.
7) Fair the views with 2H or 3H pencil, making the outlines uniform and intensely black.
8) Dimension the views completely with required notes and titles.
9) Fill up the title block and add all other necessary particulars.

1.7 Review of sectioning

The invisible feature of an object are shown by dotted lines in their orthographic views. But when the object contains too many visible features, the dotted lines make the views more complicated and difficult to interpret. In such cases, the sectional view is used.

1.8 Need for sectioning

The sectional view is necessary for the following purposes:

1) To show the invisible (internal) details.
2) To show the dimensions of hidden line details clearly.
3) To avoid too many hidden lines which make the orthographic view complicated.
4) To give additional required information about the component.

1.9 Sectional view

A *sectional view*, or simply a *section*, is a view obtained when a portion of the object between the cutting plane and the observer is assumed to be removed and the remaining portion is projected.

1.10 Cutting plane or section plane

The imaginary plane which is assumed to cut the object is known as *section plane or cutting plane.* The section plane is taken parallel to the plane on which the view is projected. Cutting planes are designated by capital letters, with arrows indicating the direction for viewing the sections.

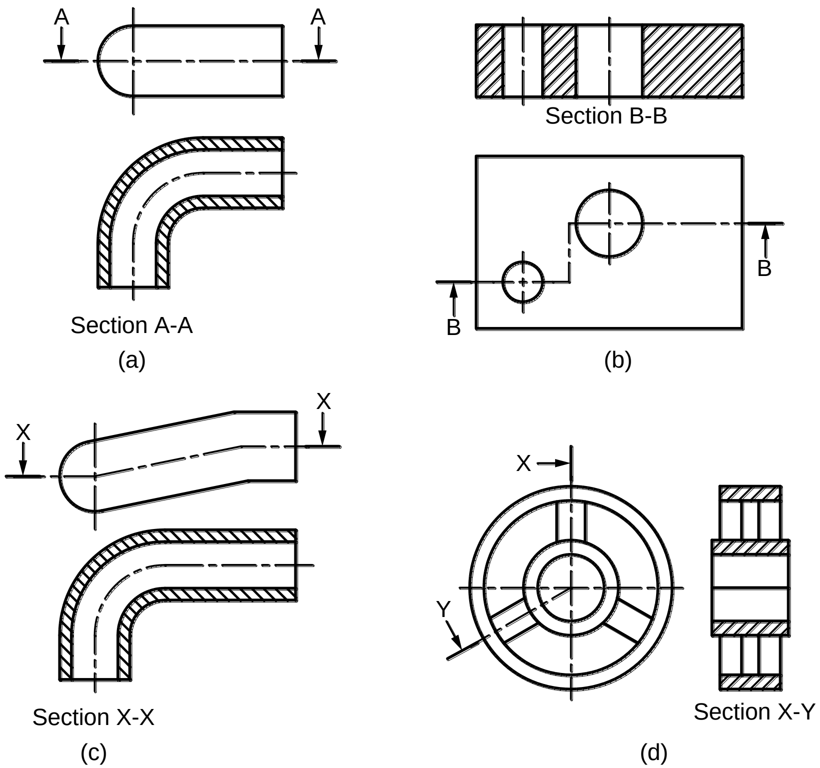


Fig.1.4 Types of section plane

The following types of section planes are used in drawings :

(a) Section in one plane

(b) Section in two parallel planes

(c) Section in three successive planes

(d) Section in two intersecting planes

1.11 Symbolic representation of cutting plane

Cutting planes are shown by lines made up of alternate long and short dashes, thick at the ends and thin elsewhere. This line is known as *cutting plane line*. It is also known as the *line of section* or *trace of the cutting plane*. The direction of viewing is shown by two arrows on thick ends and designated by capital letters.

Fig.1.5 Cutting plane

Arrow head indicates the direction in which the cut away object is viewed. The portion of the object imagined to be removed is the portion opposite to the direction of the arrows. When the cutting plane line coincides with a centre line, the cutting plane takes precedence.

1.12 Types of sections

The following are the important types of sections.

1. Full section
2. Half section
3. Broken or local section
4. Revolved section
5. Removed section
6. Offset section

1. Full section

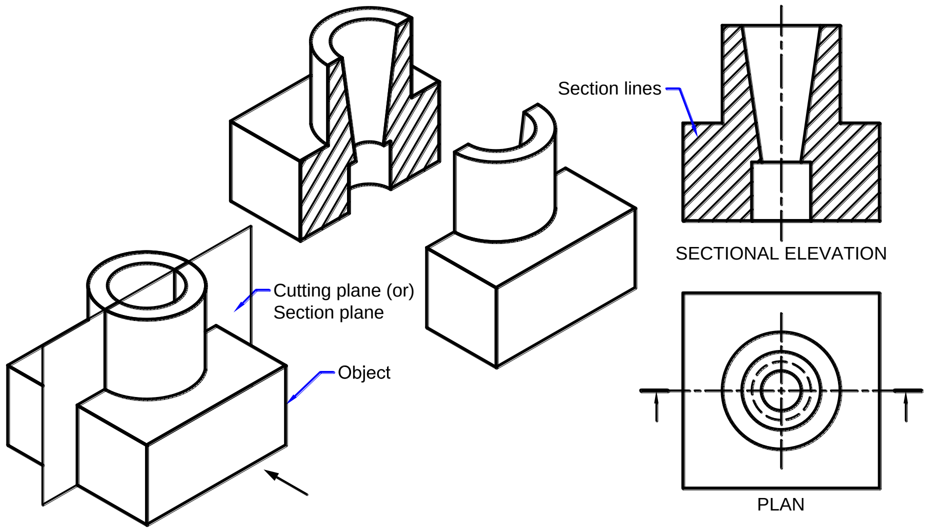


Fig.1.6 Full section

When an object is assumed to be cut through entirely and the front half removed, it is said to be in *full section.* The projected view is called a *sectional view.* Fig.1.6 shows an imaginary vertical cutting plane passing through the centre of an object entirely and cutting it into two halves. When the front half is removed, its internal features are fully exposed by the section. The sectional front view and top view are shown in Fig.1.6. When an object is cut by a horizontal section plane, the top view is seen in section.

When the cutting plane cuts an object *lengthwise*, the section obtained is called *longitudinal section*. When the cutting plane cuts an object *crosswise*, the section obtained is called *cross section*.

Uses: This type of section is used for both detail and assembly drawings.

2. Half section

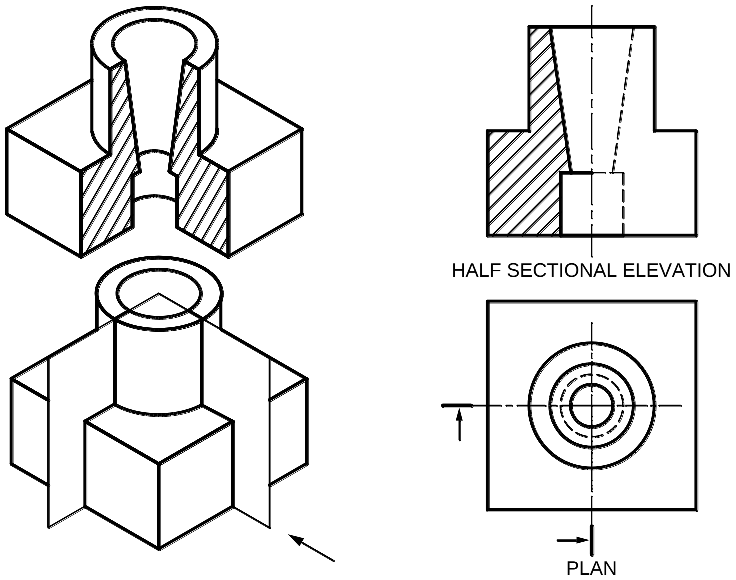


Fig.1.7 Half section

When an object is symmetrical, it may be assumed to be cut by two cutting planes at right angles to each other and containing the two centre lines of the object. The one quarter of the object between the two planes is then removed showing only a *half section*. The projected view is a *half sectional view*. A section may be the left half, right half, lower half or upper half of the view.

The external appearance and the internal details of the object are thus shown in a single view. In a half sectional view, dashed lines for the hidden features on the unsectional side are always shown for clarity.

Uses: Half-sectional view are particularly used in assembly drawings.

3. Broken section (or) local section (or) partial section

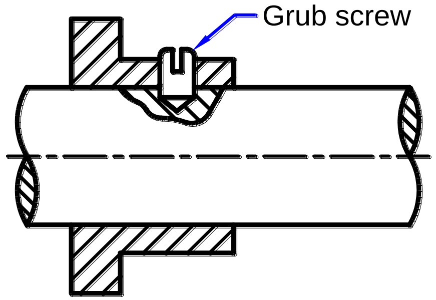


Fig.1.8 Broken or local section

When only a small portion of an object is required to be shown in section to reveal a minute feature, the view is shown in a *broken or local section*. The irregular lines show the boundary of the section.

Uses: Broken sections save drawing time and drawing space. It is particularly used when internal features of an object to be shown without drawing another view.

4. Revolved section

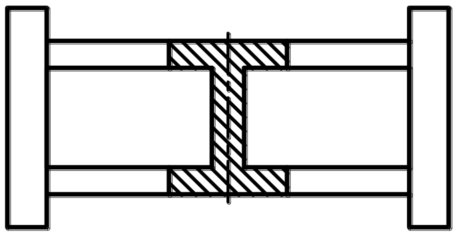


Fig.1.9 Revolved section

A section is formed by passing a cutting plane at right angles to the axis of the object. It is infact the cross section of the object. This section is then revolved and brought into the plane of the axis and shown in the view in which the axis is seen as a line. The section shown in this manner is called a *revolved section.* The outline of the revolved section is shown by a thin continuous line.

Uses : Revolved sections are used for showing the cross-section of elongated bars, rims, connecting rods, rib of pulleys, spokes, etc.

5. Removed section

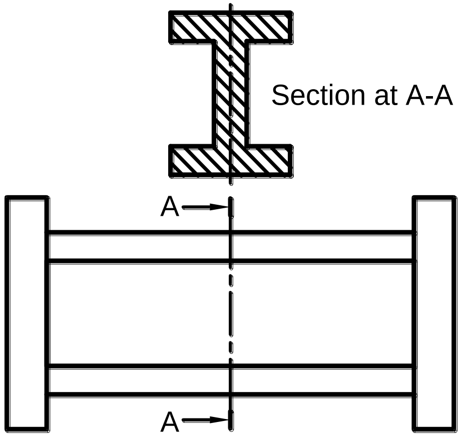


Fig.1.10 Removed section

This section is obtained in the same manner as the revolved section, but it is drawn outside the view, generally around the extension of the cutting plane line. Sometimes it may be conveniently drawn away from its location. In such a case, the section is identified by a note below it, e.g. section at A-A.

Uses : Removed section is generally used when the section is to be shown on an enlarged scale for the purpose of dimensioning.

6. Offset section

In some objects, the section obtained by a straight cutting plane may not reveal more details. In such cases, the cutting plane may be suitably offset so that to show more details. The section thus obtained is called an *offset section.* The position of the offset plane is always shown by a cutting plane line in the view in which it is seen as line.

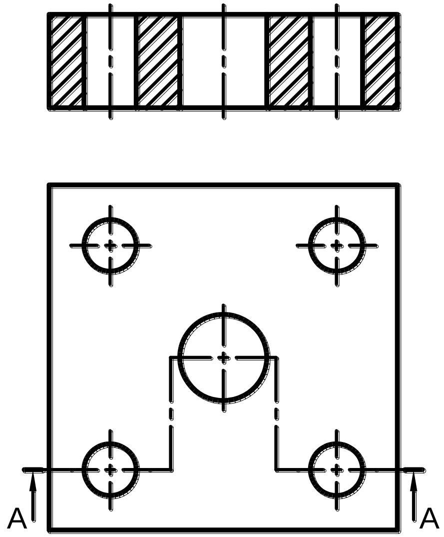


Fig.1.11 Offset section

Uses : Offset section is used when the straight cutting plane does not expose the required details of an object.

1.13 Hatching or section lining

Hatching is necessary to differentiate the cut area from the uncut portions. Many drafting applications use hatching to fill an area with a pattern. The pattern is used to differentiate components of a product or to signify the material composing an object.

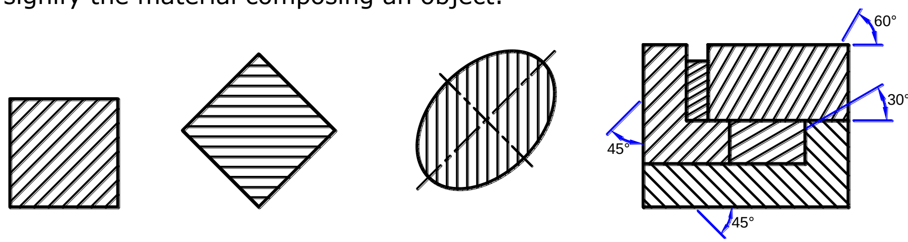
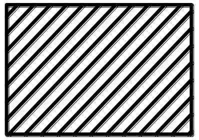
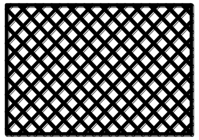
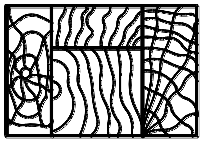


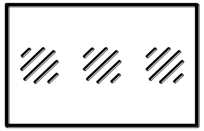
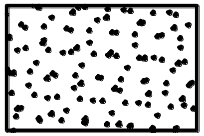
Fig.1.12 Hatching rules

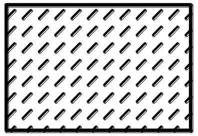
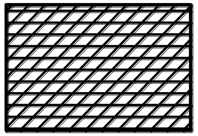
The following points should be considered while creating hatching.

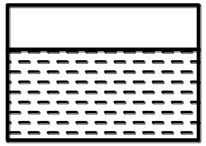
- ✦ Hatching lines should be drawn at 45° to the axis or the main outline of the section.
- ✦ When three or more parts are in contact,
  - a) Adjacent parts are hatched at 45° in opposite direction.
  - b) The other adjacent parts may be hatched at 30° or 60°.
  - c) The other parts may be hatched by varying the scale factor of section lines.
- ✦ Very thin sections are shown totally black leaving thin space between adjacent sections.
- ✦ Large surfaces are sometimes sectioned around the edges only.
- ✦ Section line of the same piece in different views or for the same piece in different place in the same view should be identical in spacing and direction.

1.14 Conventional representation of materials in section (BIS 11663–1986)

Materials	Convention
Metal Steel, cast iron, Copper, and its alloys, Aluminium and its alloy	
Lead, Zinc, Tin, White metal etc.	
Wood Wood, Plywood, etc.	

Materials	Conventions
Glass	
Concrete Brickwork masonry, Concrete, Firebricks, etc	

Materials	Convention
Packing and insulation materials Porcelain, stonewares, Marble slate, etc.	
Asbestos, Fibres, Synthetic resin products, Paper, Cork, Linoleum, Rubber, Leather, Wax, insulation and filling materials.	

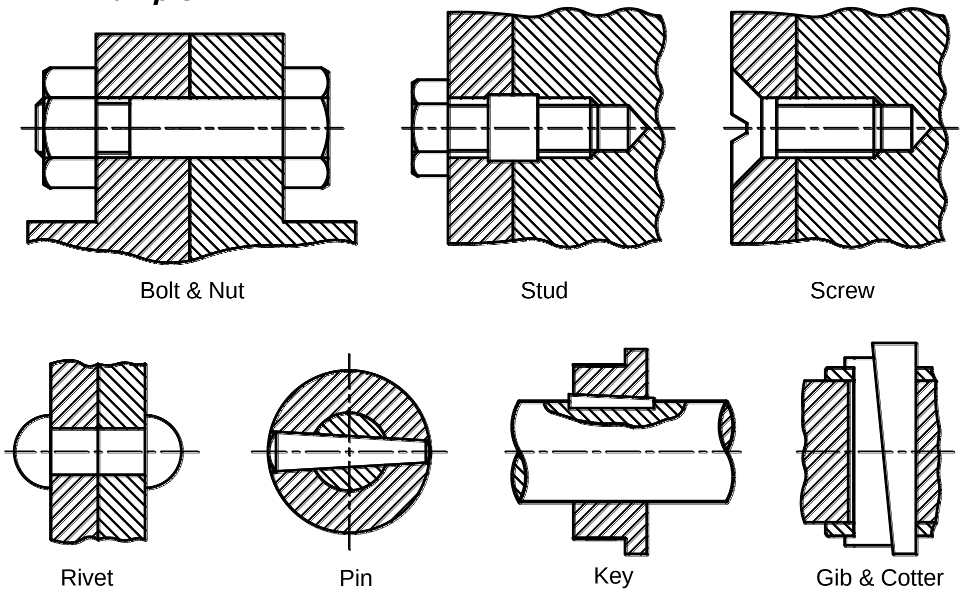
Materials	Conventions
Liquids Water, Oil, Petrol, Kerosene, etc.	

1.15 Conventions showing the section

The following are the important conventions to be followed while creating sectional views.

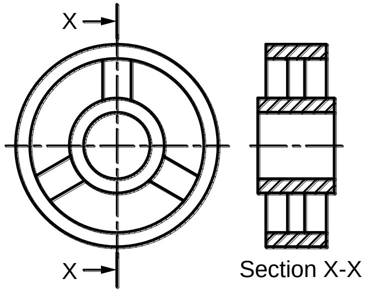
1) Bolts, nuts, studs, rivets, pins, keys, cotters, shafts etc. are never shown in section longitudinally.

Example :



2) Spokes or arms of wheels or pulleys are never sectioned longitudinally. The cutting plane is assumed to be offset so that the arms are left intact and behind the cutting plane.

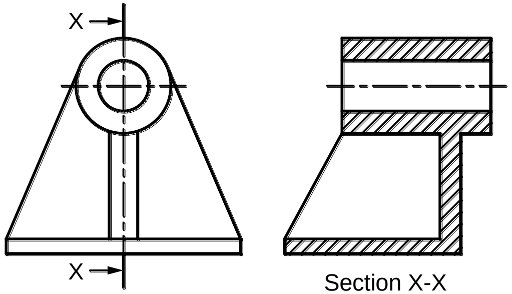
Example :



Spokes in section

3) A web or a rib is also not shown in section when a cutting plane cuts along its length and breadth.

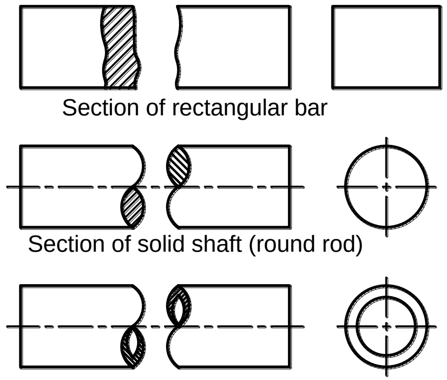
Example :



Webs and ribs in section

4) Shaft and pipes of long lengths are generally shown broken in the middle to accommodate their views in a drawing sheet without reducing the scale.

Example :



REVIEW QUESTIONS

Unit – I : SECTIONAL VIEWS

1) What are the needs for sectioning?
2) What is sectional view?
3) List out the types of section plane? Give example.
4) What is section plane? Mention the symbolic representation of section plane.
5) State the types of sections.
6) Explain full section with a sketch.
7) Explain half section with suitable sketch.
8) Explain broken section with an example.
9) Explain revolved section and list its usage.
10) Explain removed section with example.
11) Explain offset section with suitable example.

12) List out the important points to be considered while creating hatching lines.

13) Draw the conventional representation in section of various materials recommended by BIS 11663-1986.

14) List out the important conventions to be followed while creating sectional views of common machine elements.

15) Show the conventional representation of the following in section:
(a) Bolts & nuts (b) Rivets (c) Keys (d) Cotters

16) Draw the conventional representation of the following in section:
(a) Spokes and (b) Webs

17) Sketch the broken end of the solid shaft and hollow shaft as per the conventional representation.

Unit – II

LIMITS, FITS AND TOLERANCES

2.1 Introduction

The manufacture of interchangeable parts require precision. Precision is the degree of accuracy to ensure the functioning of a part as intended. However, experience shows that it is impossible to make parts economically to the exact dimensions. Therefore, the workman has to be given some allowable margin so that he can produce a part, the dimensions of which will lie between two acceptable limits, a maximum and a minimum. The study of limits, tolerances and fits is a must for technologists involved in production. The same must be reflected on production drawing for guiding craftsman on the shop floor.

2.2 Limit system

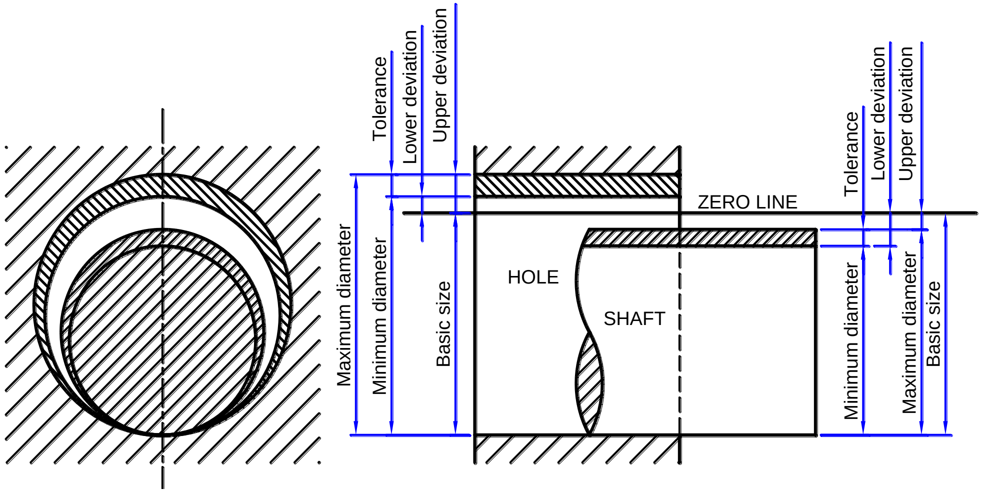


Fig.2.1 Basic size deviations and tolerances

The system in which a variation is accepted is called the *limit system.* The following are some of the terms used in the limit system

1. Basic size or nominal size

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

2. Actual size

It is the size obtained after manufacture.

3. Design size

It is the size from which the limits of size are derived by the application of tolerances. If there is no allowance, the design size is the same as the basic size.

4. Limits

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

5. Tolerance

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

6. Allowance

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

7. Deviation

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

- ***Actual deviation:*** It is the algebraic difference between the actual size and corresponding basic size.
- ***Upper deviation:*** It is the algebraic difference between the maximum limit of the size and the corresponding basic size.
- ***Lower deviation:*** It is the algebraic difference between the minimum limit of the size and the corresponding basic size.
- ***Fundamental deviation:*** It is one of the two deviations which is conveniently chosen to define the position of the tolerance zone in relation to zero line.

Upper deviation – Lower deviation = Tolerance

8. Zero line

The line corresponding to the basic size is called the *zero line* or *line of zero deviation.* When the zero line is drawn horizontally, positive deviations are shown above and negative deviations are shown below the zero line.

9. Tolerance zone

In a graphical representation of tolerance, the zone bounded by the two limits of the basic size is called *tolerance zone*.

2.3 Tolerances

Great care and judgment must be exercised in deciding the tolerances which may be applied on various dimensions of a component. If tolerances are to be minimum, that is, if the accuracy requirements are severe, the cost of production increases. In fact, the actual specified tolerances decide the method of manufacture. Hence, maximum possible tolerances must be recommended wherever possible.

Types of tolerances

The basic types of tolerances are :

1) ***Dimensional tolerances :*** The size of the components can be controlled by means of dimensional tolerances. It indicates the maximum permissible variation from the basic size.
2) ***Geometrical tolerances :*** The form of the components can be controlled by means of geometrical tolerances. It is the maximum permissible overall variation of form or position of a feature.

2.3.1 Fundamental tolerances

Tolerance is denoted by two symbols, a letter symbol and a number symbol called the *grade*. The letter symbols range from ***A*** to ***ZC*** for holes and ***a*** to ***zc*** for shafts. The letters ***I, L, O, Q, W*** and ***i, l, o, q, w*** have not be used. These letter symbols represent the degree of closeness of the tolerance zone to the basic size.

There are **18** grades of tolerances, designated as IT 01, IT 0 and IT 1 to IT 16, known as *Fundamental tolerances*. The fundamental tolerance is a function of the nominal size. Its unit is given by the following empirical relation.

Standard tolerance unit, $i = 0.45 \times \sqrt[3]{D} + 0.001\,D$

Where, D is the geometrical mean of the limiting values of the basic steps in millimeters.

2.3.2 Methods of tolerances

The following two basic methods are used to indicated the tolerances :

1) Hole basis system
2) Shaft basis system

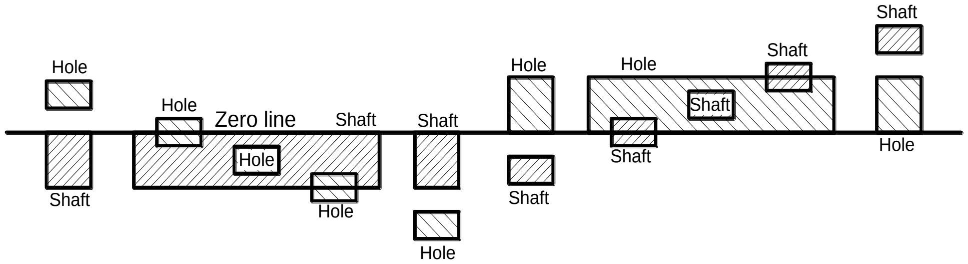


Fig.2.2 Shaft basis and hole basis system

1) Hole basis system

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

2) Shaft basis system

In this system, the size of the hole is obtained by adding the allowance to the basic size of the shaft. This gives the design size for the hole. Tolerances are then applied to each part. In this system, the upper deviation of the shaft is zero. The letter symbol for this situation is 'h'.

The shaft basis system is preferred by (i) industries using semi-finished shafting as raw materials, e.g. textile industries, where spindles of same size are used as cold-finished shafting and (ii) when several parts having different fits but one nominal size are required on a single shaft.

Why the Hole basis system is preferred?

When the shaft basis system is used to specify the limit dimensions, number of holes of different sizes are required to obtain various types of fits. Hence, tools of different types and sizes are required to produce holes of various sizes.

When the hole basis system is used, the basic hole can be produced using only one tool such as drill, boring tool, reamer or broach. The shaft can be easily machined to any desired size. This reduces the production cost. Hence the hole basis system is preferred.

2.3.3 Indication of tolerance on drawing

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

Method – I:

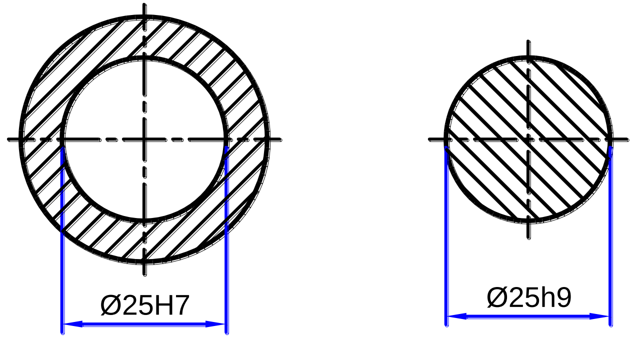


Fig.2.3 Tolerancing internal and external features

In this method, the tolerance dimension is given by its basic value, followed by a symbol, comprising of both a letter and a numeral. The following are the equivalent values of the terms given in Fig.2.3.

$\phi 25H7 = \phi 25^{+0.021}_{+0.000}$

$\phi 25h9 = \phi 25^{-0.000}_{-0.052}$

The term ϕ25H7 refer to internal feature, since the term involves capital letter symbol. The capital letter 'H' signifies that the lower deviation is zero and the number symbol 7 signifies the grade. The term ϕ25h7 refer to external feature, since the term involves lower case letter symbol. The letter 'h' signifies that the upper deviation is zero and the number symbol 9 signifies the grade.

Method – 2:

In this method, the basic size and the tolerance values are indicated above the dimension line, the tolerance values being in a size smaller than that of the basic size and the lower deviation value being indicated in line with the basic size.

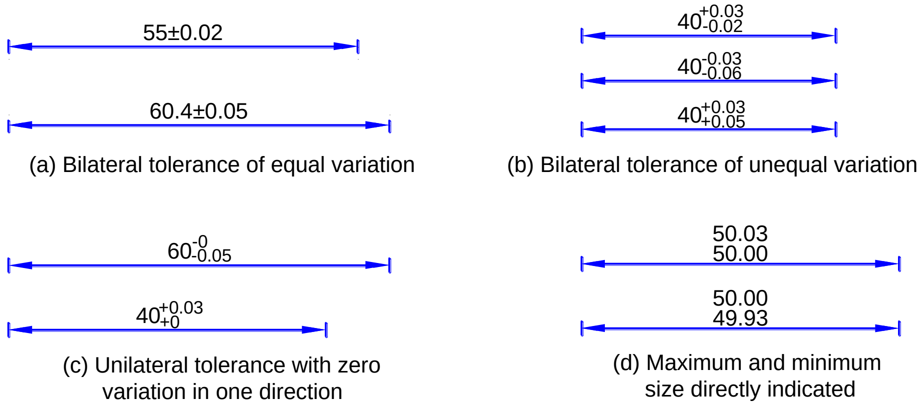


Fig.2.4 Bilateral and unilateral tolerances

- Fig.2.4(a) shows dimensioning with a bilateral tolerance, the variation from the basic size being equal on either side.
- Fig.2.4(b) shows dimensioning with a bilateral tolerance, the variation being unequal.
- Fig.2.4(c) shows dimensioning with a unilateral tolerance, the variation being zero in one direction.
- Fig.2.4(d) shows dimensioning with the maximum and minimum size directly indicated.

2.3.4 Unilateral and Bilateral tolerances

a) Unilateral tolerances : If the variation is provided on one side of the basic size, it is known as *unilateral tolerance.* An unilateral tolerance is always all plus or all minus.

Example :

1) $60^{-0}_{-0.05}$

The basic size is 60 mm. The tolerance 0.05 mm is all in one direction towards smaller size.

2) $40^{+0.03}_{+0}$

The basic size is 40 mm. The tolerance 0.03 mm is all in one direction towards larger size.

b) Bilateral tolerances : If the variation is provided on both sides of the basic size, it is known as *bilateral tolerance.* The total tolerance is divided in two parts, plus and minus.

Example :

1) ***Bilateral tolerance of equal variation***

55 ± 0.02

The basic size is 55 mm. The total tolerance 0.04 mm is divided equally into 0.02 mm and provided on both sides of the basic size.

2) ***Bilateral tolerance of unequal variation***

$40^{+0.03}_{-0.02}$

The basic size is 40 mm. The total tolerance 0.05 mm is divided unequally into 0.03 mm and 0.02 mm. +0.03 mm is provided in one side and -0.02 mm is provided on another side of the basic size.

2.4 Tolerance of form and position

Tolerance of size are not always sufficient to provide the required control of form. For example, a shaft having the same diameter measurement in all possible position, may not be circular, or a component having same thickness throughout may not be flat, etc. The form of these components can be controlled by means of geometrical tolerances.

2.4.1 Geometric tolerances

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

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

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

2.4.2 Definitions

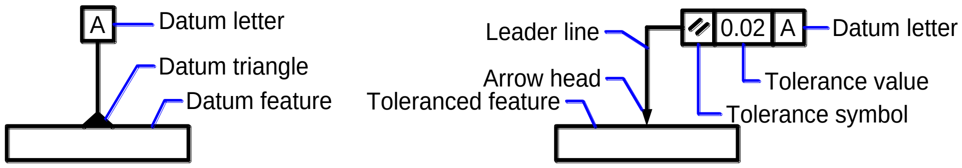


Fig.2.5 Geometric tolerance

Datum: It is theoretically exact geometric reference (such as axes, planes, straight lines, etc.) to which the tolerance features are related.

Datum feature: A datum feature is a feature of a part, such as an edge, surface, or a hole, which forms the basis for a datum or is used to establish its location.

Datum triangle: The datums are indicated by a leader line, terminating in a filled or an open triangle.

Datum letter: To identify a datum for reference purposes, a capital letter is enclosed in a frame, connected to the datum triangle.

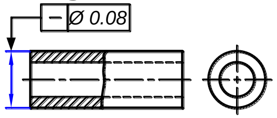
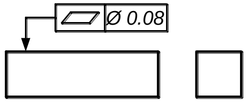
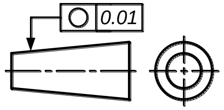
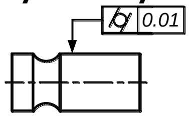
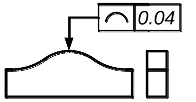
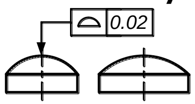
2.4.3 Geometric characteristic symbols

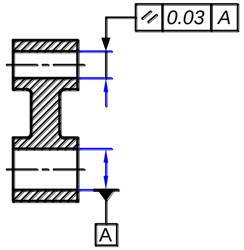
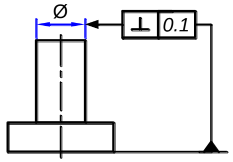
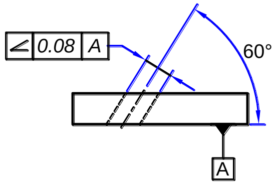
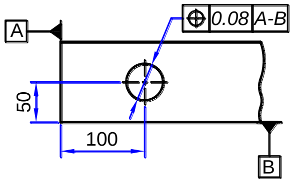
The following are the symbols representing the characteristics to be toleranced.

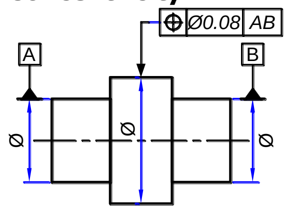
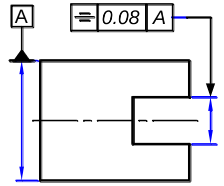
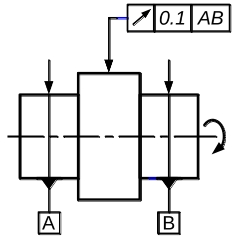
Characteristics to be toleranced		Symbols
Form of single features	Straightness	⏤
	Flatness	⏥
	Circularity (roundness)	○
	Cylindricity	⌭
	Profile of any line	⌒
	Profile of any surface	⌓
Orientation of related features	Parallelism	//
	Perpendicularity	⊥
	Angularity	∠
Position of related features	Position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

2.4.4 Indicating geometric tolerance on the drawing

To eliminate the need for descriptive notes, geometrical tolerances are indicated on drawing by symbols, tolerances and datums, all contained in compartments of a rectangular frame.

Example	Explanation
1) **Straightness** 	It refers to the axis of the cylindrical part. The tolerance value ϕ0.08 mm means that the axis of the cylinder must be contained in a cylindrical zone of diameter 0.08 mm.
2) **Flatness** 	It refers to a surface. The tolerance value 0.08 mm means that the indicated surface should be contained between two parallel plane 0.08 mm apart.
3) **Circularity** 	It refers to circularity of conical object. The tolerance value 0.1 mm means that the circumference of the each cross section should be contained between two co-planar concentric circles 0.1 mm apart.
4) **Cylindricity** 	It refers to the cylindricity of circular objects. The tolerance value 0.1 mm means that the considered cylindrical surface should be contained between two coaxial cylinders 0.1 mm apart.
5) **Profile of any line** 	It refers to a profile. The tolerance value 0.04 mm means that the considered profile must be contained between two line enveloping circles of diameter 0.04 mm, the centres of which are situated on a line having the correct geometrical profile.
6) **Profile of any surface** 	It refers to the profile of double curved surface. The tolerance value 0.02 mm means that the considered surface should be contained between two double curved surfaces enveloping spheres of diameter 0.02 mm, the centres of which are situated on a surface having the correct geometrical form.

Example	Explanation
7) **Parallelism** 	It refers to the orientation of the axis of a feature with reference to a datum line. The tolerance value indicates that the upper axis should be contained in a cylindrical tolerance zone of diameter 0.03 mm parallel to the lower axis A.
8) **Perpendicularity** 	It refers to the orientation of the axis of a feature perpendicular to a datum surface. The tolerance value indicates that the axis of the cylinder should be contained between two parallel straight lines 0.1 mm apart, lying in a plane perpendicular to the datum plane.
9) **Angularity** 	It refers to the orientation of the axis of a feature inclined to a datum surface. The tolerance value indicates that the axis of the hole should be contained between two parallel straight lines 0.08 mm apart which are inclined at 60º to the datum plane A.
10) **Position** 	It refers to the location of the axis of a hole with reference to the datum surface. The tolerance value indicates that the axis of the hole should be contained within a cylindrical tolerance zone of diameter 0.08 mm, the axis of which is in the theoretically exact position of the considered axis with reference to the datum surfaces A and B.

Example	Explanation
11) Concentricity 	It refers to the concentricity or coaxiality of the circular features with reference to a centre of an axis. The tolerance value indicates that the axis of the cylinder should be contained in a cylindrical zone of diameter 0.08 mm with the datum axis AB.
12) Symmetry 	It refers to the symmetrical disposition of a feature with reference to a median plane considered as datum. The tolerance value indicates that the slot should be contained between two parallel planes which are 0.08 mm apart and symmetrically disposed about the median plane with respect to the datum feature A.
13) Run-out 	It refers to the radial run-out of a circular feature with reference to the datum axis. The tolerance value indicates that the run-out of the cylindrical surface must not be greater that 0.1 mm in any measuring plane during one complete revolution about the common axis of the surfaces A and B.

2.4.5 Applications of geometric tolerances

Geometric tolerances are used,

(i) to specify the required accuracy in controlling the form of a feature

(ii) to ensure the correct functional positioning of the feature

(iii) to ensure the interchangeability of components, and

(iv) to facilitate the assembly of mating components.

2.5 Fits

When two parts are to be assembled, the relation resulting from the difference between their sizes before assembly is known as a *fit*.

Classification of fits :

Depending upon the actual limits of the hole or shaft sizes, fits may be classified as follows:

1) Clearance fit
2) Transition fit
3) Interference fit

2.5.1 Clearance fit

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

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

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

Example :

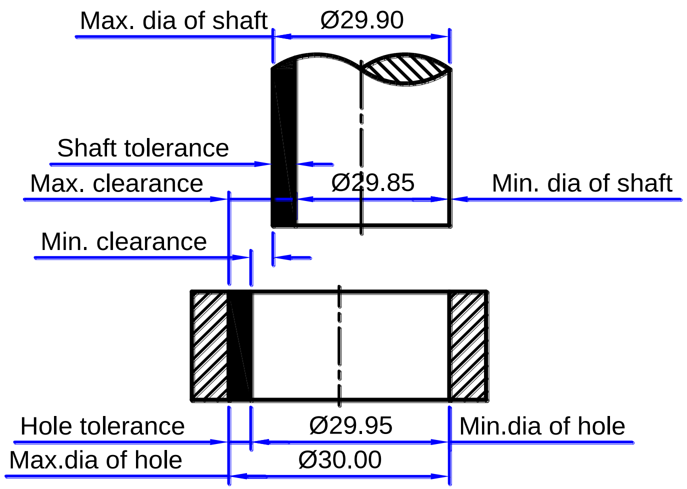


Fig.2.6 Clearance fit

The fit between the shaft and the hole in Fig.2.6 is a clearance fit that permits a minimum clearance (allowance) value of 29.95 – 29.90 =+0.05mm and a maximum clearance of 30.00 – 29.85=+0.15mm.

Applications : Clearance fit is useful in rotating shafts, loose pulley, bearings, cross head slides, etc.

2.5.2 Transition fit

This fit may result in either an interference or a clearance, depending on the actual values of the tolerance of individual parts.

Example :

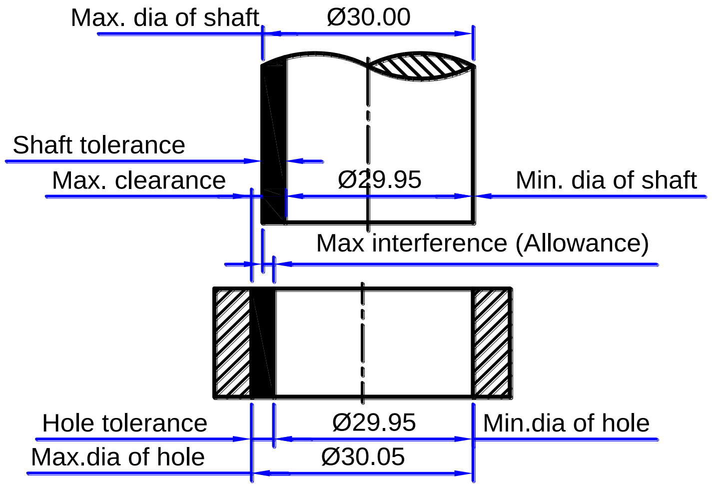


Fig.2.7 Transition fit

The shaft in Fig.2.7 may be either smaller or larger than the hole and still be within the prescribed tolerances. It results in a clearance fit when shaft diameter is 29.95mm and hole diameter is 30.05mm (+0.10mm). It results in interference fit when shaft diameter is 30.00mm and hole diameter is 29.95mm (-0.05mm).

Applications : Transition fit is useful in bushes, spigots, fasteners, pins, keys, stationary parts for location purposes, etc.

2.5.3 Interference fit

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

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

Maximum interference: It is the magnitude of the difference between the minimum size of the hole and the maximum size of the shaft in an interference or a transition fit before assembly.

Example :

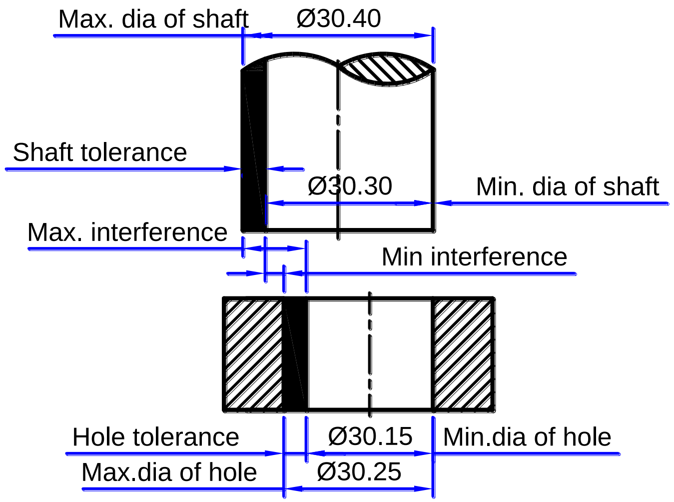


Fig.2.8 Interference fit

The shaft in Fig.2.8 is larger than the hole, so it requires a press fit, which has an effect similar to welding of two parts. The value of minimum interference is 30.25 – 30.30 = -0.05mm and maximum interference is 30.15 – 30.40 = -0.25mm.

Applications : Interference fit is useful in bushes, crank pins, shrunk-on couplings, iron tyres, railway wheel shrunk on to axles, etc.

2.6 Selection of fits

The hole basis system is the most commonly used system. However, shaft basis system is also used when a single driving shaft accommodates a large number of pulleys, couplings, collars, etc. The commonly used types of fits are given in the following table. The suitable fit is selected based on the uses.

- ✦ Shafts *a* to *h* produce clearance fit.
- ✦ Shafts *j* to *n* produce transition fit
- ✦ Shaft *p* to *z* produce interference fit.

Type of fit	Shaft	Hole				Remarks and uses
		H6	H7	H8	H11	
Clearance fit	a	-	-	-	a11	Large clearance fits – Not widely used
	b	-	-	-	-	-
	c	-	c8	c9	c11	Slack running fits.
	d	-	d8	d8-d10	d11	Loose running fits. Used in plummer block bearing and loose pulleys
	e	e7	e8	e8-e9	-	Easy running fits - Used in large electric motor and turbo generator bearing according to the working condition.
	f	f6	f7	f8	-	Normal running fits - Used in gear box shaft bearing and the bearings of small electric motor, pumps, etc.
	g	g5	g6	g7	-	Close running fit or sliding fit - Used in bearings for accurate link work and for piston and side valves.
	h	h5	h6	h7-h8	h11	Precision sliding fit - Widely used for non running parts.
Transition fit	j	j5	j6	j7	-	Push fit - Used in coupling, spigots and recesses, rings, gear clamped to steel hubs, etc.
	k	k5	k6	k7	-	True transition fit. Used in keyed shaft, non-running locked pins, etc.
	m	m5	m6	m7	-	Medium keying fit.
	n	n5	n6	n7	-	Heavy keying fit - Used in light assembly of mating parts.
Interference fit	p	p5	p6	-	-	Light press fit - Used in standard press fit with easy dismantling.
	r	r5	r6	-	-	Medium drive fit - Used in light drive fit with easy dismantling.
	s	s5	s6	d7	-	Heavy drive fit - Used in standard press fit for non-ferrous assembly.
	t	t5	t6	t7	-	Force fit - Used in ferrous parts for permanent assembly.
	u	u5	u6	u7	-	Heavy force fit or shrink fit.
	v,x,y,z	-	-	-	-	Very large interference fits – Not recommended for use.

REVIEW QUESTIONS

Unit – II : LIMITS, FITS AND TOLERANCES

1) Define : (a) Basic size (b) Actual size (c) Design size (d) Zero line
2) Differentiate between allowance and deviation.
3) Describe the various deviations.
4) Write short notes on limits and tolerances.
5) State the importance of tolerance.
6) What is tolerance? Explain its types.
7) Write short notes on fundamental tolerances.
8) What are the methods of tolerances? (or) Explain hole basis system and shaft basis system.

9) Why hole basis system is preferred?

10) How will you indicate the tolerance on linear dimension of drawings?

11) Explain (i) Unilateral tolerance (ii) Bilateral tolerance

12) Define geometrical tolerance. Explain its types.

13) Define : Datum, Datum feature, Datum triangle and Datum letter

14) Draw the symbols for the following geometrical tolerances :
(a) Parallelism (b) Perpendicularity (c) Angularity (d) Straightness
(e) Flatness

15) Explain position tolerances with symbols.

16) How will you indicate geometrical tolerances on drawing? Give examples.

17) List out the applications of geometrical tolerances.

18) Explain fits and its classifications.

19) Describe clearance fit using a neat sketch.

20) Explain interference fit with suitable example. Give its applications.

21) With a suitable sketch, explain transition fit.

22) Write short notes on selection of fits.

Unit – III

SURFACE TEXTURE

3.1 Surface texture

It is not possible to achieve in practice, a geometrically ideal surface of a component. Therefore production drawing must also contain information about the permissible surface conditions.

3.2 Importance of surface texture

The following are the importance of surface texture :

- The properties and performance of machine components are affected by the degree of roughness of the various surfaces.
- The fatigue strength and corrosion resistance can be improved due to higher smoothness of the surface.
- The rate of wear is considerably reduced due to good surface finish.
- Friction between mating parts is reduced due to better surface finish.
- Good bearing properties can be obtained when the surface has more roughness.

3.3 Surface texture characteristics

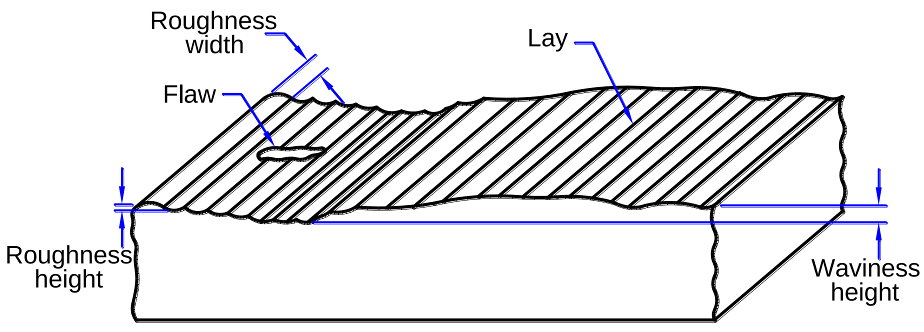


Fig.3.1 Surface texture characteristics

The following are the important characteristics related with the surface texture :

1) Surface: The surface of an object is the boundary which separates that object from another mating object.

2) Nominal surface: A theoretical geometrically perfect surface is called nominal surface. But, it is not possible to obtain a perfect surface.

3) Measured surface : It is the representation of the surface obtained by instrumentation or other means.

4) Surface finish: Surface finish or surface texture is the amount of geometric irregularity produced on the surface. The degree of surface finish is a factor in cost during manufacturing.

5) Roughness: All smooth surfaces have some small peaks and valleys caused by machine cutting operations. These finely spaced surface irregularities are called roughness.

- ***Roughness height:*** It is an arithmetical average distance measured from peak to valley in microns.
- ***Roughness width:*** It is the distance parallel to the nominal surface between successive peaks. It is measured in millimetre. It depends upon the machine, cutting tool and feed.
- ***Roughness width cut-off:*** It is the greatest spacing of repetitive surface irregularities. It must always greater than the roughness width.
- ***Sampling length:*** It is also known as cut-off length. The roughness value measured over a specified distance in microns is called sampling length.

6) Waviness: Surface irregularities of large size is called waviness. Waviness results from vibrations, work deflections, warping, heat treatment, etc.

- ***Waviness height:*** It is the distance from the peak of the wave to its valley. It is measured in millimetre.
- ***Waviness width:*** It is the spacing between successive waves. It is measured in millimetre.

7) Flaws: Flaws are infrequent irregularities that occur at random places on a machined part. The most common flaws are cracks, scratches, etc.

8) Surface roughness number: It represents the average deviation of the surface from perfection over a prescribed sampling length. It is usually selected as 0.8mm and expressed in microns.

3.4 Controlled and uncontrolled surfaces

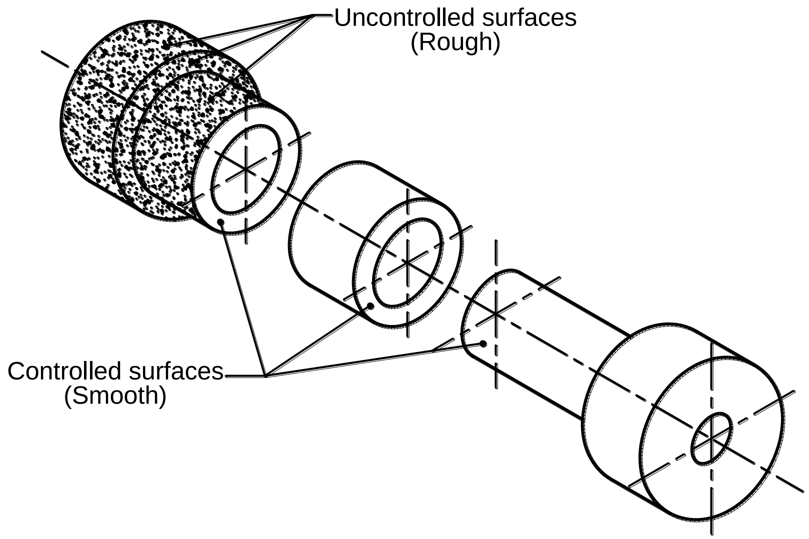


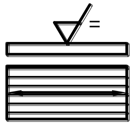
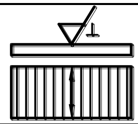
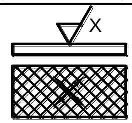
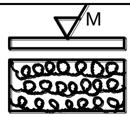
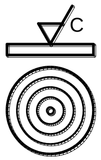
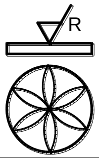
Fig.3.2 Controlled and uncontrolled surfaces

Controlled surfaces : The surfaces in a machine part which controls the proper functioning and performance of an assembly are known as *controlled surfaces*. These surfaces play a vital role for the easy and accurate assembly of the mating parts. These surfaces make contact with other surfaces in the assembly. The type of joint and the degree of accuracy will depend upon the surface finish of the mating surfaces. Hence controlled surfaces require high degree of surface finish. It results in increased manufacturing cost of the machine part.

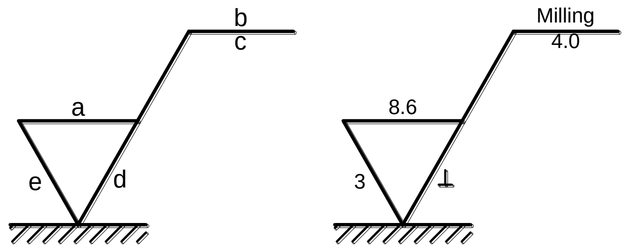
Uncontrolled surfaces : The surfaces in a machine part which are not important for the proper functioning and performance of an assembly are known as *uncontrolled surfaces*. These surfaces do not make contact with any other surfaces in the assembly. Hence uncontrolled surfaces require less degree of surface finish. It results in decreased manufacturing cost of the machine part.

3.5 Direction of lay

The direction of lay is the primary direction of the surface pattern made by the machine tool marks. The following table shows the symbols which specify the common directions of lay.

Symbol	Explanation	
= (Parallel)	Parallel to the plane of projection of the view in which the symbol is used.	
⊥ (Perpendicular)	Perpendicular to the plane of projection of the view in which the symbol is used.	
X (Crossed)	Crossed in two slant direction relative to the plane of projection of the view in which the symbol is used.	
M (Multi-directional)	Multidirectional to the plane of projection of the view.	
C (Circular)	Approximately circular relative to the centre of the surface to which the symbol is applied.	
R (Radial)	Approximately radial relative to the centre of the surface to which the symbol is applied.	

3.6 Machining symbol (or) Surface roughness symbol



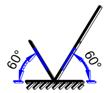
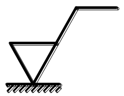
(a) Basic symbol (b) Example

Fig.3.3 Surface roughness symbol

The standard surface roughness symbol recommended by BIS is shown in the Fig.3.3. In this symbol,

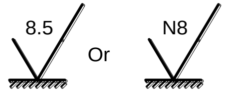
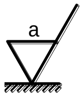
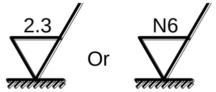
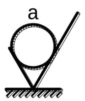
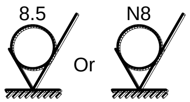
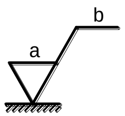
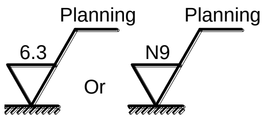
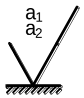
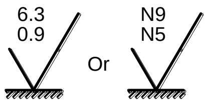
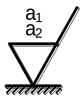
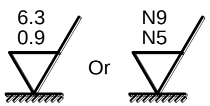
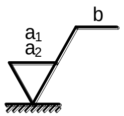
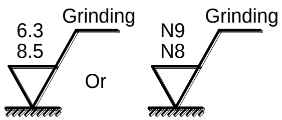
- 'a' represents the *surface roughness value* in μm or in grade
- 'b' represents the *production method*
- 'c' represents the *sampling length* in mm
- 'd' represents the *direction of lay*
- 'e' represents the *machining allowance* in mm.

The standard machining symbols and their meanings are listed below.

Symbol	Meaning
	This is the basic symbol. It consists of two legs of unequal length inclined at 60^{o} to the line representing the surface.
	A horizontal bar is added with the basic symbol. It is used to indicate the surface obtained by removal of material by machining.
	A circle is added with the basic symbol. It indicates that the removal of material from the surface is not permitted.
	A horizontal line is added with the longer leg when special surface characteristics have to be indicated.

3.7 Indication of surface roughness

The various methods of indicating the surface roughness are tabulated below.

Symbol	Meaning	Example
	Surface roughness of maximum value 'a' can be obtained by any production method.	
	Surface roughness of maximum value 'a' should be obtained only through removal of material by machining.	
	Surface roughness of maximum value 'a' should be obtained without removal of material.	
	Surface roughness of maximum value 'a' should be obtained by machining only through a particular production method.	
	A surface with a maximum roughness value of 'a_1' and minimum of 'a_2' should be obtained by any production method.	
	A surface with a maximum roughness value of 'a_1' and minimum of 'a_2' should be obtained by removal of material through machining.	
	A surface with a maximum roughness value of 'a_1' and minimum of 'a_2' should be obtained by removal of material through a particular production method.	

3.8 Indication of surface roughness symbols on drawings

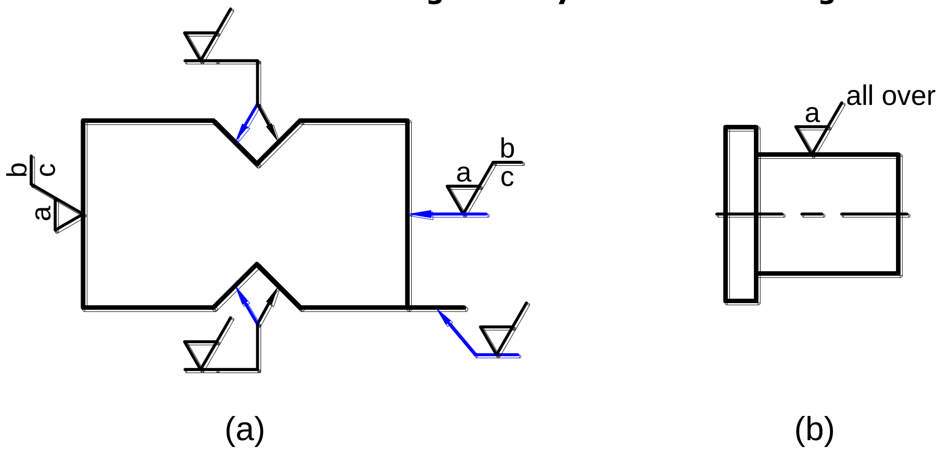


Fig.3.4 Indication of surface roughness symbols on drawings

The following are the important points to be considered while indicating the surface roughness symbols on drawings.

- The symbols and notes should be oriented on the drawing such that they may be read from the bottom or right hand side of the drawing.
- The symbol may be connected to the surface by a leader line, terminating in an arrow.
- The symbol or the arrow should point from outside the material of the piece, either to the line representing the surface, or to an extension of it.
- If the same surface roughness is required for all the surfaces of a part, it is specified
  - by a note near the view of a part
  - near the title block
  - in the space provided for general notes
  - following the part number on the drawing.

REVIEW QUESTIONS

Unit – III : SURFACE TEXTURE

1) List out the importance of surface texture.
2) Define : (a) Surface (b) Nominal surface (c) Surface finish (d) Flaw
3) Write short notes surface roughness and waviness.
4) Sketch and explain surface roughness with important terms.
5) What are controlled and uncontrolled surfaces?
6) Define lay. Explain the direction of lay using symbols.
7) Sketch and explain the surface roughness symbol and its notations.
8) List out the standard machining symbols and their meanings.
9) Explain with an example, the various methods of indicating surface roughness.
10) Mention the important points to be considered while indicating the surface roughness on drawings.

Unit – IV

KEYS, SCREW THREADS AND THREADED FASTENERS

4.1 Types of fasteners

A machine element used for holding or joining two or more parts of a machine or structure is known as fastener. The process of joining the part is called fastening. The fasteners are classified as :

(a) Temporary fasteners (b) Permanent fasteners.

(a) Temporary fasteners : Sometimes, it is necessary to dismantle the joint for repairs, replacements and inspection. In such cases, temporary fasteners are used. The parts joined together can easily be separated *without damaging* the parts.

Example : Keys, bolts and nuts, studs, screws, cotters, pins, couplings, etc. are the examples for temporary fasteners.

(b) Permanent fasteners : If the joints are not likely to be dismantled, then permanent fasteners are used. The parts joined together can be separated only by *destroying* the fasteners.

Example : Riveting, welding, forging, brazing, etc. are the examples for permanent fasteners.

Applications of fasteners :

Generally screwed fasteners are used,

i) to hold parts together
ii) to adjust parts with reference to each other
iii) to transmit power.

4.2 Keys

Keys are machine elements used to prevent relative rotational movement between a shaft and the parts mounted on it, such as pulleys, gears, wheels, couplings, etc. For making the joint, grooves or keyways are cut on the surface of the shaft and in the hub of the part to be mounted. After positioning the part on the shaft such that, both the keyways are properly aligned, the key is driven from the end, resulting in a firm joint.

For mounting a part at any intermediate location on the shaft, first the key is firmly placed in the keyway of the shaft and then the part to be mounted is slid from one end of the shaft, till it is fully engaged with the key.

4.3 Classification of keys

The keys are classified according to the shape and purpose of use. The keys are classified as follows:

a) Heavy duty keys
- Sunk keys

b) Light duty keys
- Saddle keys
- Round keys

4.3.1 Sunk keys

These are the standard forms of keys used in practice, and may be either square or rectangular in cross section. The end may be squared or rounded. Generally, half the thickness of the key fits into the shaft keyway and the remaining half in the hub keyway. These keys are used for heavy duty, as the fit between the key and the shaft is positive.

Sunk keys may be classified as:

a) Taper keys
b) Parallel or feather keys
c) Woodruff keys

a) Taper sunk keys

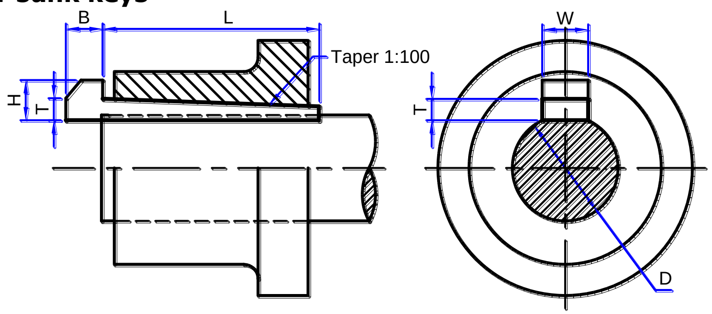


Fig.4.1 Taper sunk key key with gib head

These keys are square or rectangular in cross section, uniform in width but tapered in thickness. The bottom surface of the key is straight and the top surface is tapered, the magnitude of the taper being 1:100. Hence, the keyway in the shaft is parallel to the axis and the hub keyway is tapered.

A tapered sunk key may be removed by driving it out from the exposed small end. If this end is not accessible, the bigger end of the key is provided with a head called gib. Fig.4.1 shows the application of a key with gib end.

If D is the diameter of the shaft, then

Width of key, W = 0.25D + 2mm
Thickness of key, T = 0.67W (at the thicker end)
Standard taper = 1:100
Height of head, H = 1.75 T
Width of head, B = 1.5 T

b) Parallel or feather keys

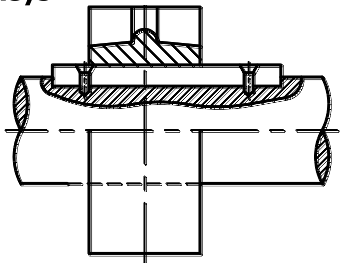


Fig.4.2 Parallel sunk key

A parallel or feather key is a sunk key, uniform in width and thickness. These keys are used when the parts (gears, clutches, etc.) mounted are required to slide along the shaft, permitting relative axial movement. To achieve this, a clearance fit must exist between the key and the keyway in which it slides.

The feather key may be fitted into the keyway provided on the shaft by two or more screws. The feather keys are classified as follows:

(i) Peg feather key
(ii) Single headed feather key
(iii) Double headed feather key

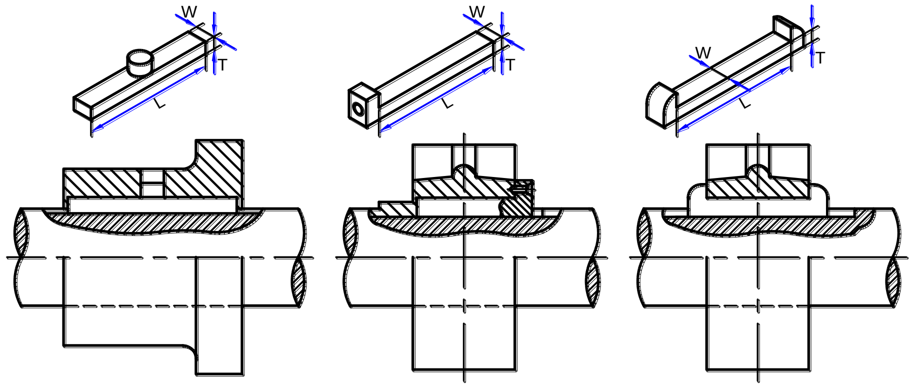


Fig.4.3 Feather keys

Peg feather key

In this key, a projection known as peg is provided at the middle of the key. The peg fits into a hole in the hub of the sliding member. Once placed in position, the key and the mounting move axially as one unit.

Single headed feather key

In this, the key is provided with a head at one end. The head is screwed to the hub of the part mounted on the shaft.

Double headed feather key

In this, the key is provided with heads on both ends. These heads prevent the axial movement of the key in the hub.

C) Woodruff key

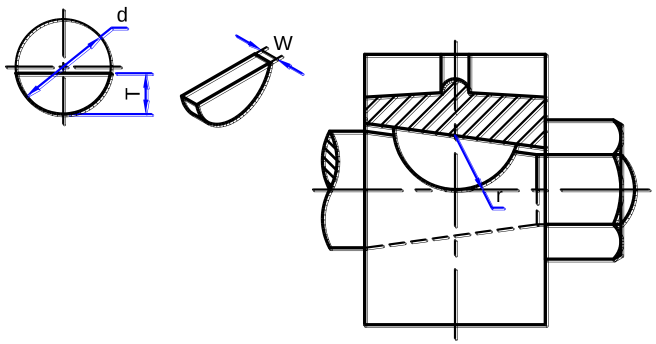


Fig.4.4 Woodruff key

It is a sunk key, in the form of a segment of a circular disc of uniform thickness. As the bottom surface of the key is circular, the keyway in the shaft is in the form of a circular recess to the same curvature as the key. A keyway is made in the hub of the mounting, in the usual manner.

Woodruff key is mainly used on tapered shafts of machine tools and automobiles. Once placed in position, the key tilts and aligns itself on the tapered shaft. The following are the proportions of woodruff keys:

If D is the diameter of the shaft,

Thickness of key, W = 0.25 D

Diameter of key, d = 3 W

Height of key, T = 1.35 W

Depth of keyway in the hub, T_1 = 0.5 W + 0.1mm

Depth of keyway in shaft, T_2 = 0.85 W

4.3.2 Saddle keys

These are taper keys, with uniform width but tapering in thickness on the upper side. The magnitude of the taper provided is 1:100. These keys are suitable only for light duty. The types of saddle keys are :

a) Hollow saddle key b) Flat saddle key

a) Hollow saddle key

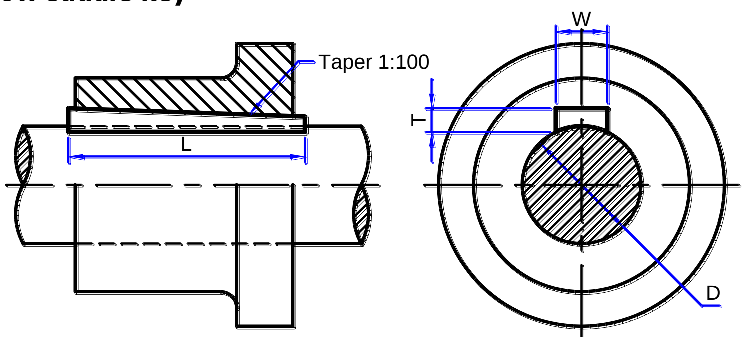


Fig.4.5 Hollow saddle key

A hollow saddle key has a concave shaped bottom to suit the curved surface of the shaft, on which it is used. A keyway is made in the hub of the mounting, with a tapered bottom surface. When a hollow saddle key is fitted in position, the relative rotation between the shaft and the mounting is prevented due to the friction between the shaft and key.

b) Flat saddle key

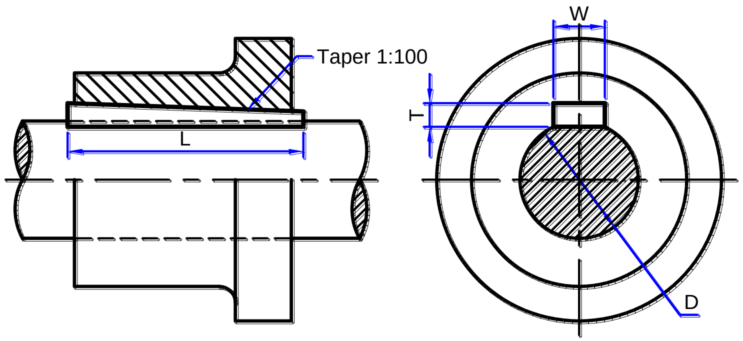


Fig.4.6 Flat saddle key

It is similar to the hollow saddle key, except that the bottom surface of it is flat. Apart from the tapered keyway in the hub of the mounting, a flat surface provided on the shaft is used to fit this key in position.

4.3.3 Round keys

Round keys are of circular cross section, usually tapered (1:50) along the length. A round key fits in the hole drilled partly in the shaft and partly in the hub. The mean diameter of the key may be taken as 0.25 D, where D is shaft diameter. Round keys are generally used for light duty, where the loads are not considerable.

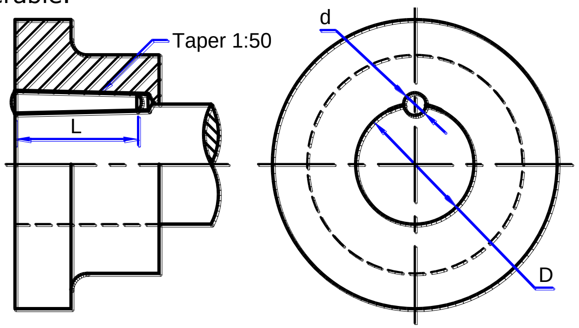


Fig.4.7 Round Key

4.4 Screw thread

A screw thread is obtained by cutting a continuous helical groove on a cylindrical surface. The threaded portion engages with a corresponding threaded hole forming a screwed fastener.

4.4.1 Nomenclature of screw thread

The following are the important terms associated with screw threads:

Major diameter (Nominal diameter): This is the largest diameter of a screw thread, touching the crests of an external thread or the roots of an internal thread.

Minor diameter (Core diameter): This is the smallest diameter of screw thread, touching the roots or core of an external thread or the crests of an internal thread.

Pitch diameter: This is the diameter of an imaginary cylinder, passing through the threads at the points where the thread width is equal to the space between the threads.

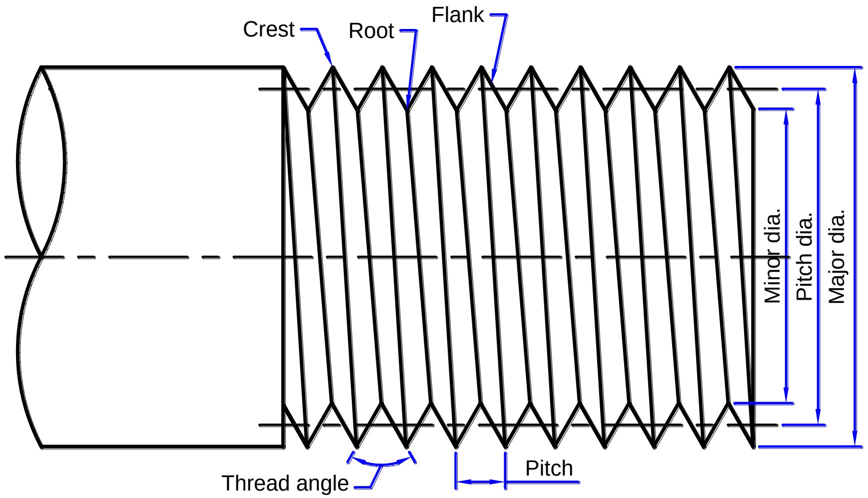


Fig.4.8 Nomenclature of screw thread

Pitch: It is the distance measured parallel to the axis, between corresponding points on adjacent screw threads.

Lead: It is the distance a screw advances axially in one turn.

Flank: Flank is the straight portion of the surface, on either side of the screw thread.

Crest: It is the peak edge of a screw thread, that connects the adjacent flanks at the top.

Root: It is the bottom edge of the thread that connects the adjacent flanks at the bottom.

Thread angle: This is the angle included between the flanks of the thread, measured in an axial plane.

4.5 Types of thread profiles

The two main profile of screw threads are (i) triangular or 'V' thread and (ii) square thread. Other profiles are either modified forms of square thread or a combination of the two forms. The commonly used profiles of screw threads are :

1) ISO metric thread 2) BSW thread 3) Buttress thread
4) Square thread 5) ACME thread 6) Knuckle thread

1) ISO metric thread

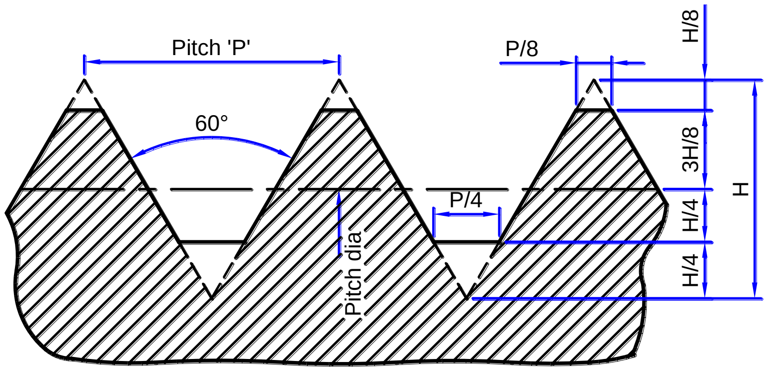


Fig.4.9 ISO metric thread

The Bureau of Indian Standards has recommended the adoption of ISO metric thread for use in India. In this system, the pitch of the thread is fixed. This thread has symmetrical 'V' form with an included angle of 60^{o} between flanks. In order to avoid sharp corners, the basic profile is rounded at the root of the design profile. Metric thread is specified by the letter M followed by the diameter, e.g. M20, where 20 is the diameter of the screw thread in millimeters.

2) BSW (British Standard Whitworth) thread

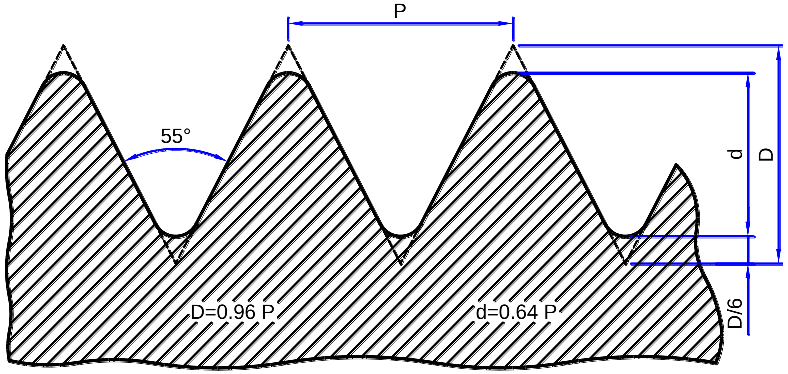


Fig.4.10 BSW thread

This thread form is adopted in Britain in inch units. It has symmetrical 'V' form with an included angle of 55° between flanks. It has rounded crest and root.

3) Buttress thread

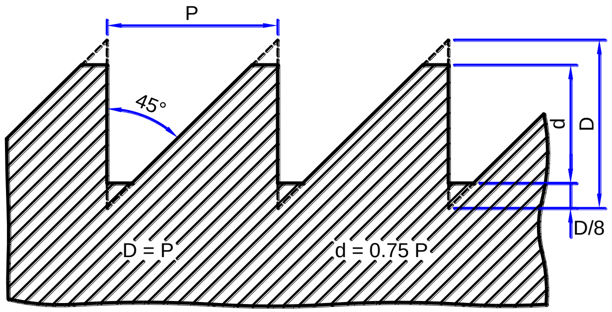


Fig.4.11 Buttress thread

This thread is a combination of the triangular and the square threads. One flank of the thread is perpendicular to the axis of the screw. The angle between its two flanks is 45°. The theoretical depth is equal to the pitch. One-eighth of the depth is cut-off parallel to the axis at the crest and at the root. This thread is suitable only when the force acts entirely in one direction. It is commonly used in the screw of a bench vice.

Theoretical depth, D = p ; Actual depth, d = 0.75 p

4) Square thread

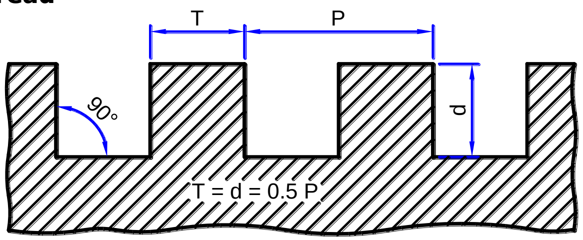


Fig.4.12 Square thread

This thread has its flanks or sides normal to the axis and hence parallel to each other. It is generally used for transmission of power. It is also used for obtaining larger axial movement of the nut of the screw per revolution. The depth and thickness of the thread are each equal to half the pitch.

5) ACME thread

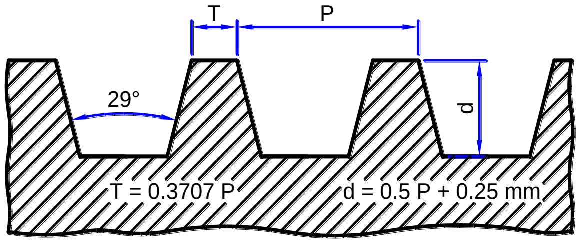


Fig.4.13 ACME thread

It is the modified form of square thread. It is much stronger than square thread because of the wider base and it is easy to cut. The thread angle is 29°. The inclined sides of the thread facilitate quick and easy engagement and disengagement.

6) Knuckle thread

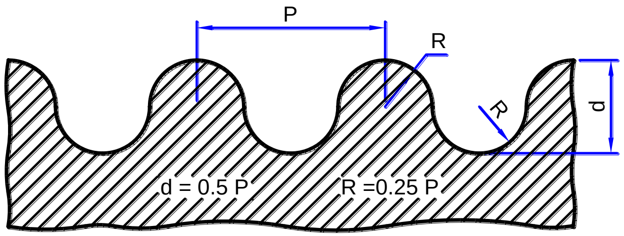


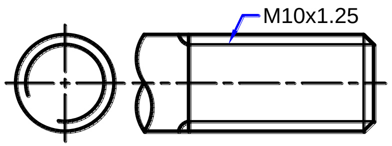
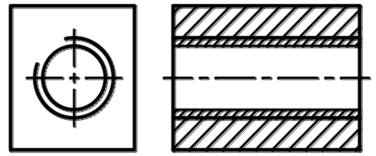
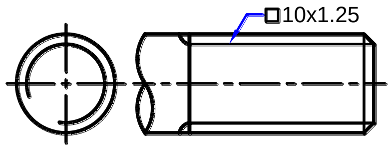
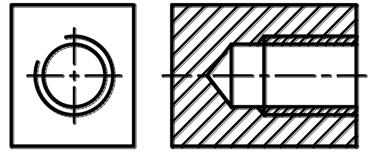
Fig.4.14 Knuckle thread

Knuckle thread is also a modification of the square thread. It is formed by rounding off the corners of the square thread. It is designated by the letter **K** followed by its nominal diameter and pitch, the two being separated by x. For example, **K10x1.25** represents a knuckle thread of nominal diameter 10mm and pitch of 1.25mm.

This thread can withstand heavy wear. It is generally used in electrical bulbs and sockets, bottle taps, pen caps, etc.

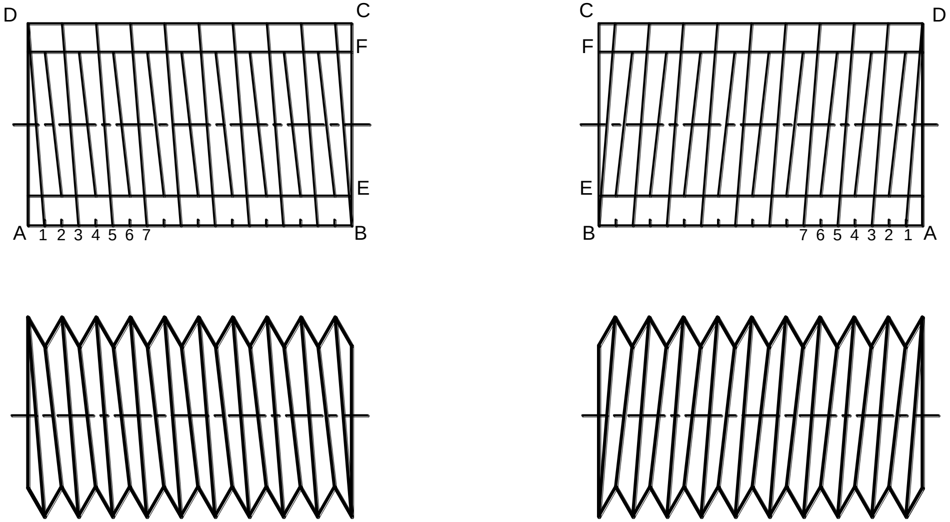
4.6 Threads in section

The conventional representation of threads in section are as shown below :

Description	BIS convention
External V-thread	
Internal V-thread	
External square thread	
Internal V-thread in blind hole	

4.7 Drawing of external metric V-thread

Example 1: Draw an external right hand and left hand V-thread of 36mm diameter, 50mm long and 4mm pitch.



(a) Right hahd 'V' thread (b) Left hahd 'V' thread

Fig.4.15 Drawing of external metric V – thread

Procedure

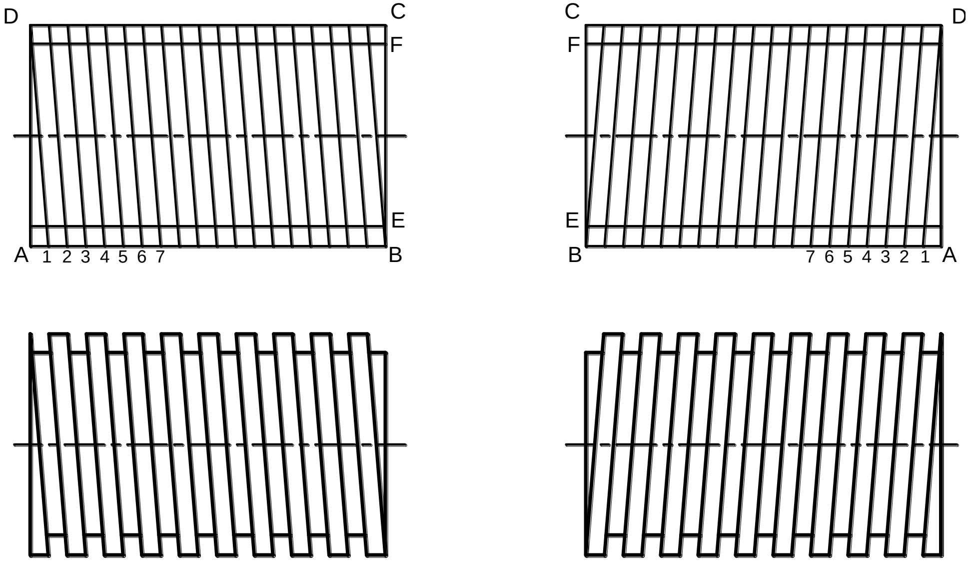
Right hand external 'V' thread

1. Draw a horizontal centre line. Draw a rectangle ABCD of length 50mm and height 36mm.
2. Calculate the depth of thread
   Depth of thread, d = 0.61 p = 0.61 x 4 = 2.44mm say 2.5mm
3. Mark two points E and F on BC at a distance of 2.5mm from B and C respectively.
4. Draw two horizontal construction lines through the points E and F.
5. Mark off the points 1, 2, 3, . . . on AB at a distance of 2mm (p/2) from each other.
6. Draw a thin dark line joining the points D and 1. It is crest line.
7. Draw a thick dark line through point 2 parallel to line D1. It is valley line.
8. Similarly draw alternative thin and thick dark lines through the remaining points.
9. Draw inclined lines by joining the ends of crest lines and valley lines on both sides to form 'V' profile and complete the drawing.

Left hand external 'V' thread

Follow the above procedure and complete the drawing of left hand external 'V' thread as shown in Fig.4.15(b).

Example 2: Draw a external right hand and left hand square thread of 40mm diameter, 60mm long and 4mm pitch.



(a) Right hand square thread (a) Left hand square thread

Fig.4.16 Drawing of external square thread

Follow the same procedure as explained in example 1 and complete the drawing as shown in Fig.4.16.

Note : Depth of square thread = p/2 = 4/2 = 2mm.

BE = FC = 2mm

4.8 Drawing of hexagonal nut

Draw the front view, top view and side view of a hexagonal nut for a bolt of 24mm diameter.

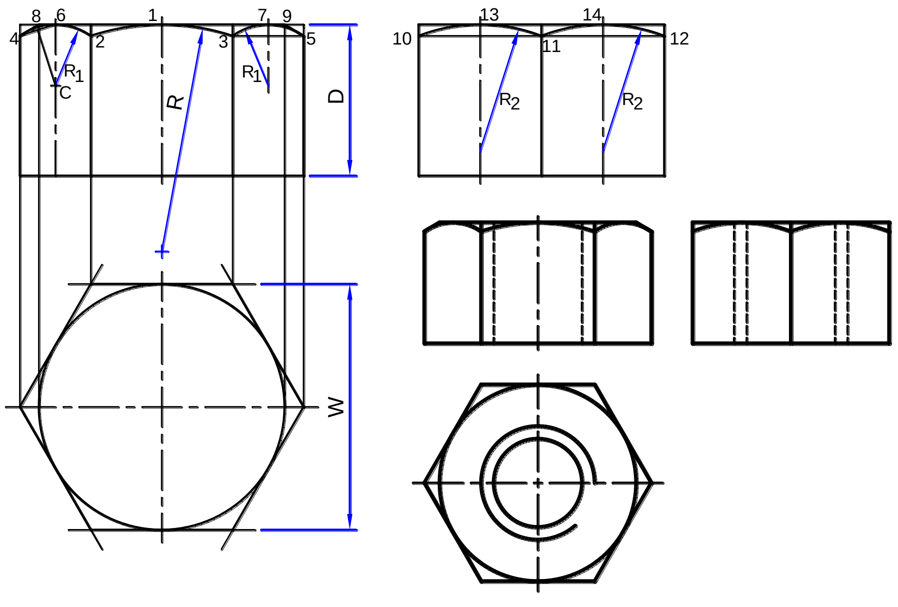


Fig.4.17 Drawing of hexagonal nut

Empirical relations:

Diameter of bolt, D = 24mm

Thickness of nut, T = D = 24mm

Width of nut across flat surfaces, W = 1.5 D + 3mm

= (1.5 x 24) + 3 = 39mm

Radius of chamfer, R = 1.5 D = 1.5 x 24 = 36mm

1. Draw a circle of diameter W (39mm) and describe a regular hexagon on it, by keeping any two parallel sides of the hexagon horizontal.
2. From this view, project the front view and side view with the height equal to D (24mm).
3. With radius R (36mm), draw the chamfer arc 2-1-3 passing through the point 1 in the front face.
4. Mark points 4 and 5, lying in line with 2 and 3.
5. Locate points 8, 9 on the top surface, by projecting from the circle in the top view.
6. Draw the chamfer 4-8 and 5-9.
7. Locate points 6 and 7, lying at the middle of the outer two faces.
8. Draw circular arcs passing through the points 4,6,2 and 3,7,5 with radius R_1. The centre point *C* can be dterimined as follows :

   (a) Draw a line joining 4 & 6 and a vertical line through 6.

   (b) Draw perpendicular bisector to line 4-6. It meets the vetcial line at *C*.
9. Locate points 10, 11 and 12 on the side view in line with 3-5
10. Mark points 13 and 14, lying at the middle of the two faces.
11. Draw circular arcs passing through the points 10, 13, 11 and 11, 14, 12, after determining the radius R_2 geometrically.

4.9 Drawing of square nut

Draw the front view, top view and side view of a square nut for a bolt diameter of 24mm.

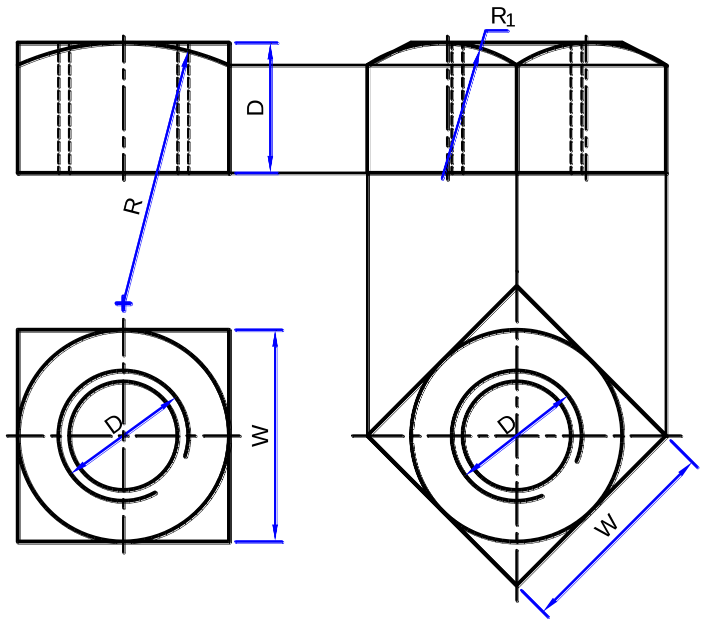


Fig.4.18 Drawing of square nut

Empirical relations:

Diameter of bolt, D = 24mm

Thickness of nut, T = D = 24mm

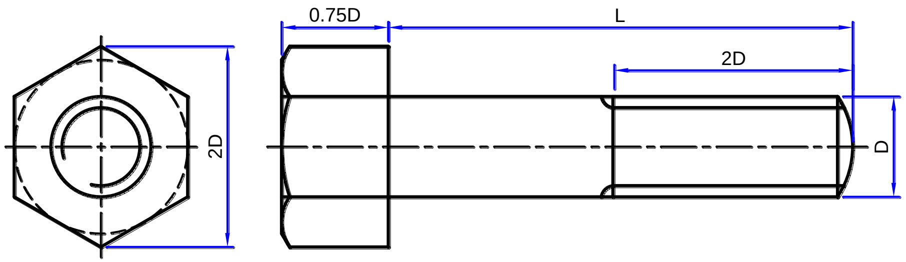
Width of nut across flat surfaces, W = 1.5 D + 3mm

= (1.5 x 24) + 3 = 39mm

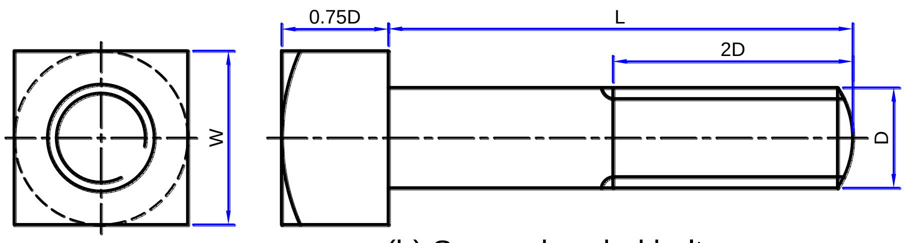
Radius of chamfer, R = 2 D = 2 x 24 = 48mm

Fig.4.18 illustrates the method of drawing views of a square nut in two orientations.

4.10 Drawing of hexagonal and square headed bolts



(a) Hexagonal headed bolt



(b) Square headed bolt

Fig.4.19 Drawing of hexagonal and square headed bolts

Fig.4.19 shows the two views of a hexagonal headed bolt and square headed bolt, with the proportions marked.

4.11 Threaded fasteners

Threaded fasteners are temporary type of fasteners used for holding two or more parts together. The important threaded fasteners are :

1) Bolts & nuts 2) Through bolt 3) Tap bolt 4) Stud bolt
5) Set screw 6) Cap screws 7) Machine screws, etc.

4.12 Bolts and nuts

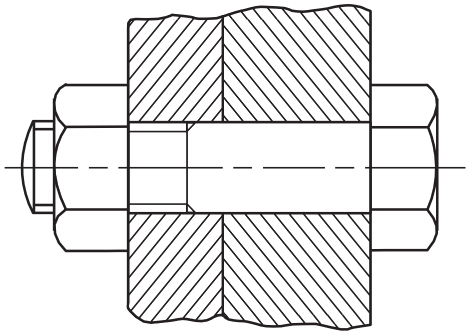


Fig.4.20 Bolt and nut

A bolt and nut in combination is a fastening device used to hold two parts together. The body of the bolt is called shank and it is in cylindrical form. The head may be in square or hexagonal shape. Screw threads are cut on the other end of the shank.

Nuts in general are square or hexagonal in shape. The nuts with internal threads engage with the corresponding size of the external threads of the bolt. However, there are other forms of nuts used to suit specific requirements. The hexagonal shape nut is mainly preferred because it is easy to tighten even in a limited space. The sharp corners on the head of bolts and nuts are removed by chamfering.

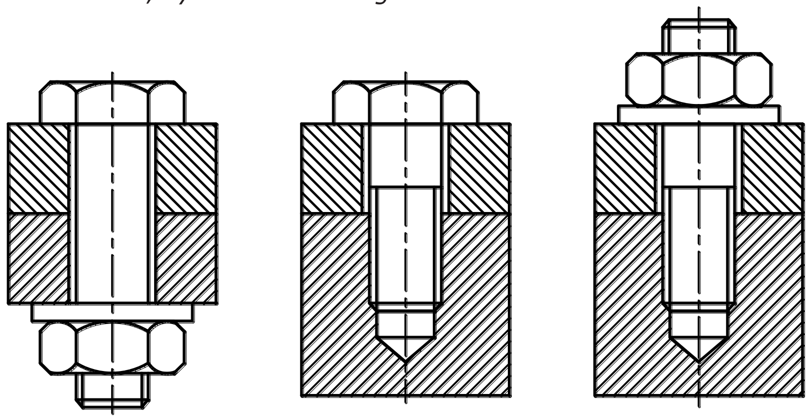
4.13 Types of bolts

a) Though bolt

A through bolt is simply called as bolt. The bolt consists of a cylindrical rod with head at one end and threads at the other end. The cylindrical portion between the head and the threads is called shank. The shank passes through the holes in the parts to be joined. The threaded portion of the bolt is screwed into the nut.

The head of the bolt and the nut are either hexagonal or square in shape. Hexagonal head bolt and nut are mainly used in the machine building industry. Square head and nuts are used mostly with rough type of bolts in construction work.

Depending upon the usage, through bolts are called *machine bolts, automobile bolts, eyebolts or carriage bolts.*



a) Through bolt b) Tap bolt c) Stud

Fig.4.21 Types of bolts

b) Tap bolt

The tap bolt consists of a cylindrical rod with head at one end and threads at the other end. The threaded end of the tap bolt is screwed into a tapped hole in one of the parts to be joined. In this type of bolt, there is no need of nut. Tap bolts are used when there is no place to accommodate the nut. Tap bolts are cheaper than through bolts.

When the tap bolt is removed frequently, the threads in the part get worn out. Hence tap bolts are used for joining the parts that are not often dismantled.

c) Stud bolt or stud

A stud is a cylindrical rod having threads at both ends. One end of the stud is screwed into the tapped hole in one of the parts to be joined. A nut is screwed at the other end of the stud. It is used where there is no place for accommodating the bolt head or when one of the parts to be joined is too thick to use an ordinary bolt.

Studs are mainly used instead of tap bolts for securing various kinds of covers such as covers of engine and cylinders, valves, chests, etc. Studs are use for joining the parts that requires frequent dismantling and reassembly.

d) Square headed bolt with square neck

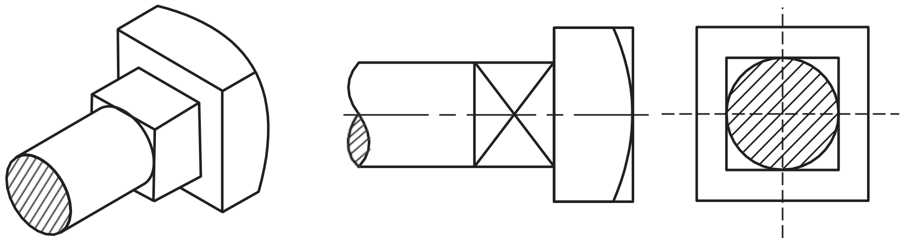


Fig.4.22 Square headed bolt with square neck

It is provided with a square neck, which fits into a corresponding square hole in the adjacent part, preventing the rotation of the bolt.

e) T-headed bolt with square neck

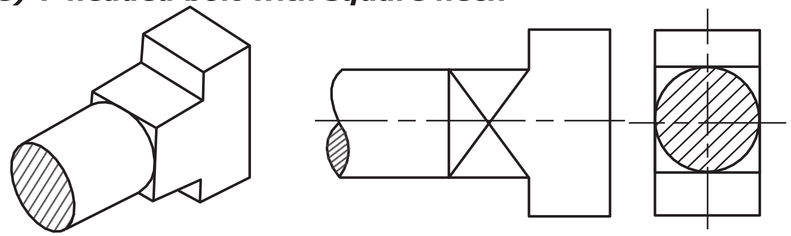


Fig.4.23 T-headed bolt

In this type, a square neck is provided below the head to prevent the rotation of the bolt. This type of bolt is used for fixing vices, work pieces, etc., to the machine table having T-slots

f) Hook bolt

This bolt passes through a hole in one part only, while the other part is gripped by the hook shaped bolt head. It is used where there is no space for making a bolt hole in one of the parts. The square neck prevents the rotation of the bolt.

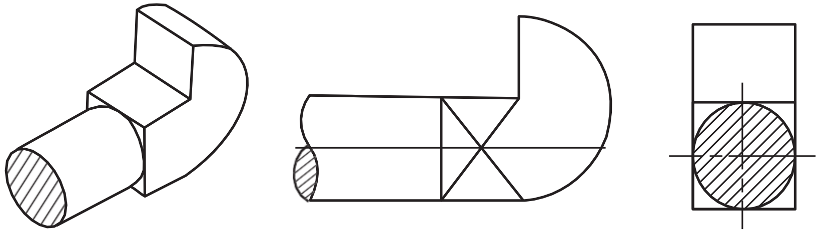


Fig.4.24 Hook bolt

h) Eye bolt

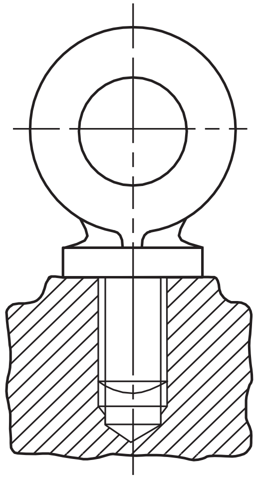


Fig.4.25 Eye bolt

In order to facilitate lifting of heavy machinery, like electric generators, motors, turbines, etc., eye bolts are screwed on to their top surfaces. For fitting an eye bolt, a tapped hole is provided, above the centre of gravity of the machine.

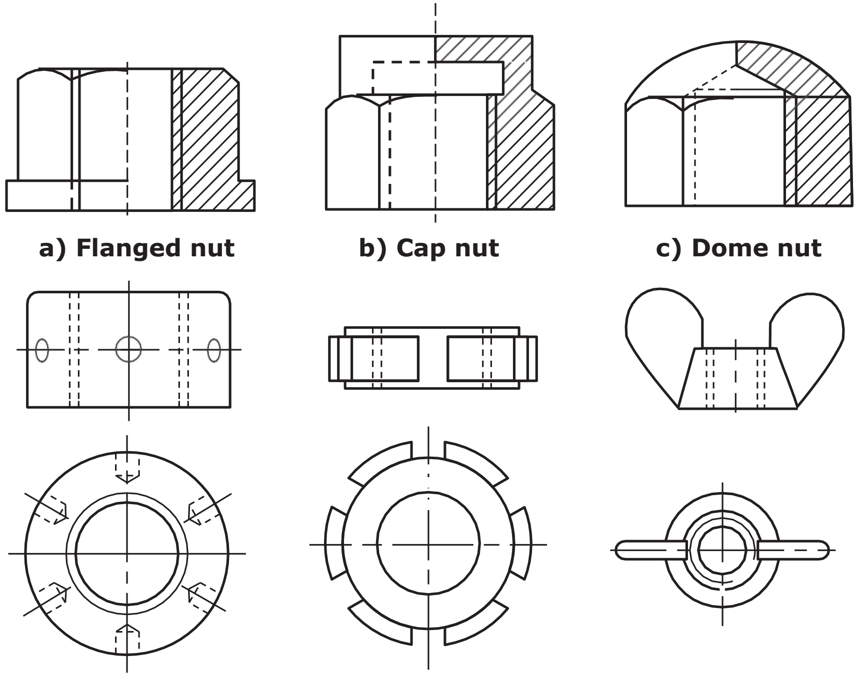
4.14 Types of nuts

a) Flanged nut

This is a hexagonal nut with a collar or flange, provided integral with it. This permits the use of a bolt in a comparatively large size hole.

b) Cap nut

It is a hexagonal nut with a cylindrical cap at the top. This design protects the end of the bolt from corrosion and also prevents leakage through the threads. Cap nuts are used in smoke boxes of locomotive and steam pipe connections.



a) Flanged nut b) Cap nut c) Dome nut

d) Capstan nut e) Ring nut f) Wing nut

Fig.4.26 Types of nut

c) Dome Nut

It is another form of a cap nut, having a spherical dome at the top.

d) Capstan nut

This nut is cylindrical in shape, with holes drilled laterally in the curved surface. A tommy bar may be used in the holes for turning the nut. Holes may also be drilled in the upper flat face of the nut.

e) Slotted or ring nut

This nut is in the form of a ring, with slots in the curved surface, running parallel to the axis. A special C-spanner is used to operate the nut. These nuts are used on large screws, where the use of ordinary spanner is inconvenient.

d) Wing nut

This nut is used when frequent removal is required, such as inspection covers, lids, etc. It is operated by the thumb.

4.15 Cap screws and machine screws

Cap screws and machine screws are similar in shape, differing only in their relative sizes. Machine screws are usually smaller in size, compared to cap screws. These are used for fastening two parts, one with clearance hole and the other with tapped hole.

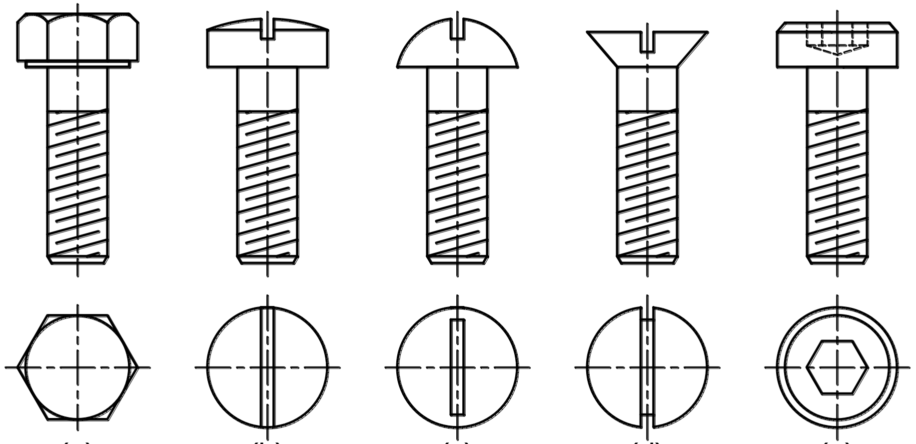


Fig.4.27 Types of machine and cap screws

Types of machine and cap screws

Cap screws are produced in finish form and are used on machines where accuracy and appearance are important. Cap screws are used only on machines requiring few adjustments and are not suitable where frequent removal is necessary. These are produced in different diameters, up to a maximum of 100 mm and lengths 250 mm.

Cap screws with the following head are generally used :

a) ***Hexagonal and square head :*** A cap screw with hexagonal or square head is tightened externally by means of a spanner. These cap screws are used in ordinary applications. Head of increased height is used for the screws which are frequently turned in and out. Square head cap screws are used in jigs and fixtures.

b) ***Fillister head :*** A fillister head cap screw has cylindrical head with a slot for the screw driver.

c) ***Button head :*** A button head cap screw has spherical head with similar slot for the screw driver.

d) ***Flat head :*** A flat head cap screw has conical head with a slot.

e) ***Hexagonal socket head :*** A cap screw with hexagonal socket head is tightened by a simple wrench made of hexagonal bar bent at right angle.

4.16 Setscrews

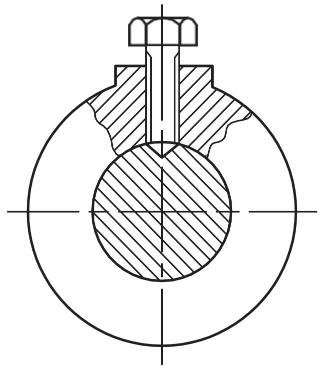


Fig.4.28 Setscrew

Setscrew is used to prevent relative motion between two parts. The threaded portion of the set screw passes through a tapped hole in one of the parts. The end of the screw presses against the other part. The end of the screw is called the point of the screw.

The fastening action is by friction between the screw and the part to be held. Setscrew can be used instead of key to prevent relative motion between the hub and the shaft in small power transmission.

Setscrews with different types of points and heads are illustrated in the figure.

a) ***Flat point :*** Flat point is used when the lateral force is randomly applied. It is also used when the part with tapped hole does not have sufficient thickness.

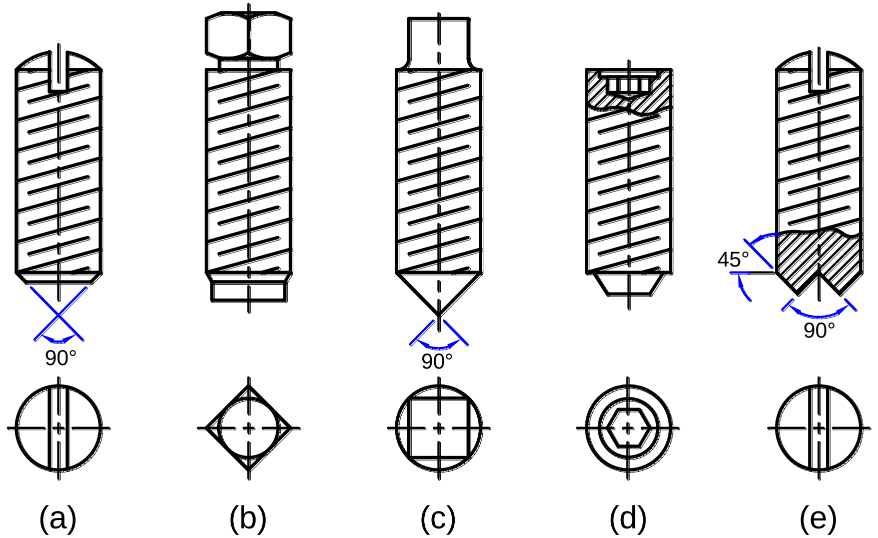


Fig.4.29 Types of setscrews

b) ***Dog point :*** Dog point is used when the lateral force is large. The part should have sufficient thickness to accommodate a cylindrical hole for the dog point.

c) ***Cone point :*** Cone point is used when the lateral force is small. The part to be held is provided with conical hole.

d) ***Hanger point :*** Hanger point has a small taper. It is used when the lateral force is large. Hanger point ensures good location of the part.

e) ***Cut point :*** Cut point is used when the part being held cannot be drilled or hardened. It is also used to transmit forces to steel balls or spherical parts.

4.17 Foundation bolts

Foundation bolts are used for fixing machines to their foundations. Foundation bolts are made by forging from mild steel or wrought iron rods. The bolt size depends upon the size of the machine and the magnitude of the forces that act on them when the machine is in operation.

For setting the bolts in position, their positions are marked and then suspended in the holes made in the ground. Afterwards, cement concrete is filled in the space around in the bolts. Once the concrete sets, the bolts are firmly secured to the ground. The various type of foundations bolts are explained below :

a) Eye foundation bolt

This is the simplest form of all foundation bolts. In this, one end of the bolt is forged into an eye and a cross piece is fixed in it.

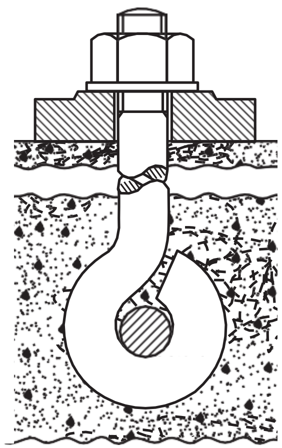


Fig.4.30(a) Eye foundation bolt

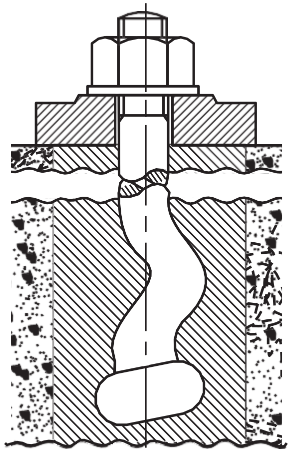


Fig.4.30(b) Bent foundation bolt

b) Bent foundation bolt

As the name implies, this bolt is forged in bent form and set in cement concrete. When machines are to be placed on stone beds, the bolts are set in lead. Figure shows a bent foundation bolt that is set first in lead and then in cement concrete, resulting in a firm and stable bolt.

c) Rag foundation bolt

This bolt consists of a tapered body, square or rectangular in cross-section. The tapered edges are grooved. Figure shows a rag foundation bolt that is set first in lead and then in cement concrete.

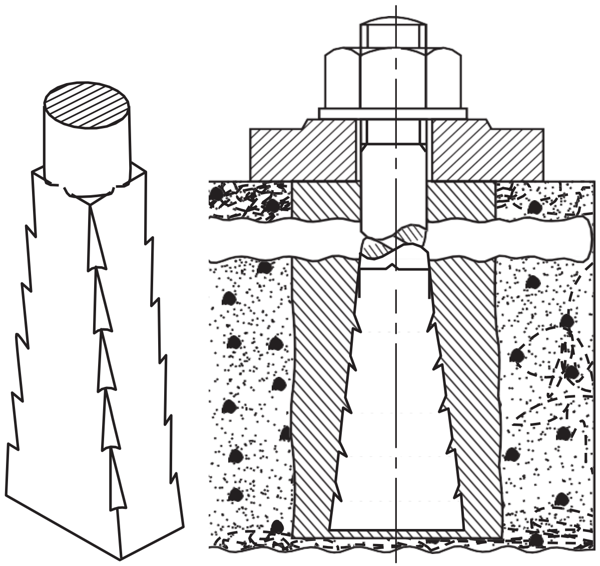


Fig.4.30(c) Rag foundation bolt

d) Lewis Foundation Bolt

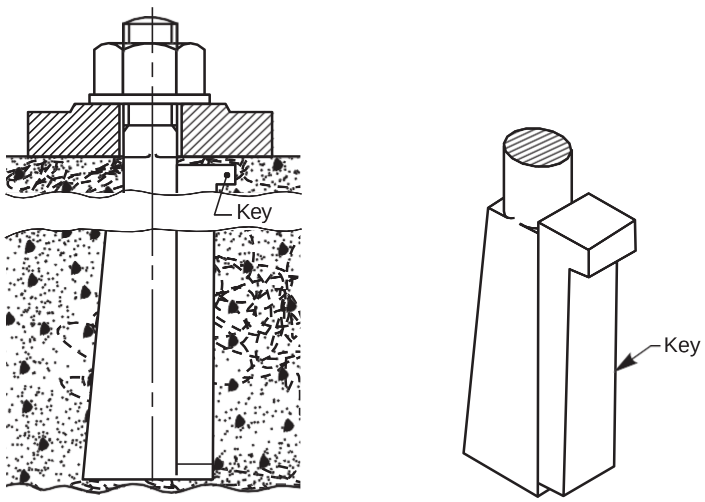


Fig.4.30(d) Lewis foundation bolt

This is a removable foundation bolt. The body of the bolt is tapered in width on one side. To use this bolt, a pit is made in cement concrete, by using a block. Once the concrete sets-in, the bolt is placed in it so that the tapered bolt surface, bears against the tapered face of the pit. A key is then inserted, bearing against the straight surfaces of the pit and the bolt. This arrangement makes the bolt firm in the bed. However, the bolt may be removed by withdrawing the key.

This type of foundation bolt is not commonly used for fixing machines. However, the principle is advantageously used for lifting huge stones. For this, a groove, similar to the pit is chiseled in the stone and the bolt is fitted in. The top end of the bolt may be forged into an eye and used for lifting purposes.

e) Cotter Foundation Bolt

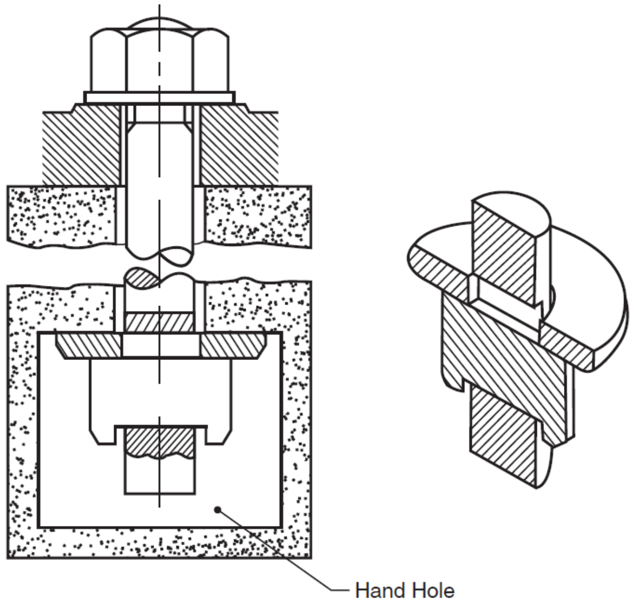


Fig.4.30(e) Cotter foundation bolt

It is used for fixing heavy machines. It has a rectangular slot at its bottom end, to receive a cotter. For putting the bolts in position, the foundation bed is first made, providing holes for inserting cotters. Figure shows a cotter foundation bolt in position. A cast iron washer is placed to provide bearing surface for the cotter.

REVIEW QUESTIONS

Unit – IV : KEYS, SCREW THREADS AND THREADED FASTENERS

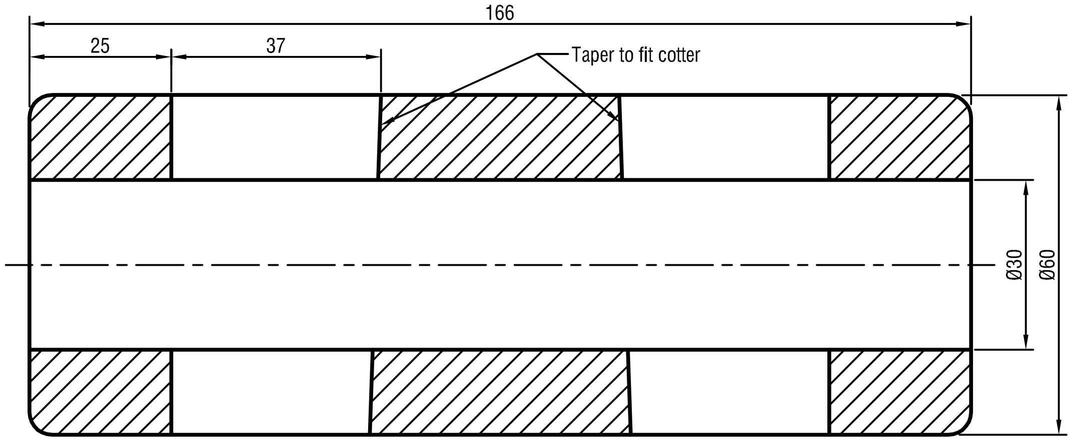
1) What are the types of fasteners? Give examples.
2) List out the applications of fasteners.
3) What are the keys? Give its classification.
4) What are sunk keys? Explain taper sunk key.
5) Briefly explain various types of parallel sunk keys.
6) Explain woodruff key. Give its applications.
7) Explain : (a) Hollow saddle key (b) Flat saddle key
8) Explain thread nomenclature with sketch.
9) Explain different types of thread profiles.
10) Explain the ISO thread profile with sketch.
11) Explain (i) BSW thread (ii) Buttress thread
12) Write short notes on (a) ACME thread (b) Square thread
13) Explain knuckle thread with sketch. State its applications.
14) Sketch the convention of V-threads and square threads in section.
15) Draw the hexagonal nut of diameter D = 24 mm.
16) Draw the square nut of diameter D = 24 mm.
17) What are threaded fasteners? Give examples.
18) What are through bolts and tap bolts? Explain with sketches.
19) Explain stud bolt with sketch.
20) Write short notes on various types nuts.
21) Sketch any five types of cap screws (machine screws) and state its purposes.
22) Sketch the types of set screws and give its applications.
23) What are foundation bolts? Name important types of foundation bolts.
24) Briefly explain various types of foundation bolts with suitable sketches.

PART - B

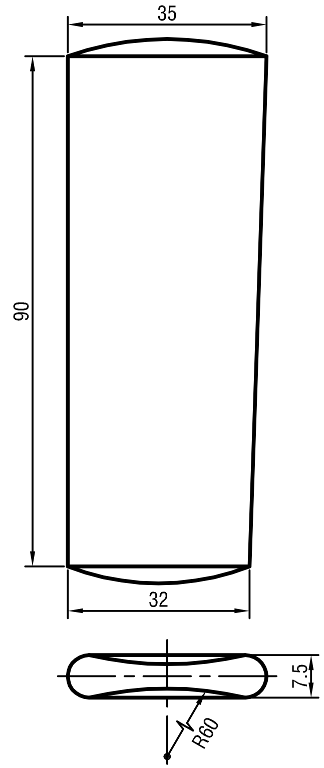
MANUAL DRAWING PRACTICE

Hints :

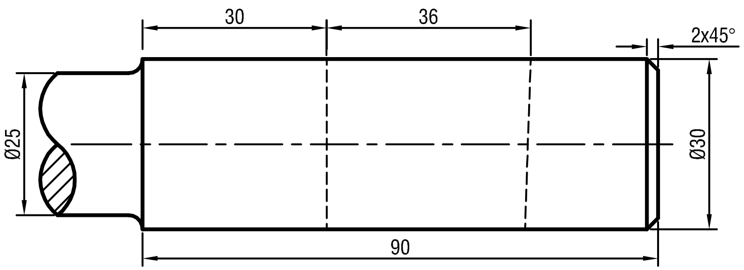
- Elevation = Front view
- Plan = Top view
- End elevation = Side view
- Sectional elevation = Full sectional front view
- Sectional plan = Full sectional top view
- Half sectional elevation = Half sectional front view
- Half sectional plan = Half sectional top view
- Sectional end elevation = Full sectional side view
- Half sectional end elevation = Half sectional side view



② SLEEVE (MS) - 1 0FF



③ COTTER (STEEL) - 2 0FF



① ROD END (MS) - 2 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

DETAILS OF SLEEVE AND COTTER JOINT

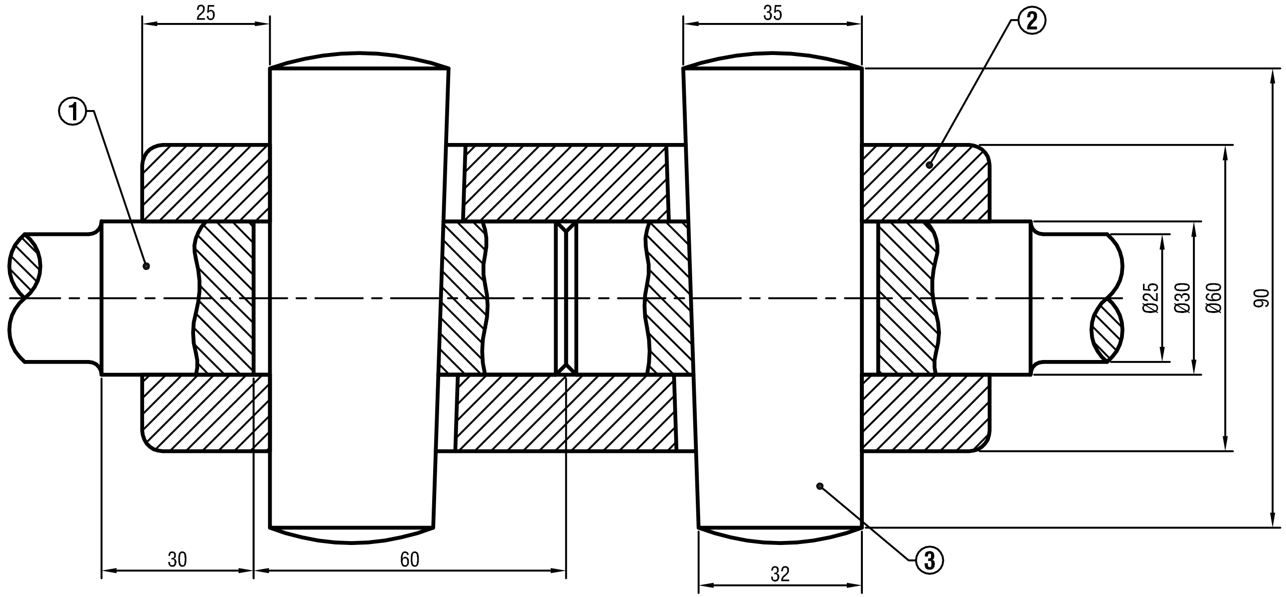
Example : 1

☞ **Assemble and draw the following views of SLEEVE AND COTTER JOINT shown in the sketch. Also add bill of materials.**

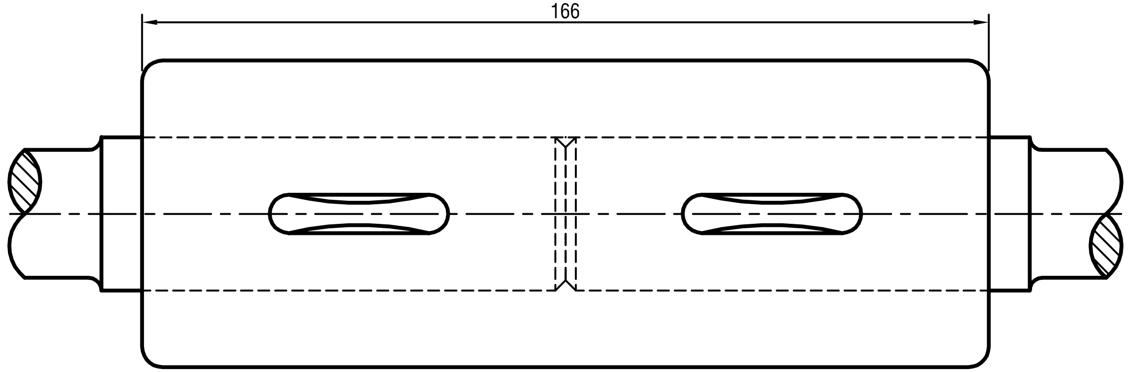
A. (a) Sectional front view (b) Top view

B. (a) Half sectional front view (b) Top view (c) Side view

✍ Solution : 1 (A)



SECTIONAL FRONT VIEW



TOP VIEW

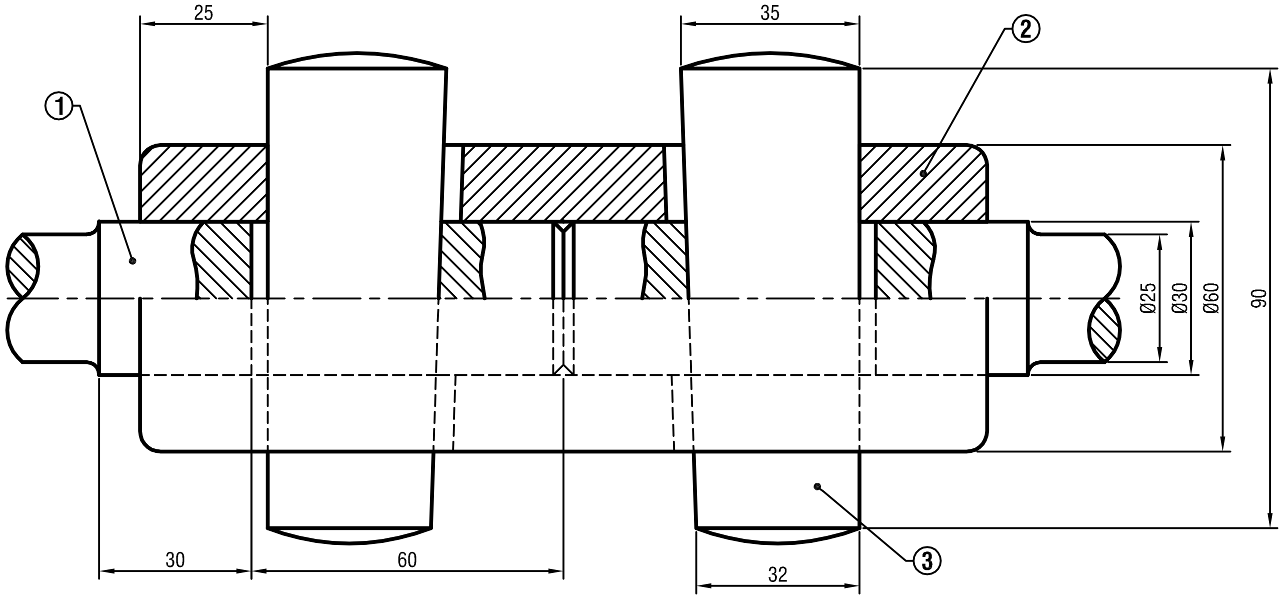
ALL DIMENSIONS ARE IN mm

3	COTTER	STEEL	2
2	SLEEVE	MILD STEEL	1
1	ROD END	MILD STEEL	2
PART NO.	NAME	MATERIAL	NO.OFF

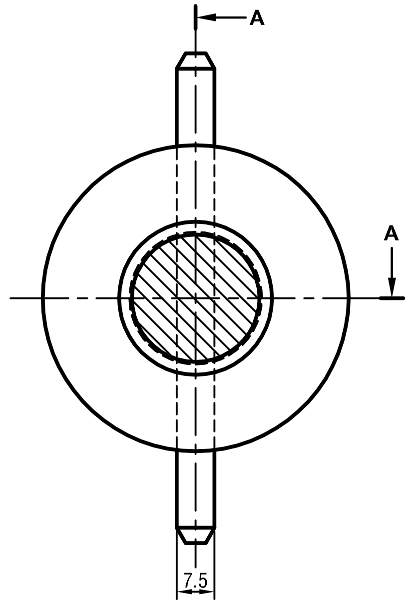
SLEEVE AND COTTER JOINT

SCALE 1:2

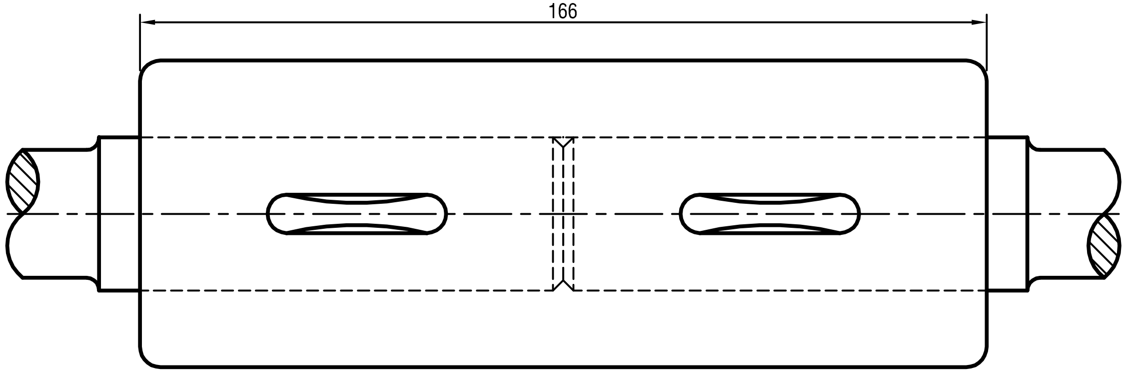
Solution : 1 (B)



HALF SECTIONAL FRONT VIEW (SECTION AT A-A)



LEFT SIDE VIEW



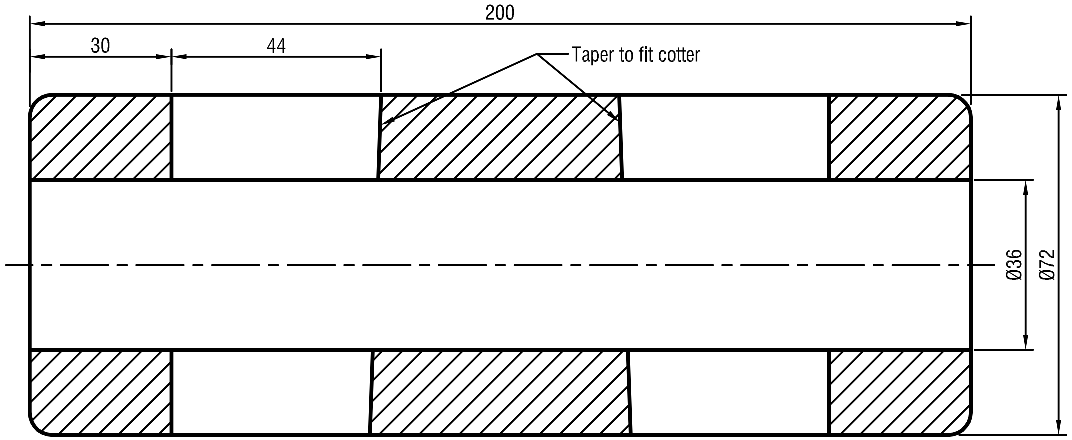
TOP VIEW

ALL DIMENSIONS ARE IN mm

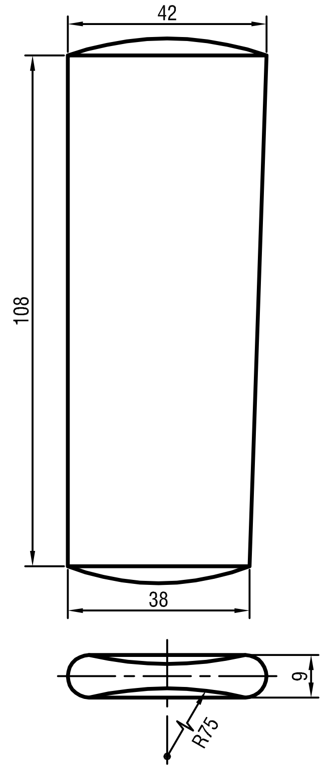
PART NO.	NAME	MATERIAL	NO.OFF
3	COTTER	STEEL	2
2	SLEEVE	MILD STEEL	1
1	ROD END	MILD STEEL	2

SLEEVE AND COTTER JOINT

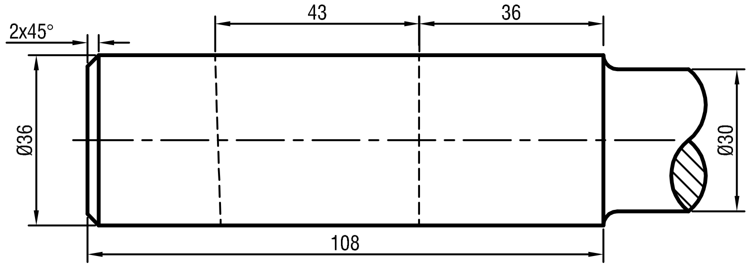
SCALE 1:2



② SLEEVE (MS) - 1 0FF



③ COTTER (STEEL) - 2 0FF



① ROD END (MS) - 2 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

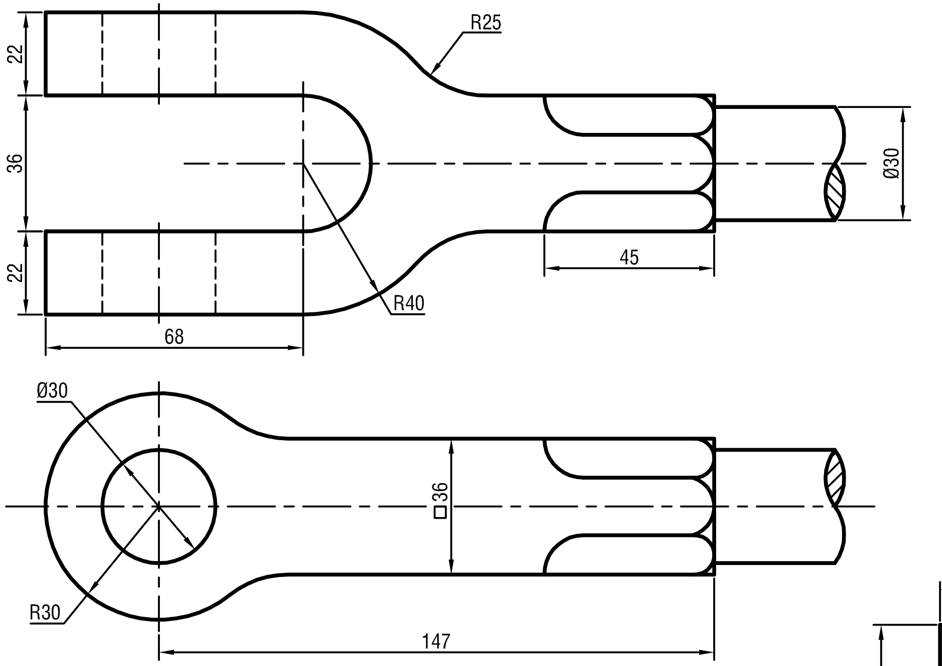
DETAILS OF SLEEVE AND COTTER JOINT

Exercise : 1

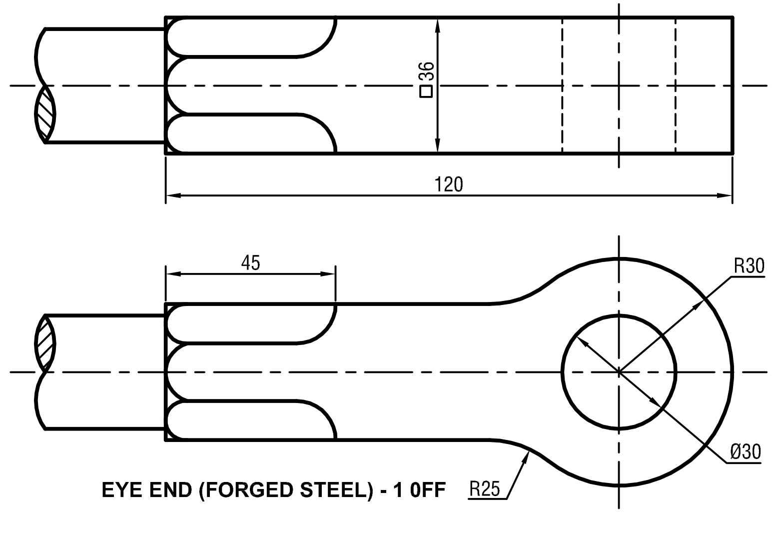
☞ **Assemble and draw the following views of SLEEVE AND COTTER JOINT shown in the sketch. Also add bill of materials.**

A. (a) Sectional front view (b) Top view

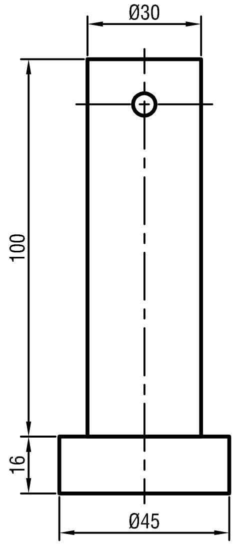
B. (a) Top half sectional elevation (b) Plan (c) Side view



FORK (FORGED STEEL) - 1 OFF



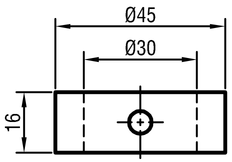
EYE END (FORGED STEEL) - 1 OFF



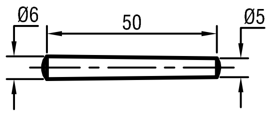
PIN (MILD STEEL) - 1 OFF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm



COLLAR (MILD STEEL) - 1 OFF



TAPER PIN (MILD STEEL) - 1 OFF

Example : 2

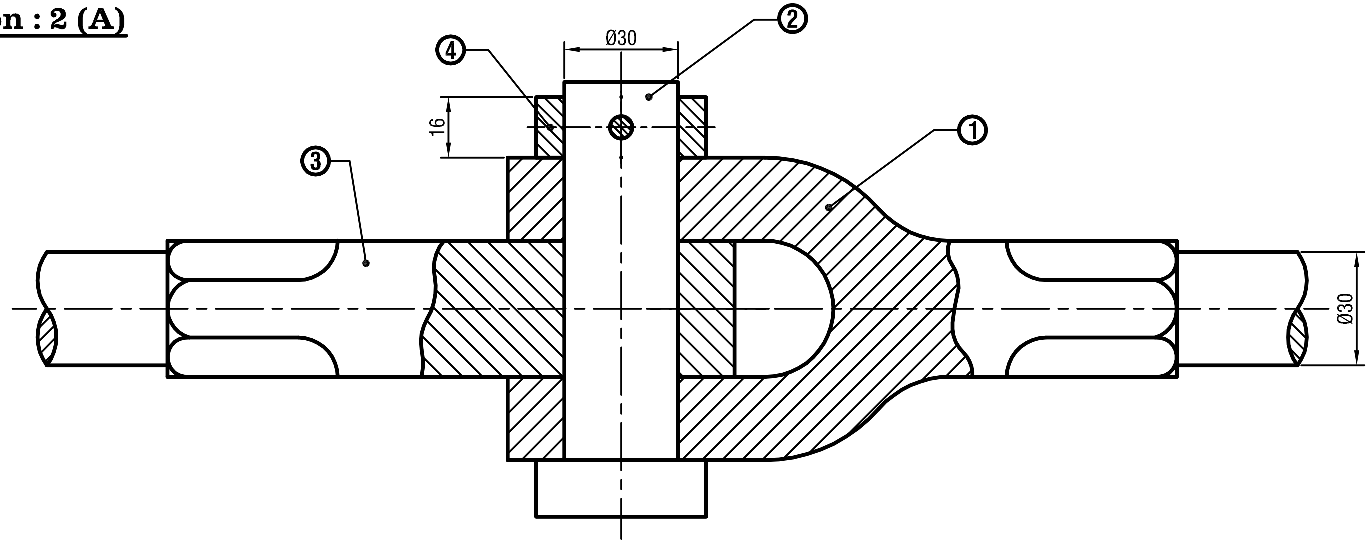
☞ **Assemble and draw the following views of KNUCKLE JOINT shown in the sketch. Also add bill of materials.**

A. (a) Sectional front view (b) Top view

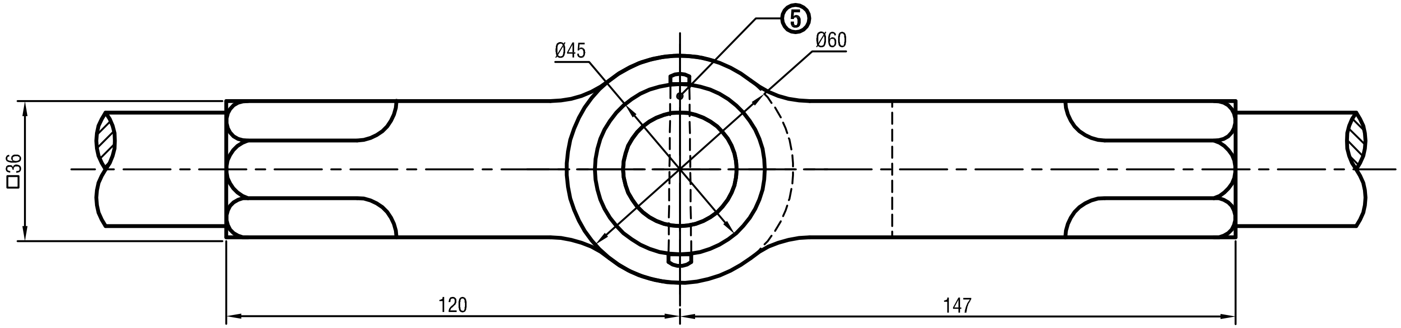
B. (a) Half sectional elevation (b) Sectional plan (c) Side view

DETAILS OF KNUCKLE JOINT

Solution : 2 (A)



SECTIONAL FRONT VIEW



TOP VIEW

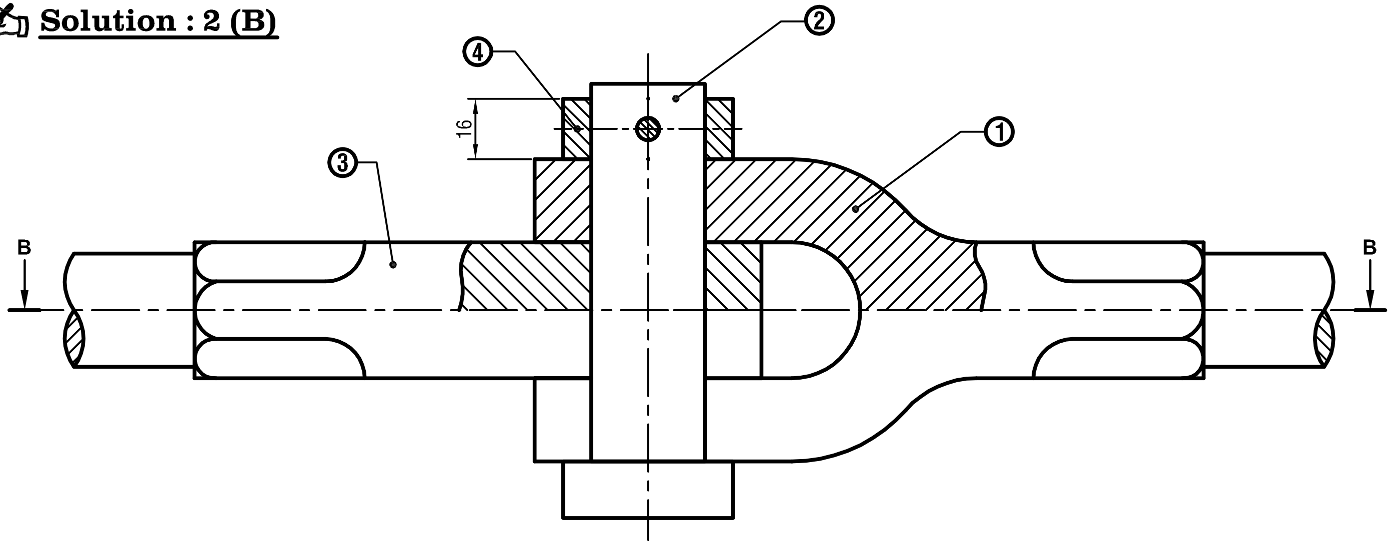
ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
5	TAPER PIN	MILD STEEL	1
4	COLLAR	MILD STEEL	1
3	ROD	FORG. STEEL	1
2	PIN	MILD STEEL	1
1	FORK	FORG. STEEL	1

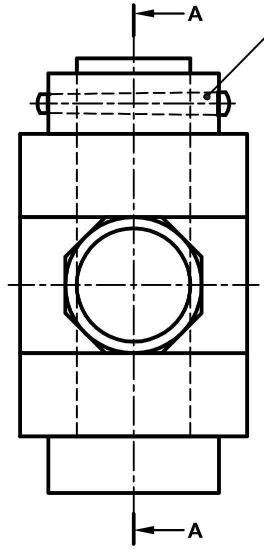
KNUCKLE JOINT

SCALE 1:2

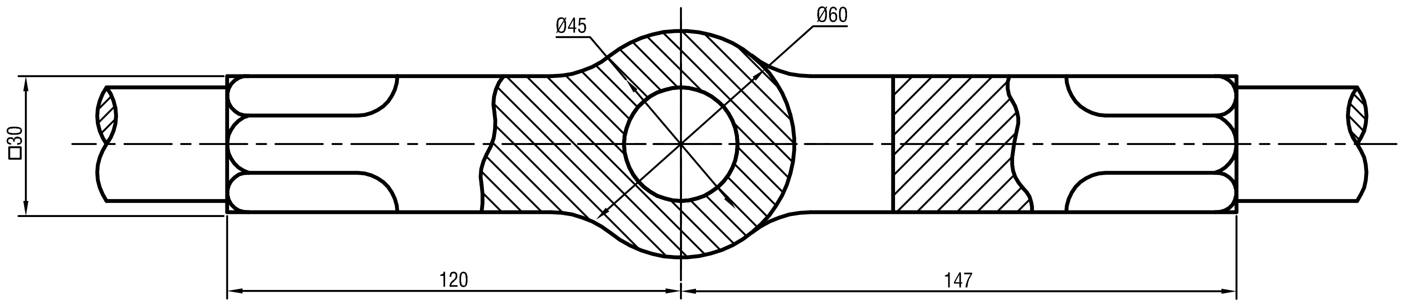
Solution : 2 (B)



HALF SECTIONAL ELEVATION (SECTION AT A-A)



LEFT SIDE VIEW



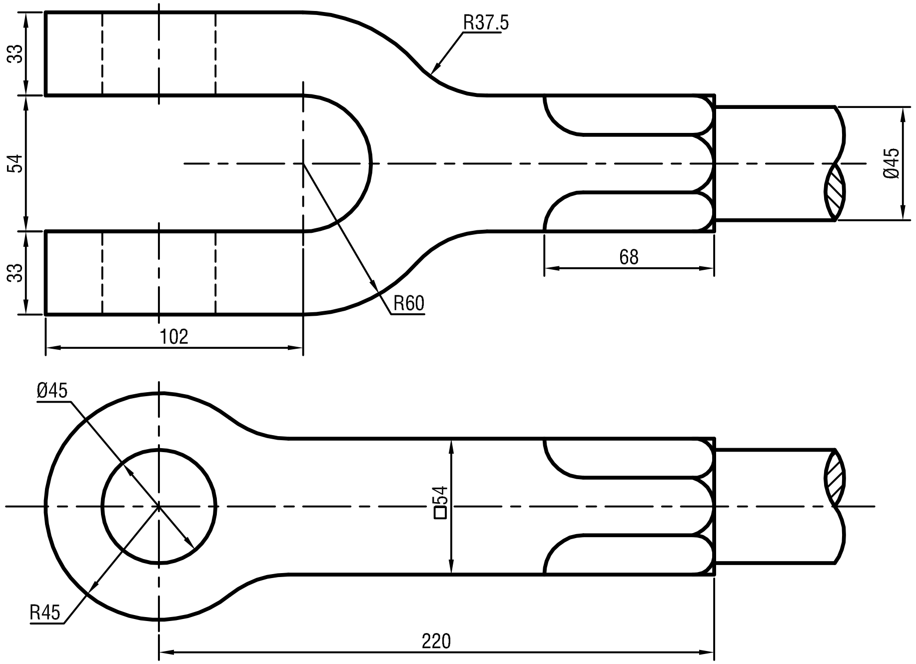
SECTIONAL PLAN (SECTION AT B-B)

ALL DIMENSIONS ARE IN mm

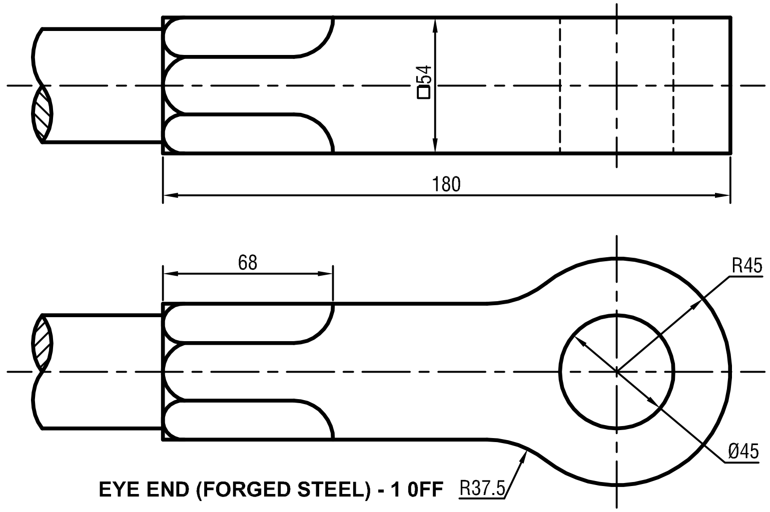
PART NO.	NAME	MATERIAL	NO.OFF
5	TAPER PIN	MILD STEEL	1
4	COLLAR	MILD STEEL	1
3	ROD	FORG. STEEL	1
2	PIN	MILD STEEL	1
1	FORK	FORG. STEEL	1

KNUCKLE JOINT

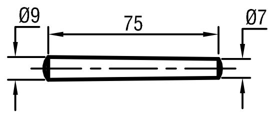
SCALE 1:2



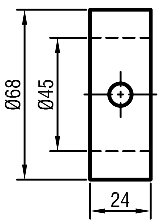
FORK (FORGED STEEL) - 1 0FF



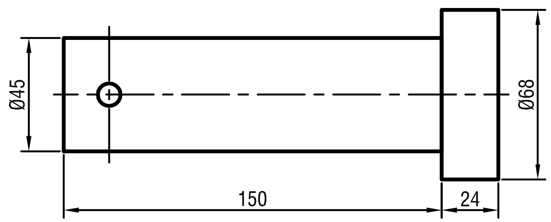
EYE END (FORGED STEEL) - 1 0FF



TAPER PIN (MILD STEEL) - 1 0FF



COLLAR (MILD STEEL) - 1 0FF



PIN (MILD STEEL) - 1 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

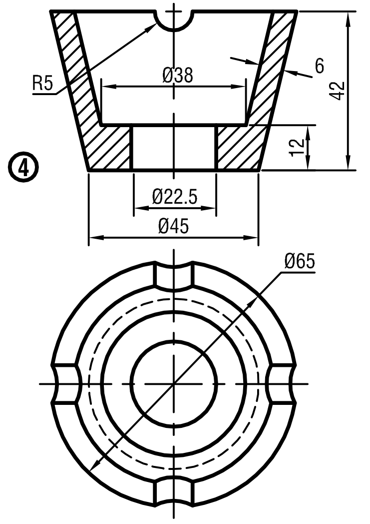
Exercise : 2

☞ **Assemble and draw the following views of KNUCKLE JOINT shown in the sketch. Also add bill of materials.**

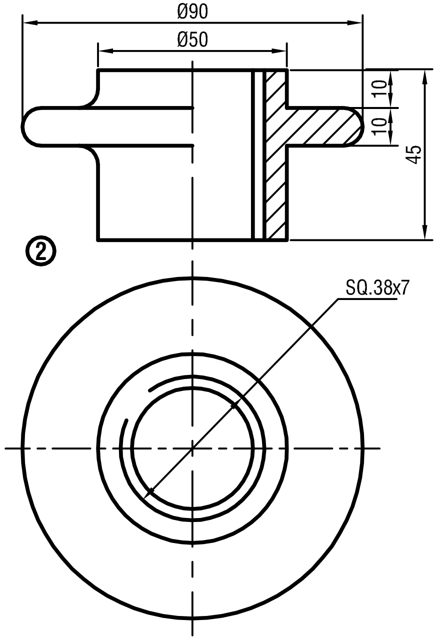
A. (a) Sectional elevation (b) Plan (c) Side view

B. (a) Half sectional front view (b) Sectional top view

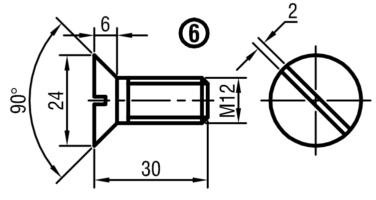
DETAILS OF KNUCKLE JOINT



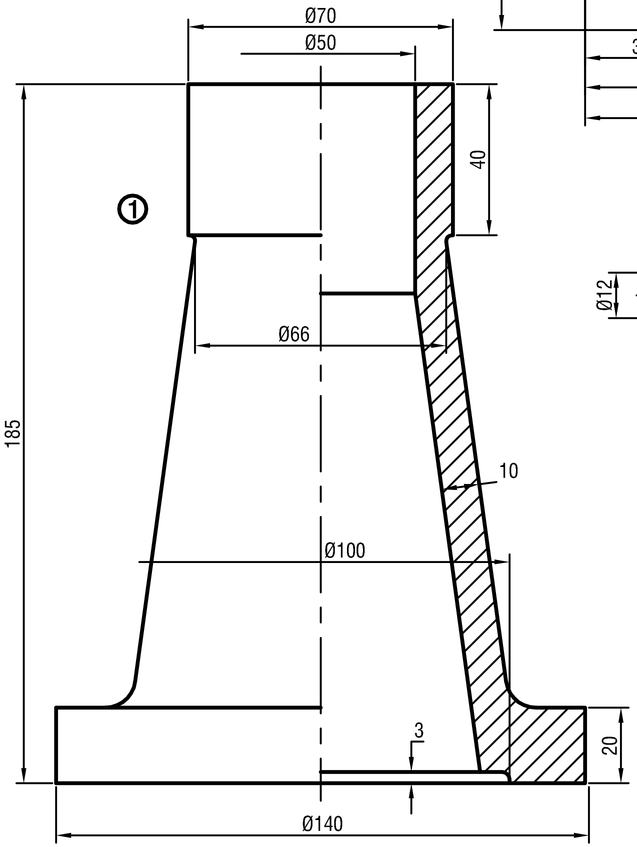
CUP(CI) - 1 0FF



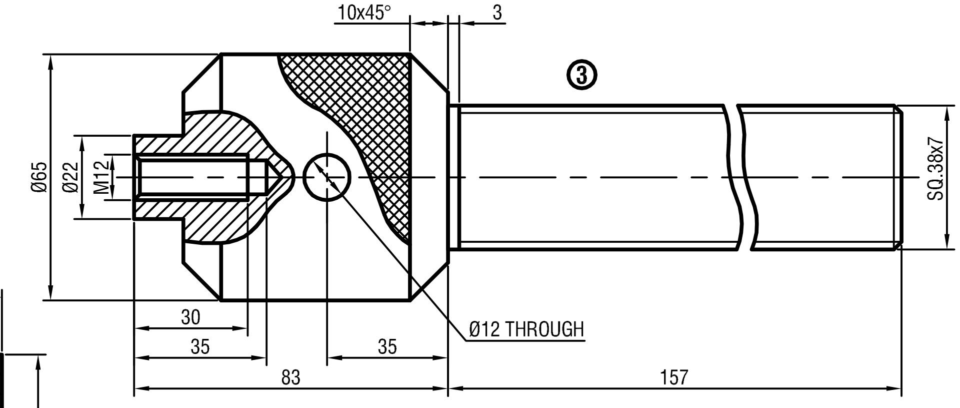
NUT(GUN METAL) - 1 0FF



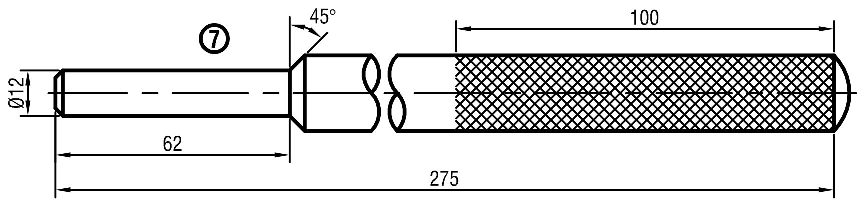
SET SCREW (MS) - 1 0FF



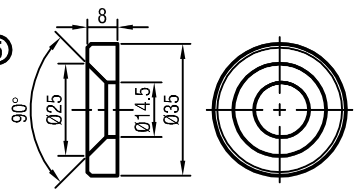
BODY(CI) - 1 0FF



SCREW - SPINDLE (MS) - 1 0FF



TOMMY BAR (MS) - 1 0FF



WASHER (MS) - 1 0FF

<u>ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm</u>

ALL DIMENSIONS ARE IN mm

Example : 3

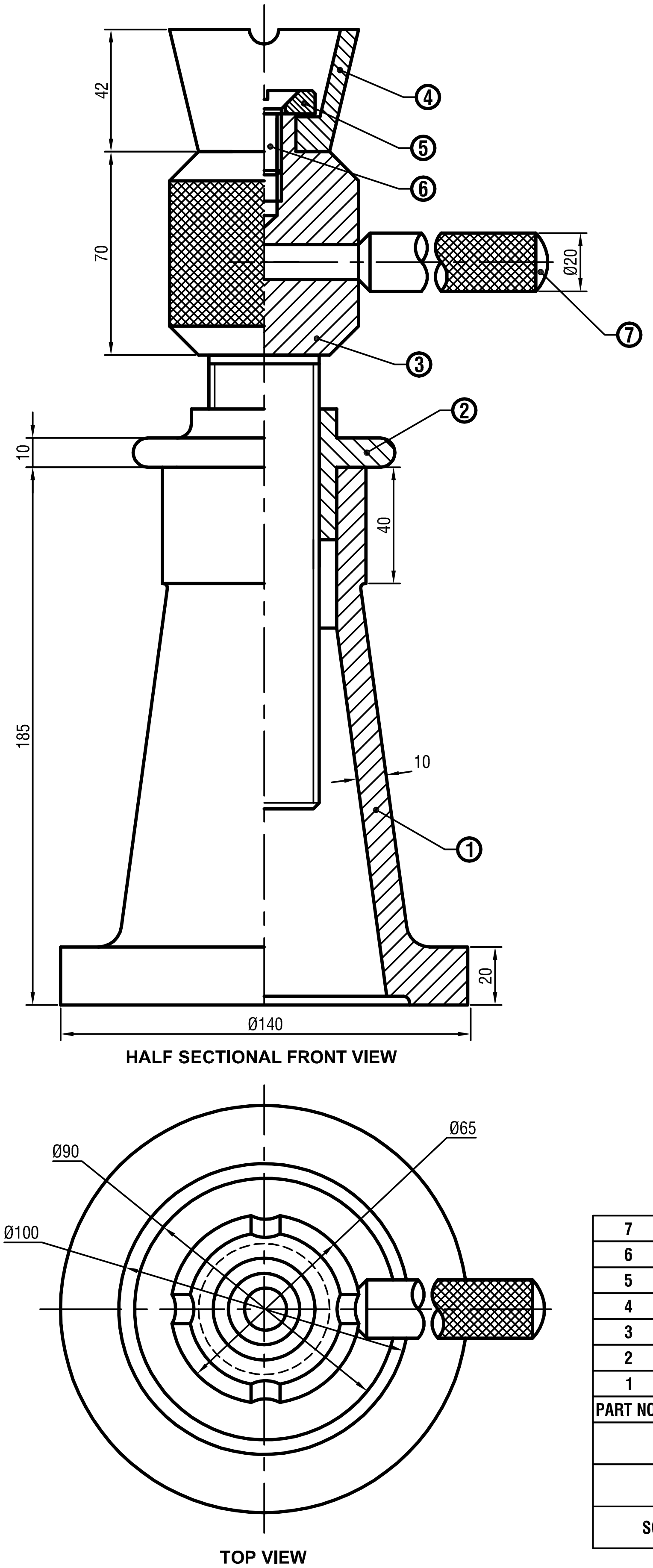
☞ Assemble and draw the following views of SCREW JACK shown in the sketch. Also add bill of materials.

A. (a) Half sectional front view (b) Top view

B. (a) Sectional elevation (b) Plan

DETAILS OF SCREW JACK

Solution : 3 (A)



HALF SECTIONAL FRONT VIEW

TOP VIEW

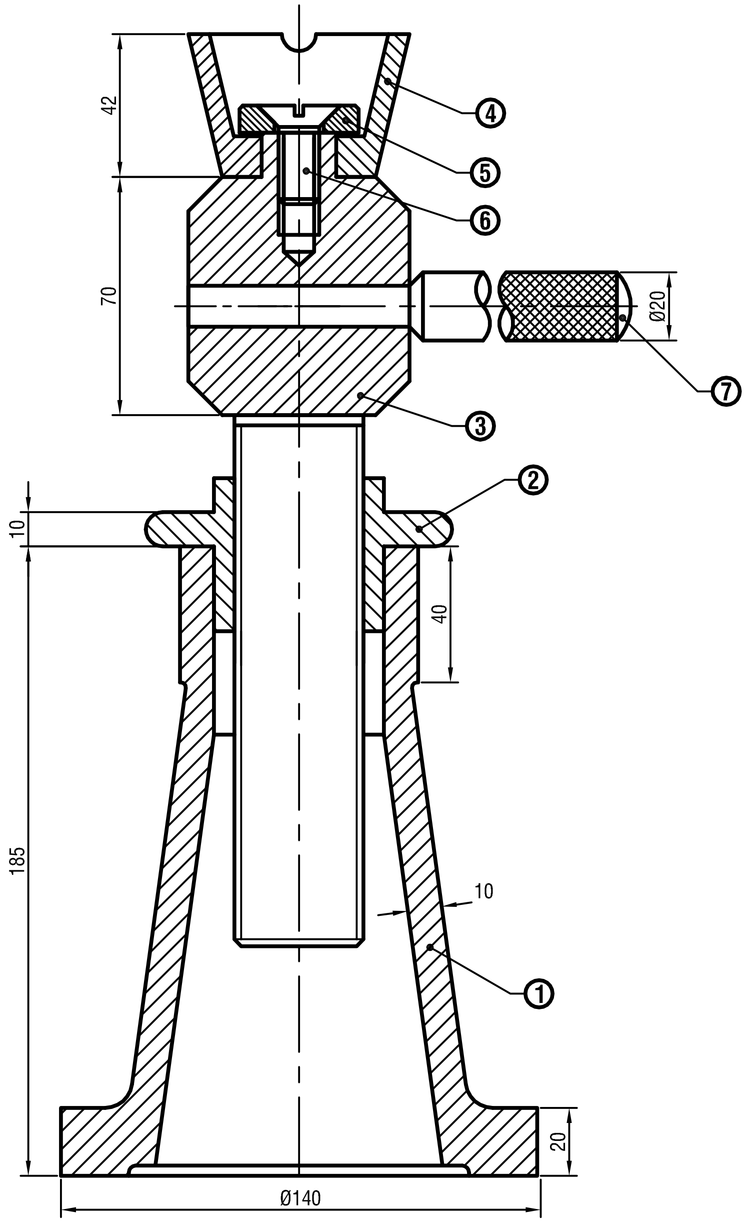
ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
7	TOMMY BAR	MILD STEEL	1
6	SET SCREW	MILD STEEL	1
5	WASHER	MILD STEEL	1
4	CUP	CAST STEEL	1
3	SCREW	MILD STEEL	1
2	NUT	GUN METAL	1
1	BODY	CAST IRON	1

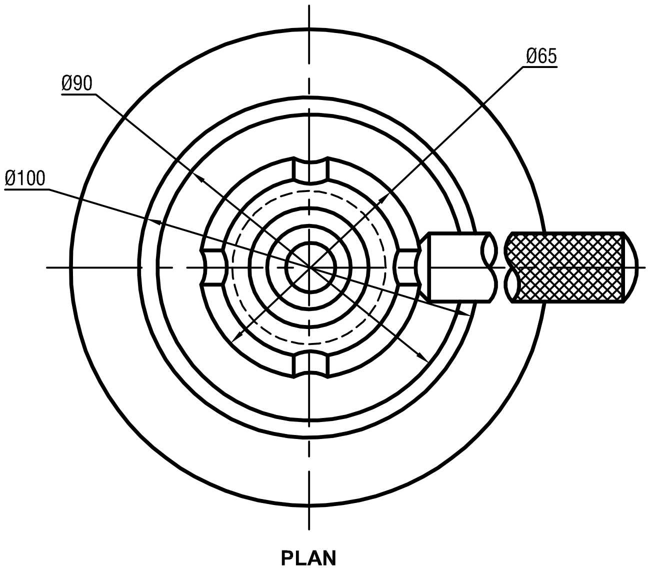
SCREW JACK

SCALE 1:2

Solution : 3 (B)



SECTIONAL ELEVATION



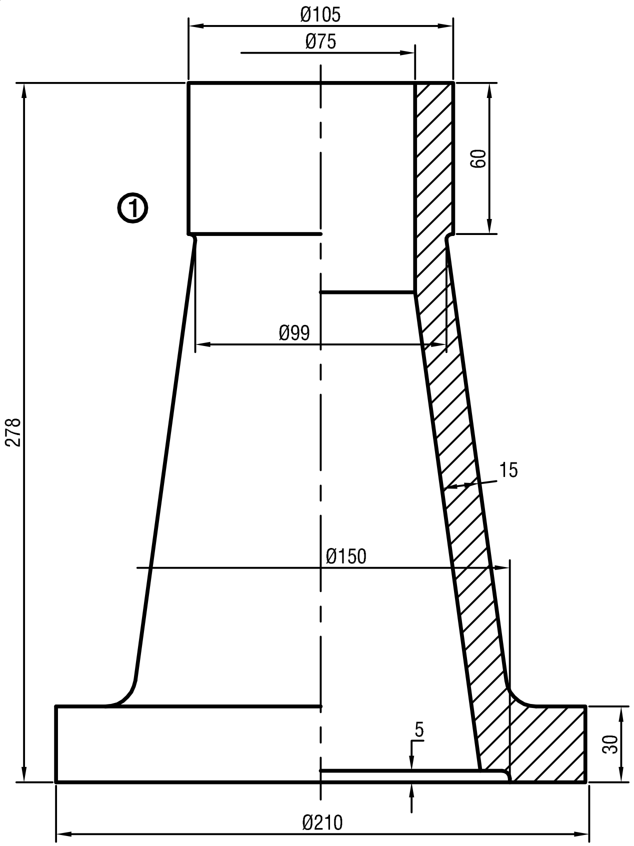
PLAN

ALL DIMENSIONS ARE IN mm

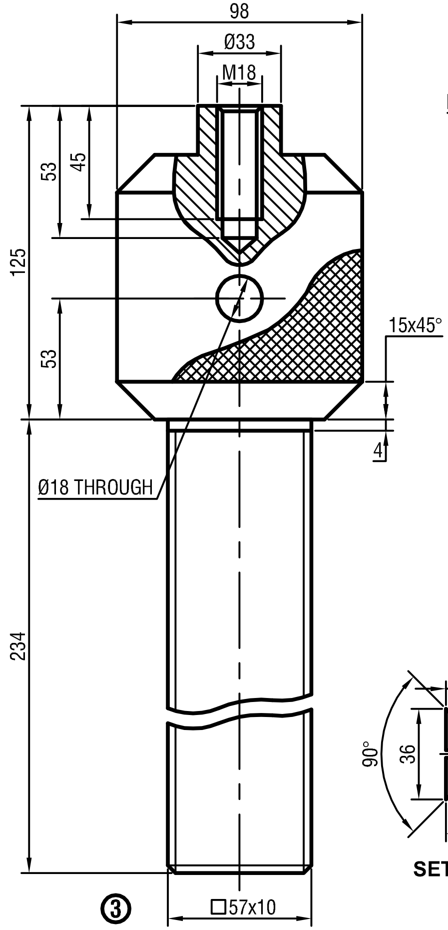
PART NO.	NAME	MATERIAL	NO.OFF
7	TOMMY BAR	MILD STEEL	1
6	SET SCREW	MILD STEEL	1
5	WASHER	MILD STEEL	1
4	CUP	CAST STEEL	1
3	SCREW	MILD STEEL	1
2	NUT	GUN METAL	1
1	BODY	CAST IRON	1

SCREW JACK

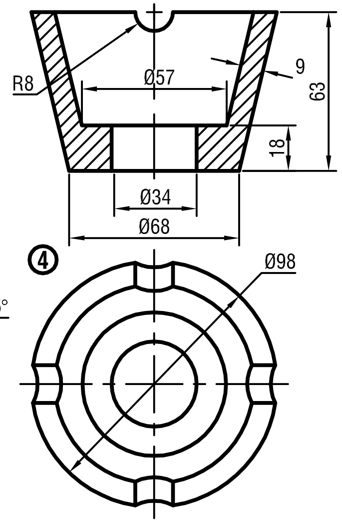
SCALE 1:2



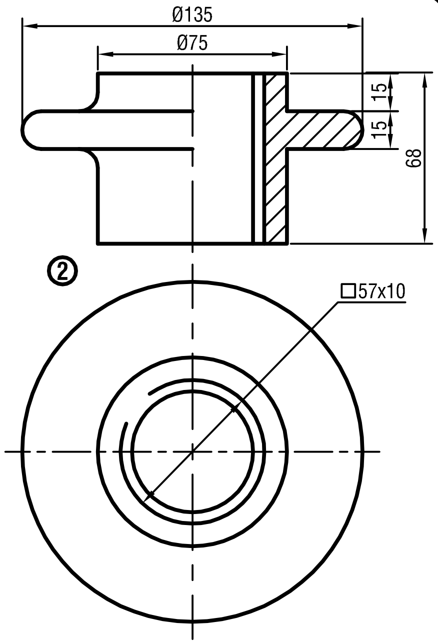
BODY(CI) - 1 0FF



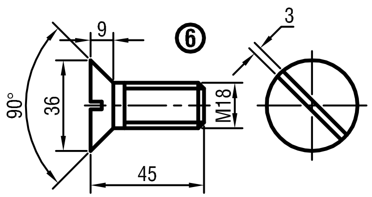
SCREW - SPINDLE (MS) - 1 0FF



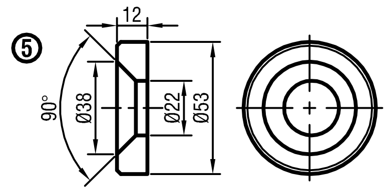
CUP(CI) - 1 0FF



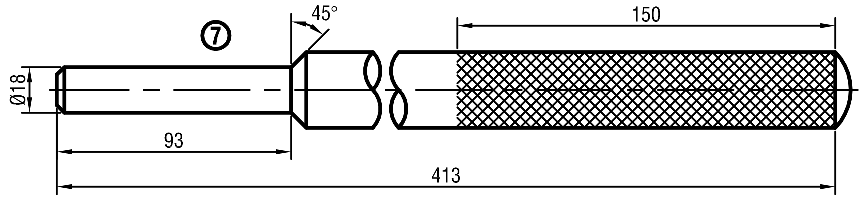
NUT(GUN METAL) - 1 0FF



SET SCREW (MS) - 1 0FF



WASHER (MS) - 1 0FF



TOMMY BAR (MS) - 1 0FF

DETAILS OF SCREW JACK

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

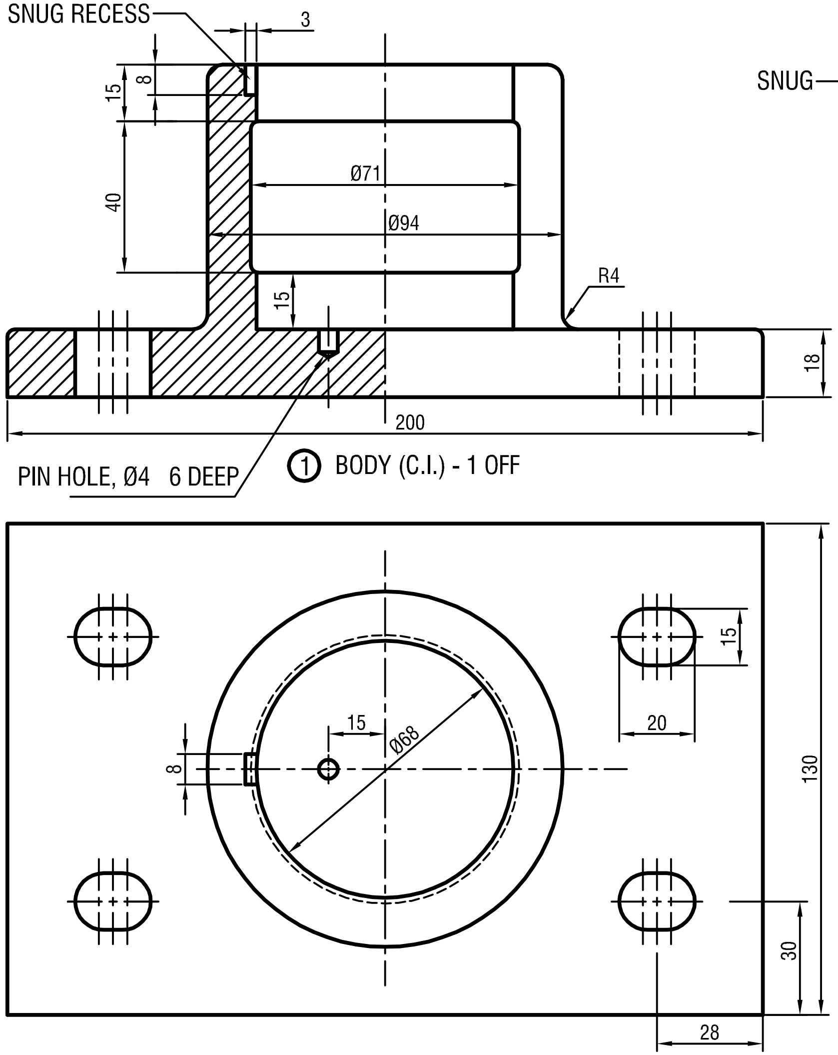
ALL DIMENSIONS ARE IN mm

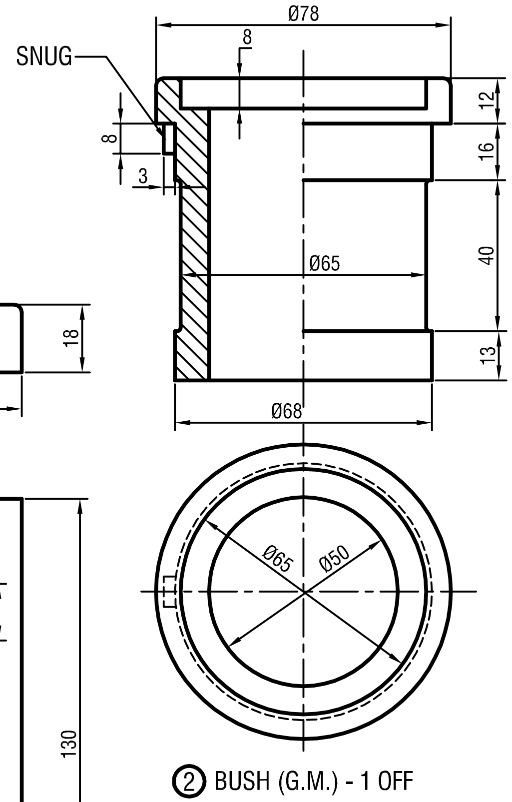
Exercise : 3

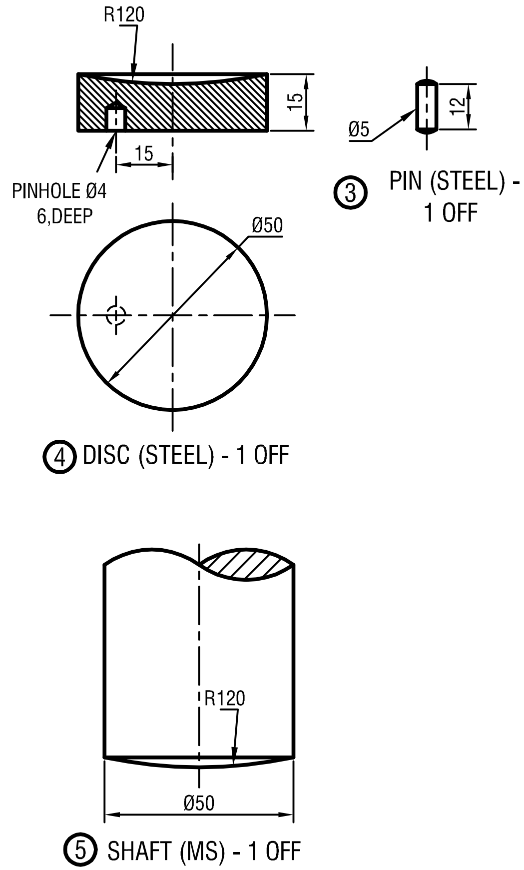
☞ **Assemble and draw the following views of SCREW JACK shown in the sketch. Also add bill of materials.**

A. (a) Sectional front view (b) Top view

B. (a) Half sectional elevation (b) Plan







ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

Example : 4

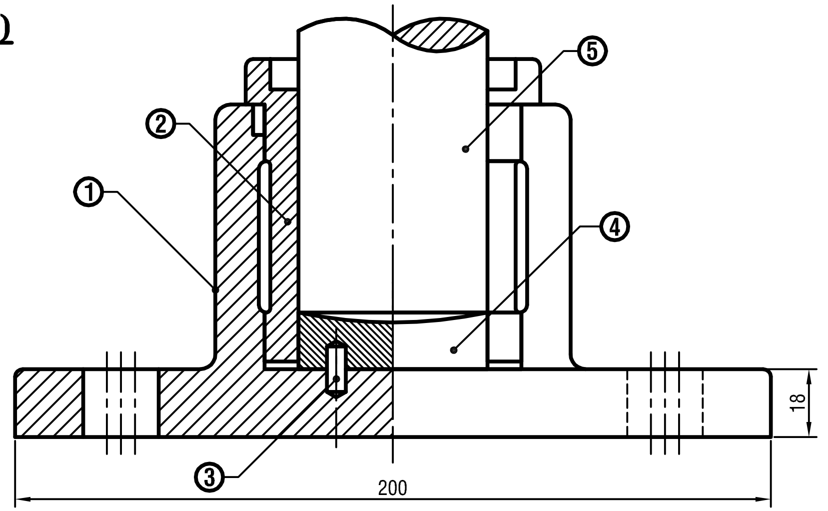
☞ **Assemble and draw the following views of FOOT STEP BEARING shown in the sketch. Also add bill of materials.**

A. (a) Half sectional front view (b) Top view

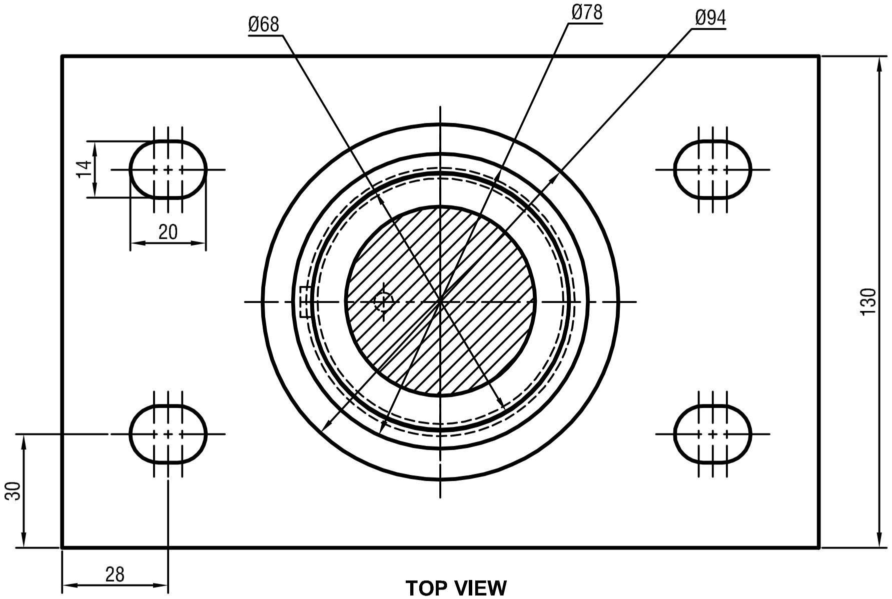
B. (a) Sectional elevation (b) Plan

DETAILS OF FOOT STEP BEARING

Solution : 4 (A)



HALF SECTIONAL FRONT VIEW



TOP VIEW

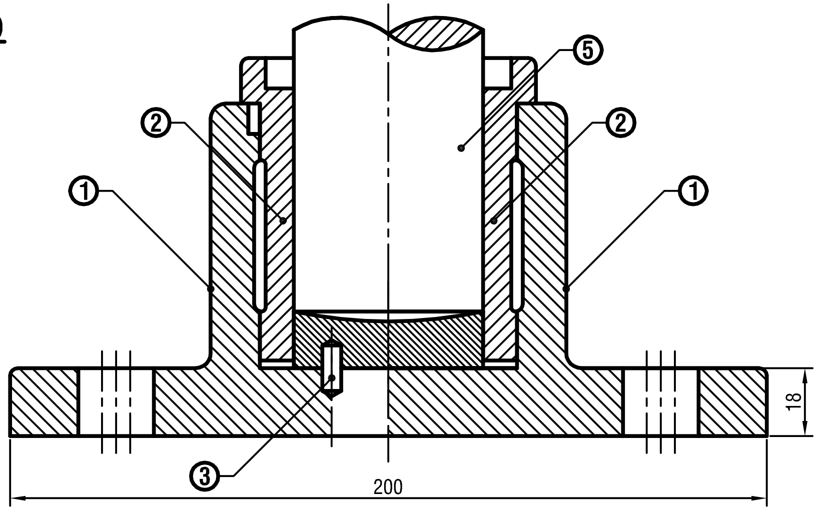
ALL DIMENSIONS ARE IN mm

5	SHAFT	MILD STEEL	1
4	DISC	STEEL	1
3	PIN	STEEL	1
2	BUSH	GUN METAL	1
1	BODY	CAST IRON	1
PART NO.	NAME	MATERIAL	NO.OFF

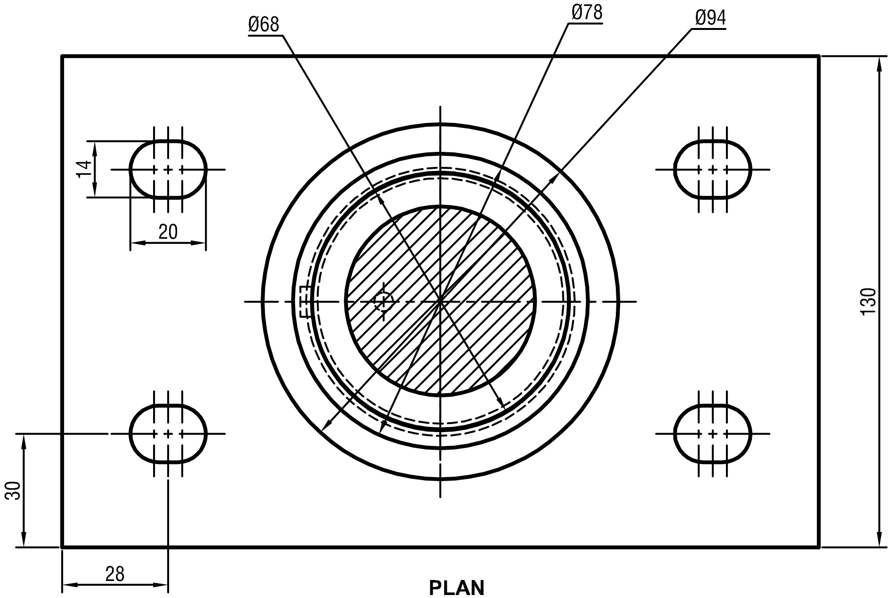
FOOT STEP BEARING

SCALE 1:2

Solution : 4 (B)



SECTIONAL ELEVATION



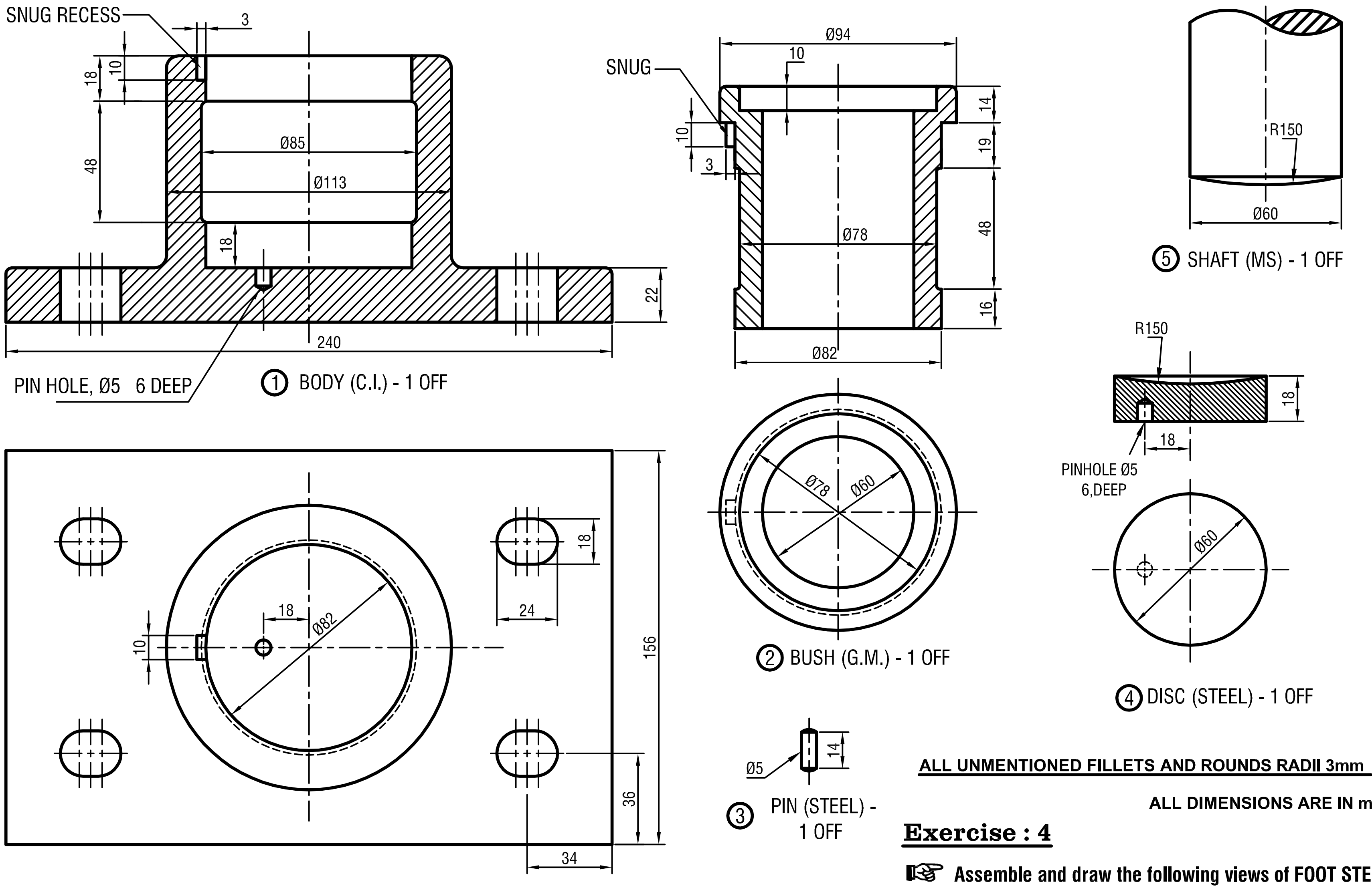
PLAN

ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
5	SHAFT	MILD STEEL	1
4	DISC	STEEL	1
3	PIN	STEEL	1
2	BUSH	GUN METAL	1
1	BODY	CAST IRON	1

FOOT STEP BEARING

SCALE 1:2



DETAILS OF FOOT STEP BEARING

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

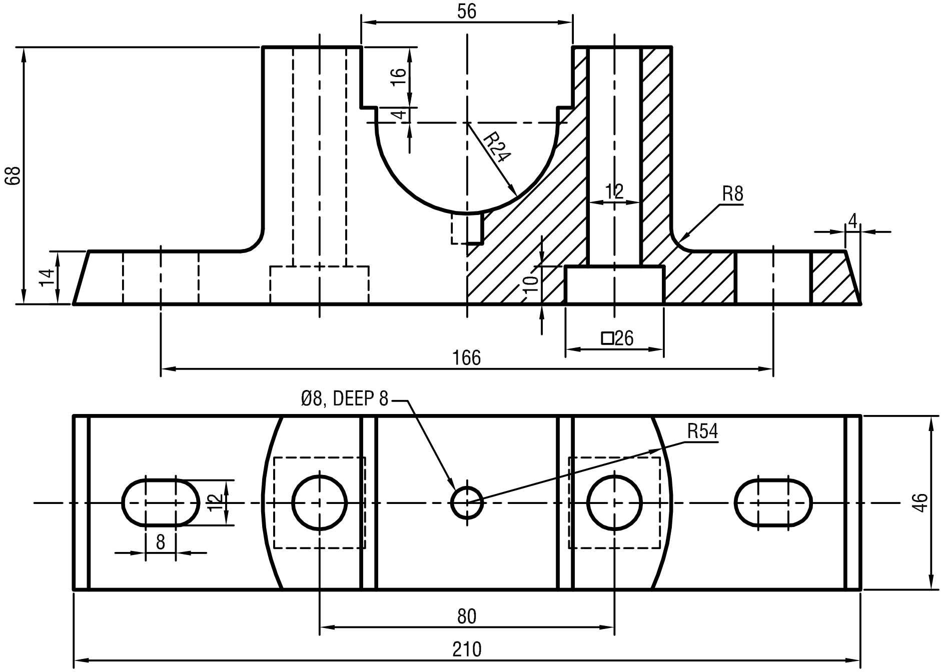
ALL DIMENSIONS ARE IN mm

Exercise : 4

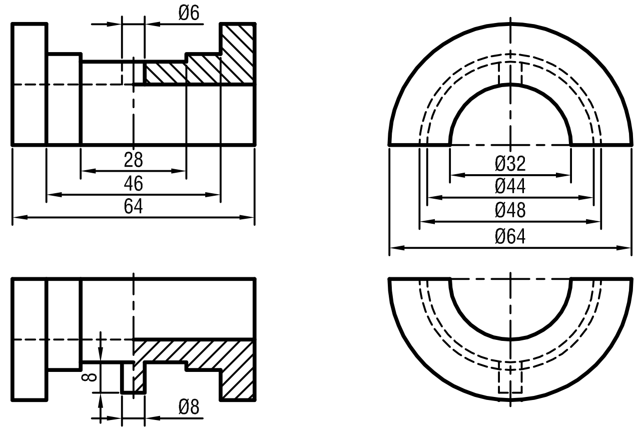
☞ **Assemble and draw the following views of FOOT STEP BEARING shown in the sketch. Also add bill of materials.**

A. (a) Sectional front view (b) Top view

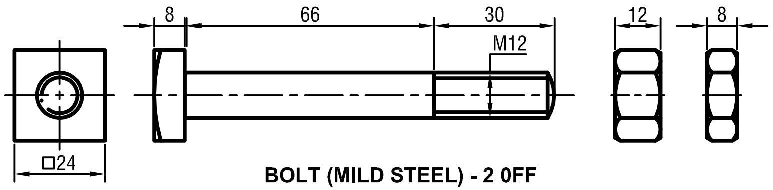
B. (a) Half sectional elevation (b) Plan



BODY (CAST IRON) - 1 0FF



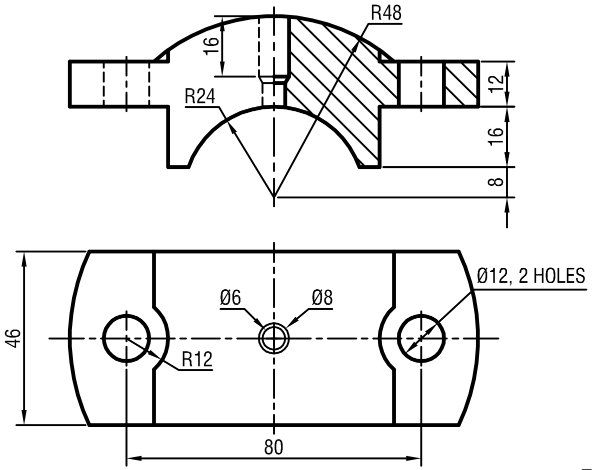
BRASSES(GUN METAL) - 2 0FF



BOLT (MILD STEEL) - 2 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm



CAP (CAST IRON) - 1 0FF

DETAILS OF PLUMMER BLOCK

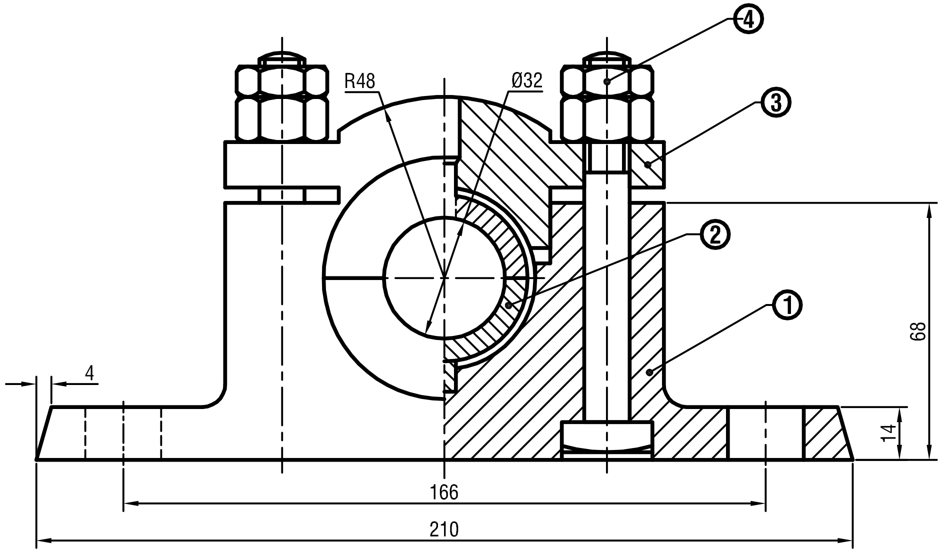
Example : 5

☞ **Assemble and draw the following views of PLUMMER BLOCK shown in the sketch. Also add bill of materials.**

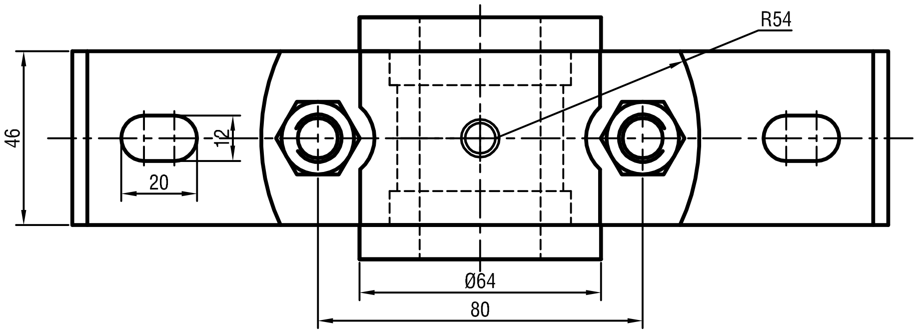
A. (a) Half sectional front view (b) Top view

B. (a) Sectional elevation (b) Plan (c) Side View

Solution : 5 (A)



HALF SECTIONAL FRONT VIEW



TOP VIEW

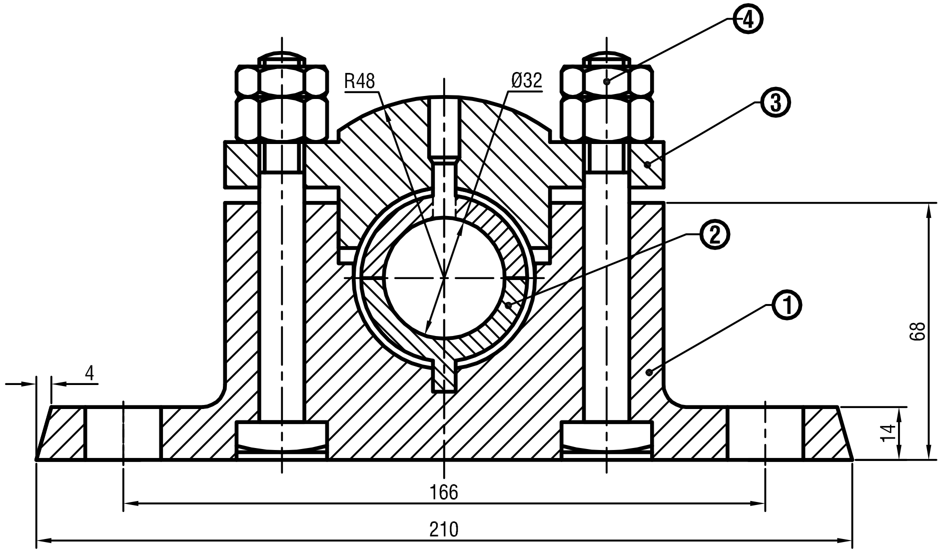
ALL DIMENSIONS ARE IN mm

4	BOLT&NUTS	MILD STEEL	2
3	CAP	CAST IRON	1
2	BRASSES	GUN METAL	2
1	BODY	CAST IRON	1
PART NO.	NAME	MATERIAL	NO.OFF

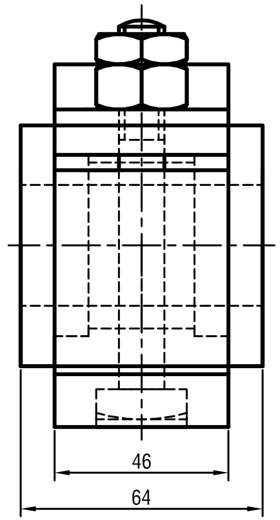
PLUMMER BLOCK

SCALE 1:2

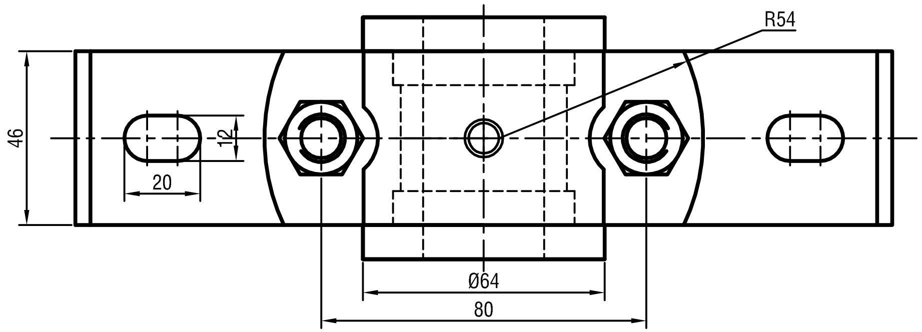
Solution : 5 (B)



SECTIONAL ELEVATION



LEFT SIDE VIEW



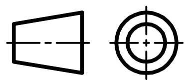
PLAN

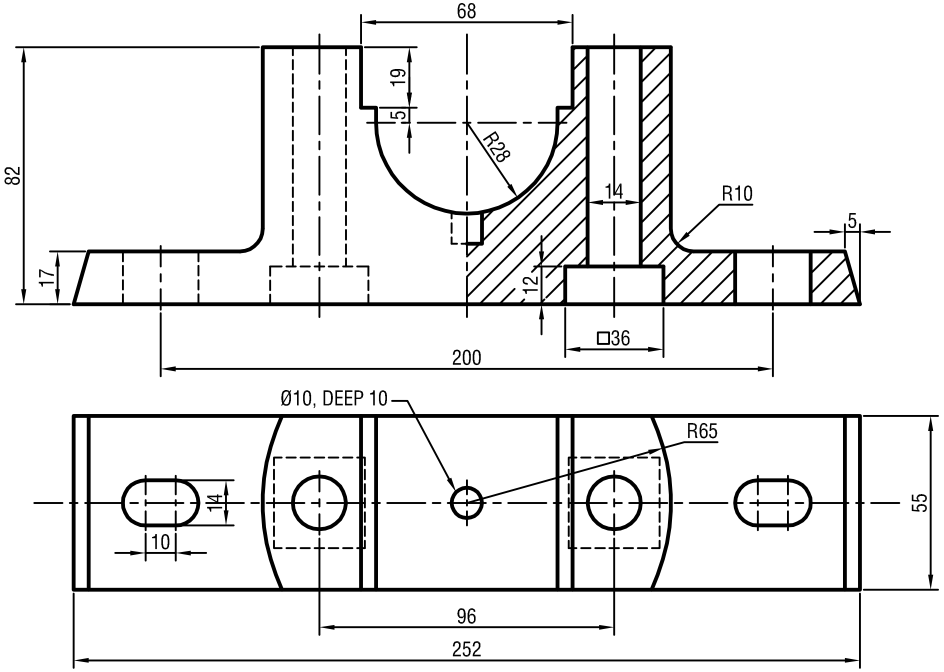
ALL DIMENSIONS ARE IN mm

4	BOLT&NUTS	MILD STEEL	2
3	CAP	CAST IRON	1
2	BRASSES	GUN METAL	2
1	BODY	CAST IRON	1
PART NO.	NAME	MATERIAL	NO.OFF

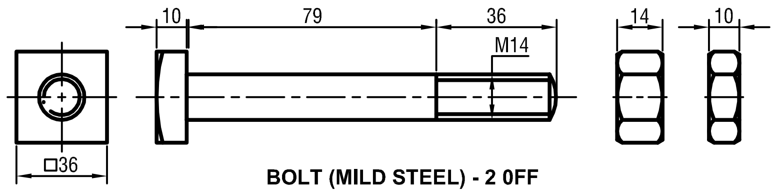
PLUMMER BLOCK

SCALE 1:2

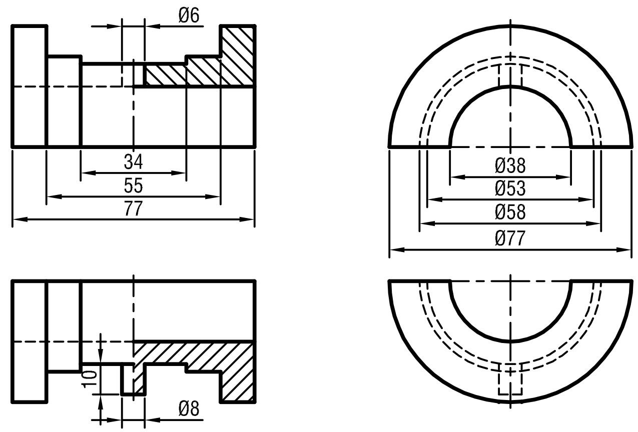




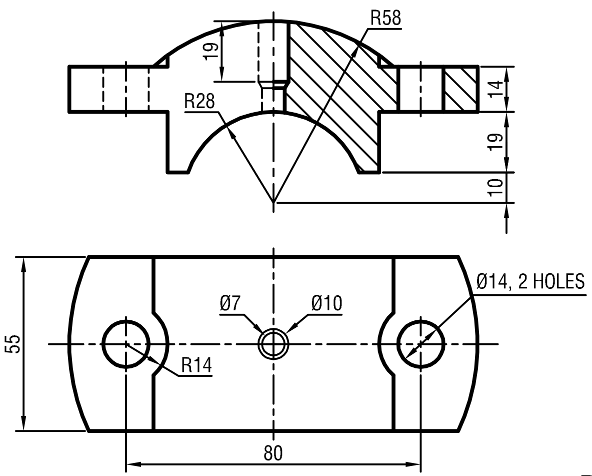
CASTING (CAST IRON) - 1 0FF



BOLT (MILD STEEL) - 2 0FF



BRASSES(GUN METAL) - 2 0FF



CAP (CAST IRON) - 1 0FF

DETAILS OF PLUMMER BLOCK

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

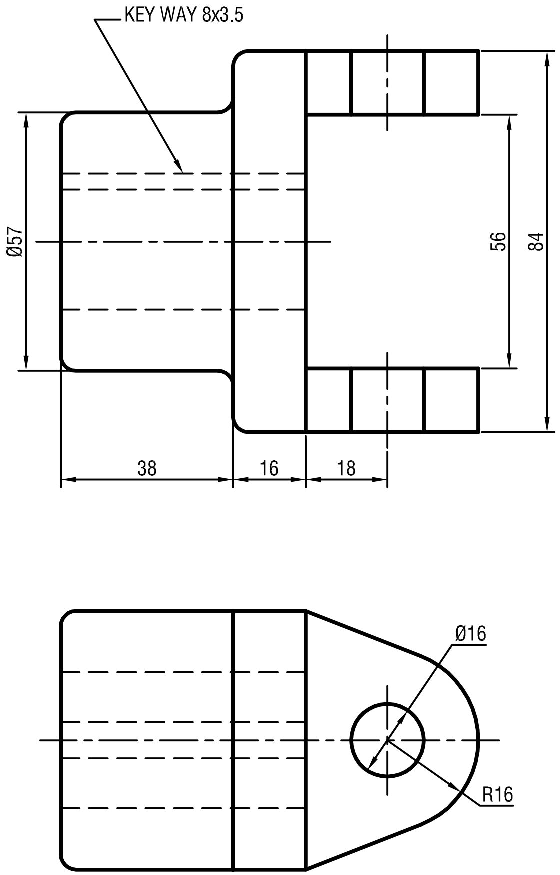
ALL DIMENSIONS ARE IN mm

Exercise : 5

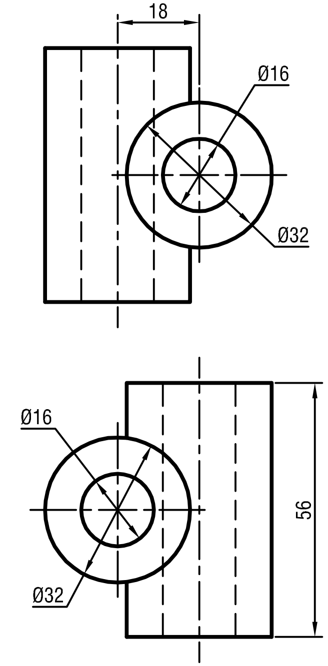
☞ **Assemble and draw the following views of PLUMMER BLOCK shown in the sketch. Also add bill of materials.**

A. (a) Half sectional front view (b) Top view

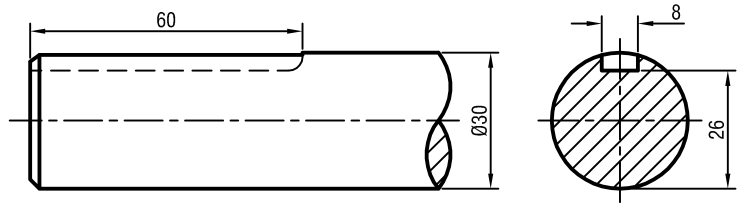
B. (a) Sectional elevation (b) Plan (c) Side View



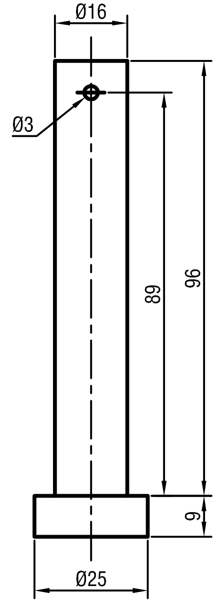
FORK (STEEL) - 2 0FF



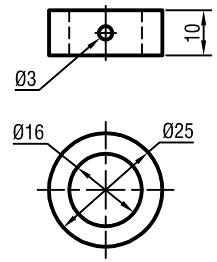
CENTRE(CI) - 1 0FF



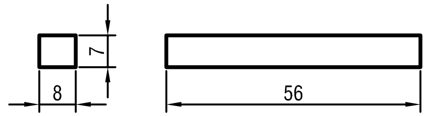
SHAFT (STEEL) - 2 0FF



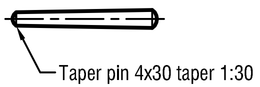
PIN(STEEL) - 2 0FF



COLLAR (STEEL) - 2 0FF



PARALLEL KEY(STEEL) - 2 0FF



TAPER PIN(STEEL) - 2 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

Example : 6

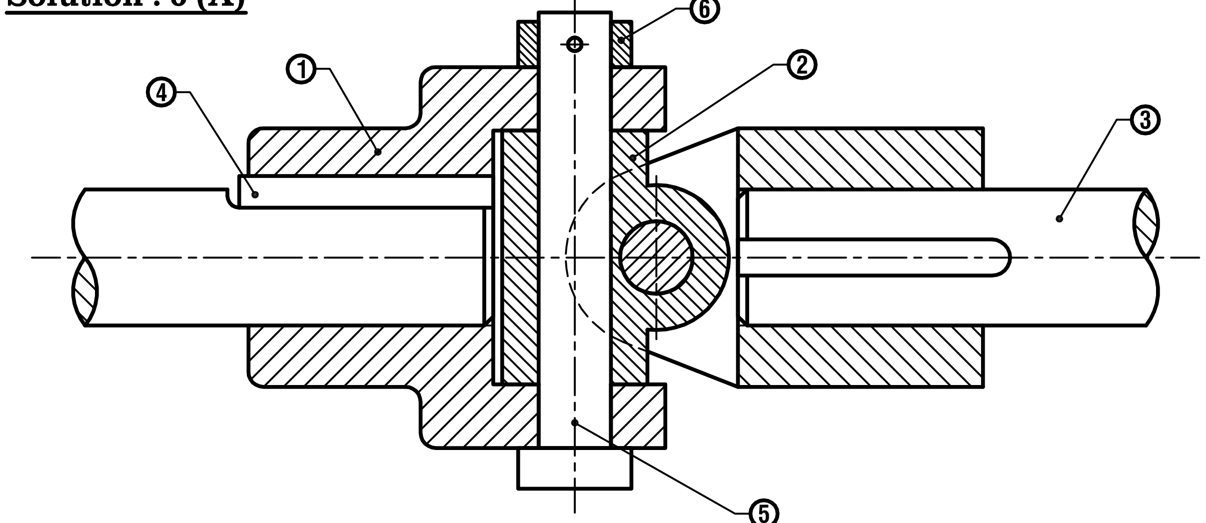
☞ **Assemble and draw the following views of UNIVERSAL COUPLING shown in the sketch. Also add bill of materials.**

A. (a) Sectional front view (b) Top view

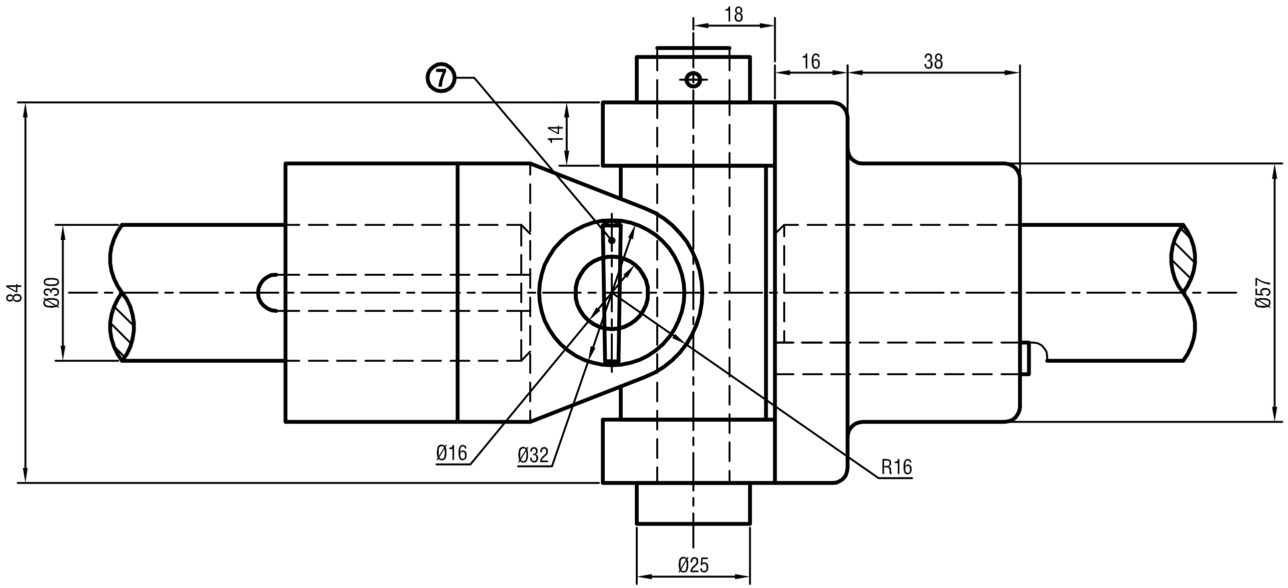
B. (a) Half Sectional elevation (b) Plan (c) Side View

DETAILS OF UNIVERSAL COUPLING

Solution : 6 (A)



SECTIONAL FRONT VIEW



TOP VIEW

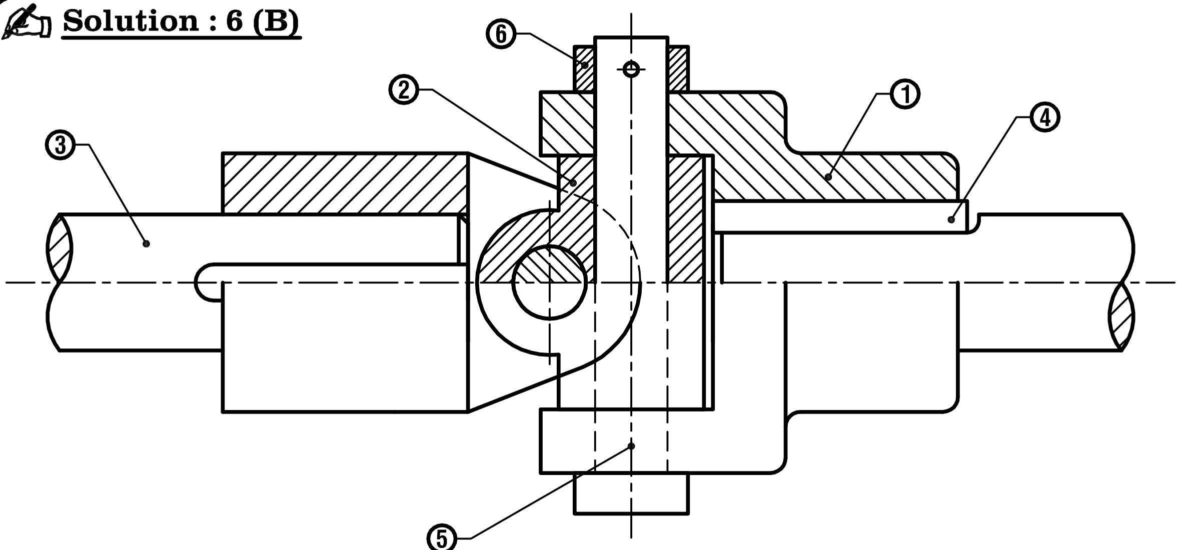
ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
7	TAPER PIN	STEEL	2
6	COLLAR	STEEL	2
5	PIN	STEEL	2
4	PARALLEL KEY	STEEL	2
3	SHAFT	STEEL	2
2	CENTRE	CAST IRON	1
1	FORK	CAST STEEL	2

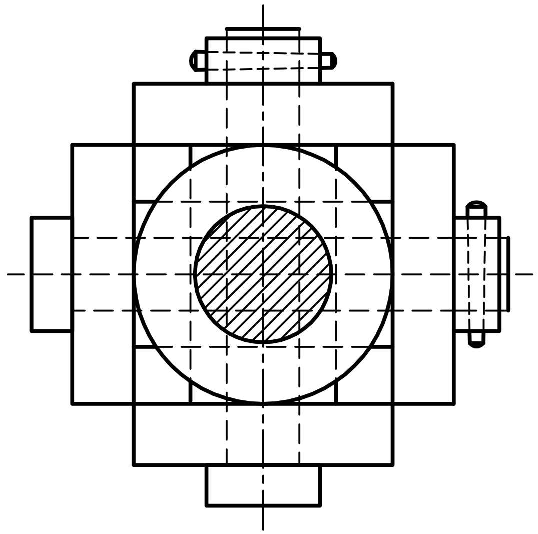
UNIVERSAL COUPLING

SCALE 1:2.5

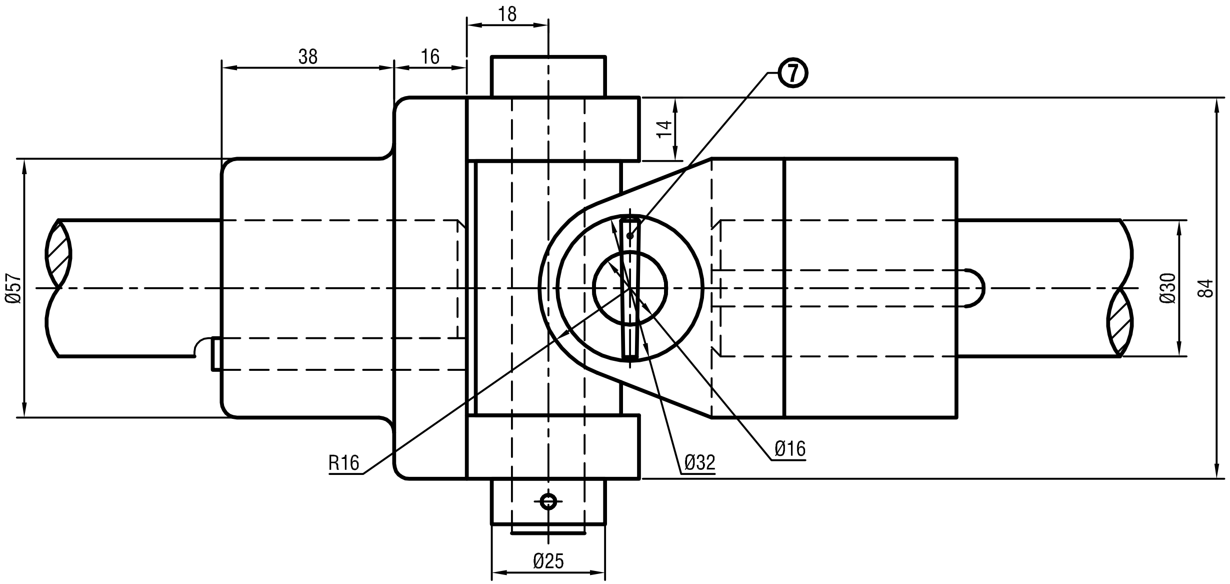
Solution : 6 (B)



HALF SECTIONAL ELEVATION



LEFT SIDE VIEW



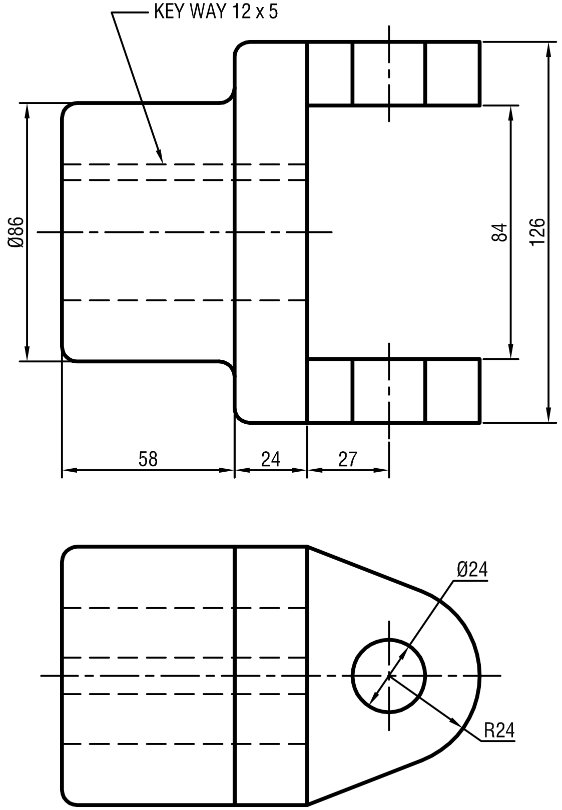
PLAN

ALL DIMENSIONS ARE IN mm

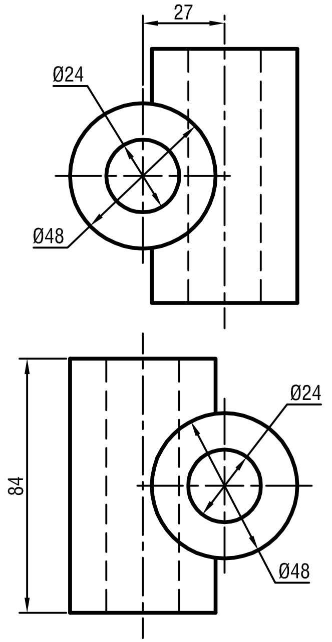
PART NO.	NAME	MATERIAL	NO.OFF
7	TAPER PIN	STEEL	2
6	COLLAR	STEEL	2
5	PIN	STEEL	2
4	PARALLEL KEY	STEEL	2
3	SHAFT	STEEL	2
2	CENTRE	CAST IRON	1
1	FORK	CAST STEEL	2

UNIVERSAL COUPLING

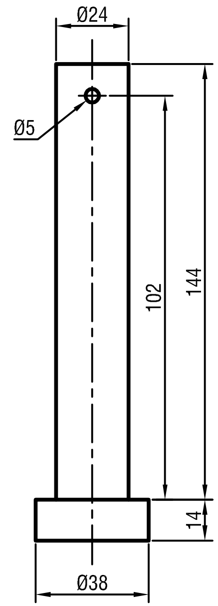
SCALE 1:2.5



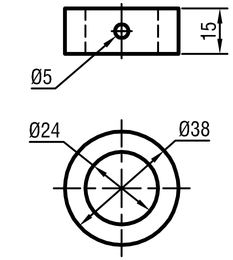
FORK (STEEL) - 2 0FF



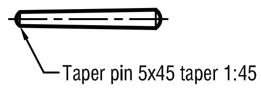
CENTRE BLOCK (CI) - 1 0FF



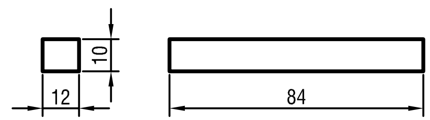
PIN(STEEL) - 2 0FF



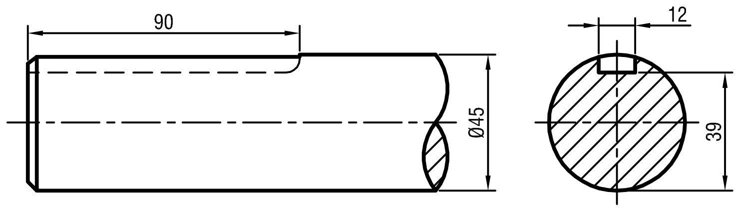
COLLAR (STEEL) - 2 0FF



TAPER PIN(STEEL) - 2 0FF



PARALLEL KEY(STEEL) - 2 0FF



SHAFT (STEEL) - 2 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

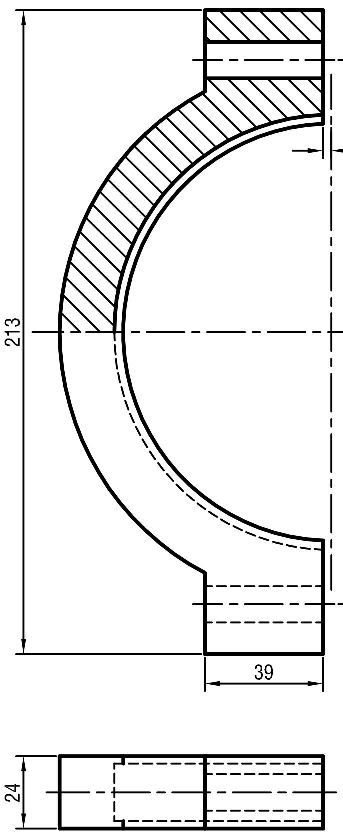
DETAILS OF UNIVERSAL COUPLING

Exercise : 6

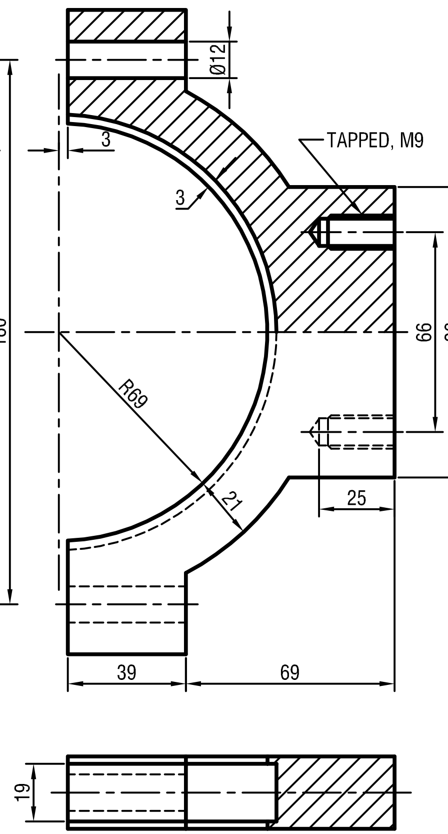
☞ **Assemble and draw the following views of UNIVERSAL COUPLING shown in the sketch. Also add bill of materials.**

A. (a) Sectional front view (b) Top view

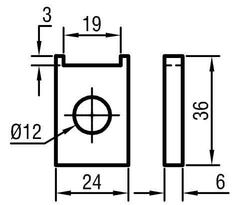
B. (a) Half Sectional elevation (b) Plan (c) Side View



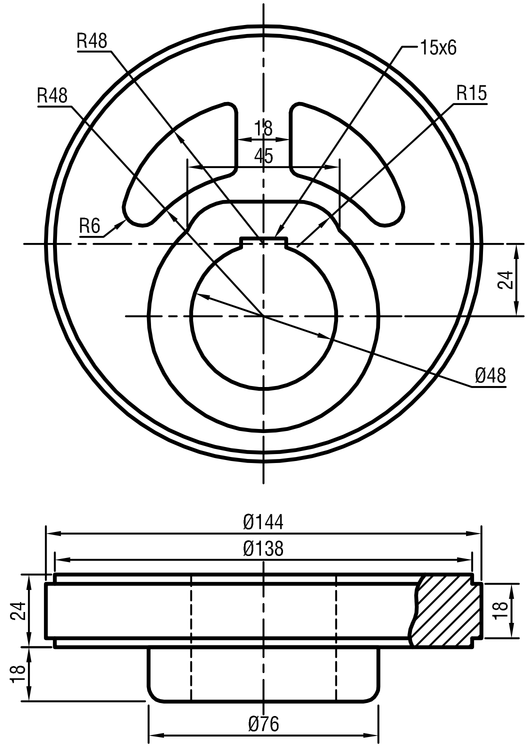
STRAP (CI) - 1 0FF



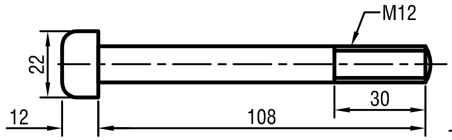
STRAP (CI) - 1 0FF



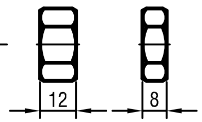
PACKING STRIP (LEATHER) - 2 0FF



SHEAVE (CI) - 1 0FF



STRAP BOLT(MS) - 2 0FF



NUTS (MS) - 2 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

Example :7

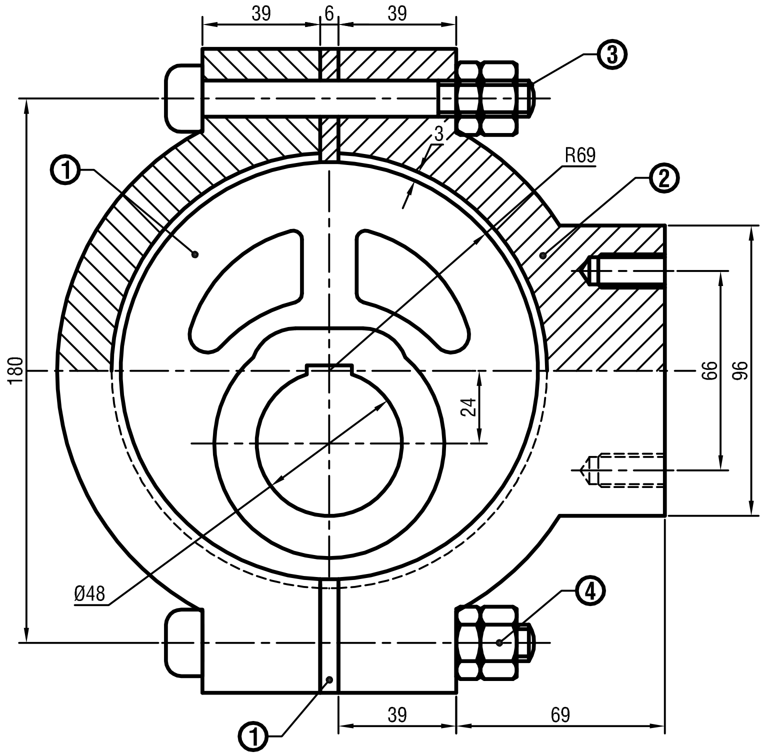
☞ **Assemble and draw the following views of SIMPLE ECCENTRIC shown in the sketch. Also add bill of materials.**

A. (a) Half sectional front view (b) Top view

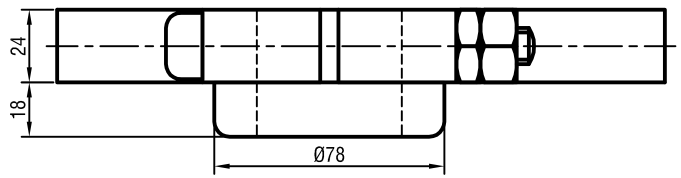
B. (a) Sectional elevation (b) Plan (c) Side View

DETAILS OF SIMPLE ECCENTRIC

Solution : 7 (A)



HALF SECTIONAL FRONT VIEW



TOP VIEW

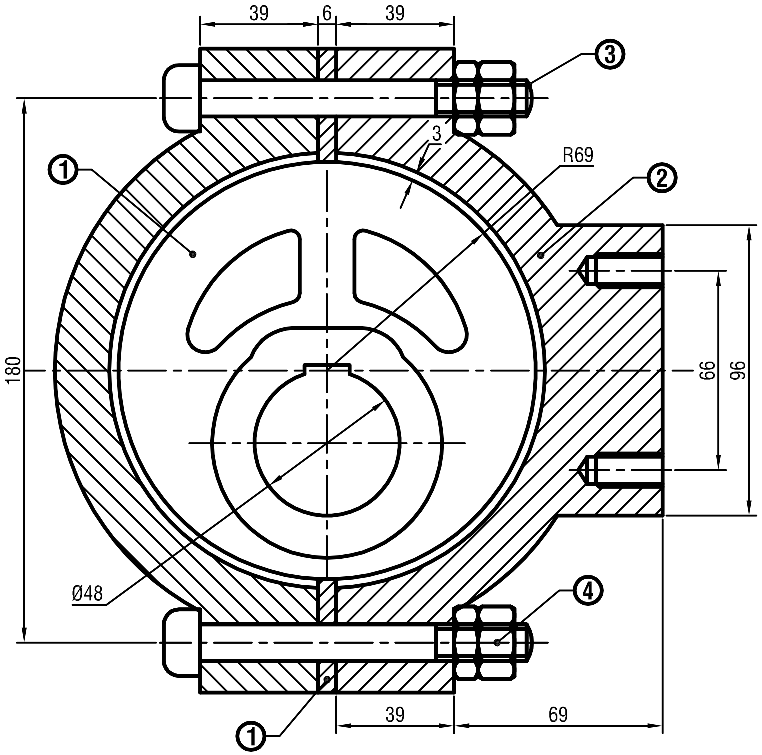
ALL DIMENSIONS ARE IN mm

5	PACKING	LEATHER	2
4	NUTS	MILD STEEL	4
3	BOLTS	MILD STEEL	2
2	STRAP	CAST IRON	2
1	SHEAVE	CAST IRON	1
PART NO.	NAME	MATERIAL	NO.OFF

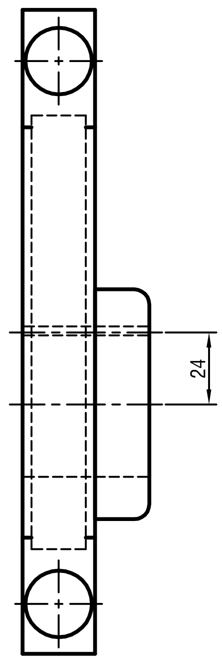
SIMPLE ECCENTRIC

SCALE 1:2

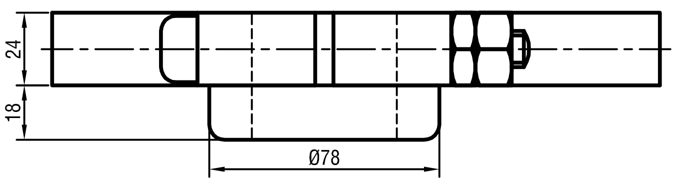
Solution : 7 (B)



SECTIONAL ELEVATION



LEFT SIDE VIEW



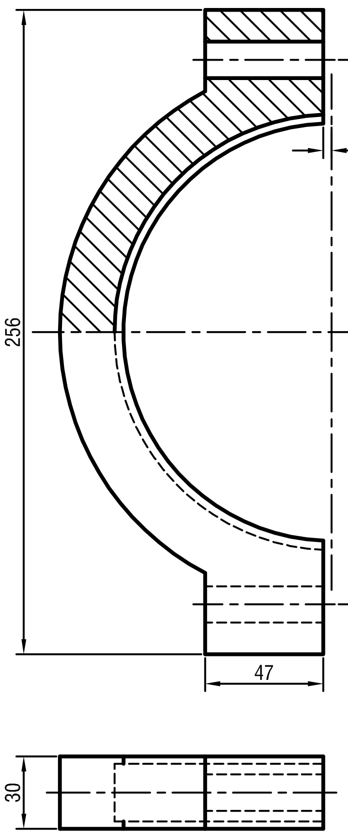
PLAN

ALL DIMENSIONS ARE IN mm

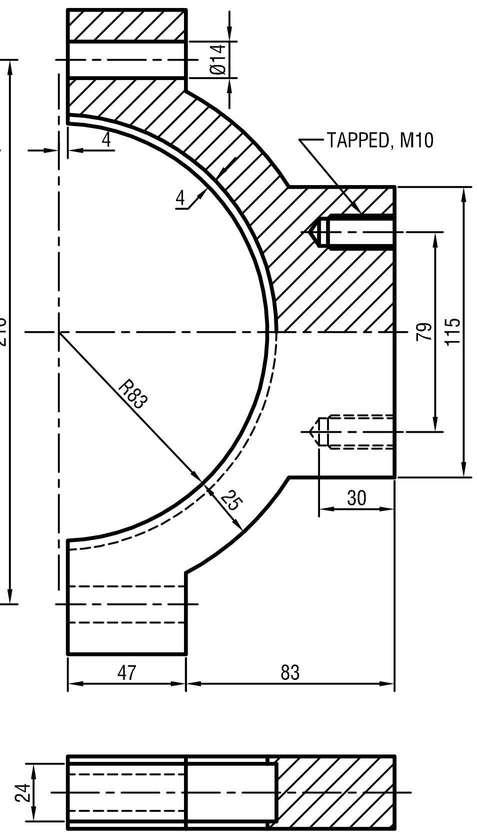
PART NO.	NAME	MATERIAL	NO.OFF
5	PACKING	LEATHER	2
4	NUTS	MILD STEEL	4
3	BOLTS	MILD STEEL	2
2	STRAP	CAST IRON	2
1	SHEAVE	CAST IRON	1

SIMPLE ECCENTRIC

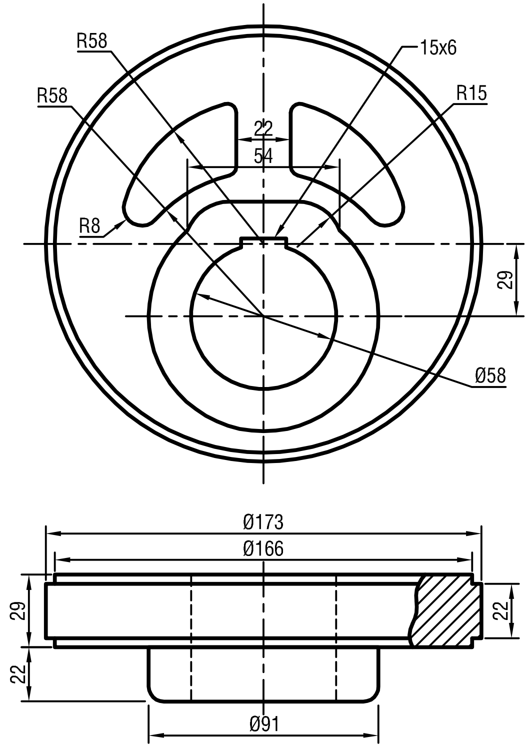
SCALE 1:2



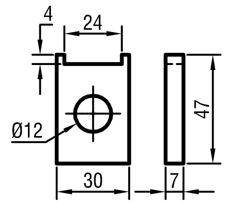
STRAP (CI) - 1 0FF



STRAP (CI) - 1 0FF



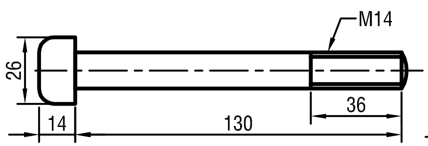
SHEAVE (CI) - 1 0FF



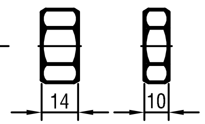
PACKING STRIP (LEATHER) - 2 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm



STRAP BOLT(MS) - 2 0FF



NUTS (MS) - 2 0FF

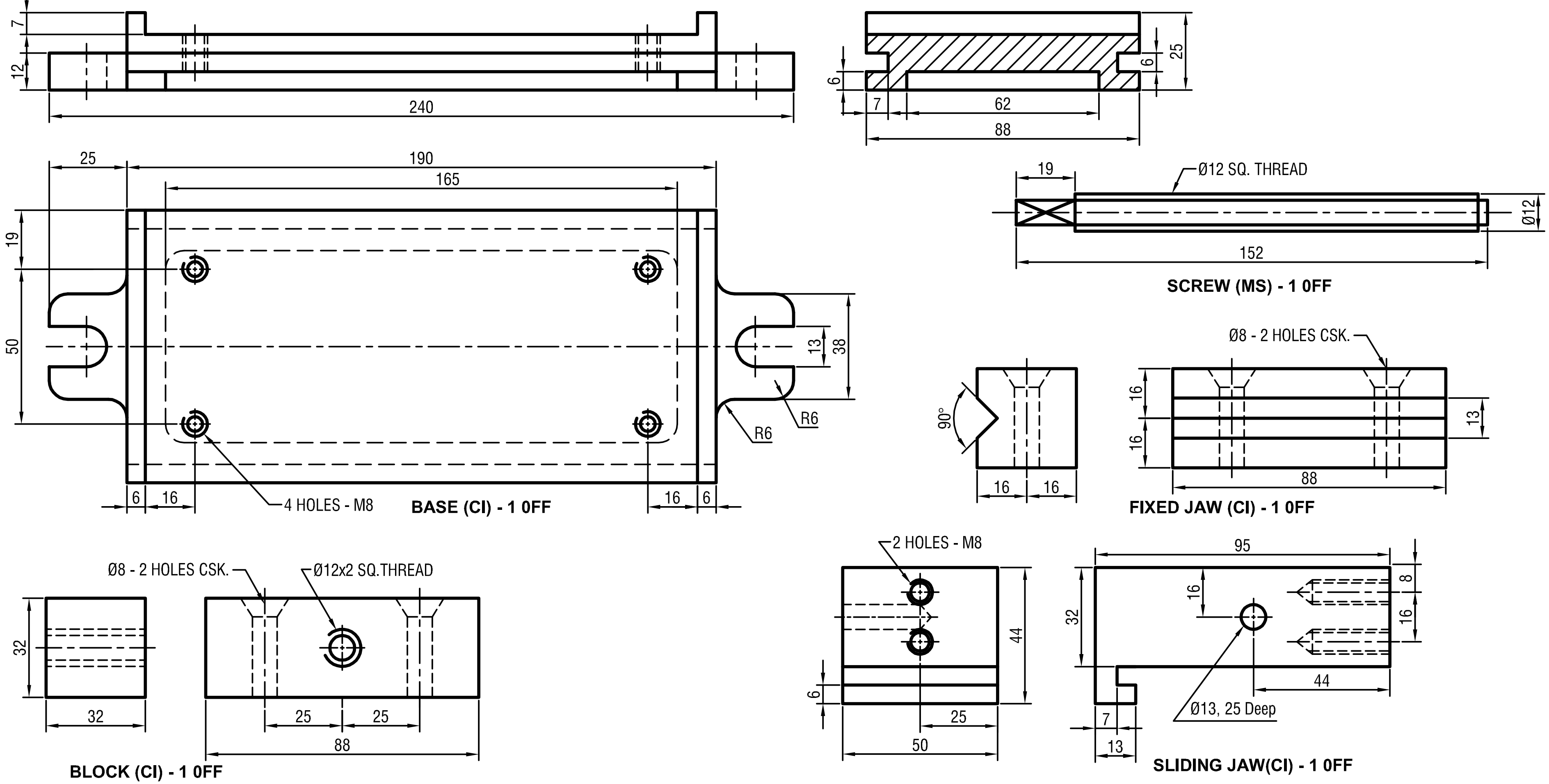
Exercise :7

☞ **Assemble and draw the following views of SIMPLE ECCENTRIC shown in the sketch. Also add bill of materials.**

A. (a) Sectional front view (b) Top view

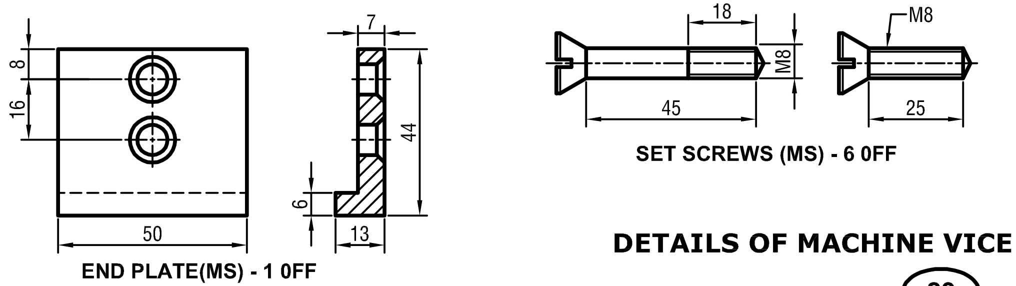
B. (a) Half sectional elevation (b) Plan (c) Side View

DETAILS OF SIMPLE ECCENTRIC



ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm



DETAILS OF MACHINE VICE

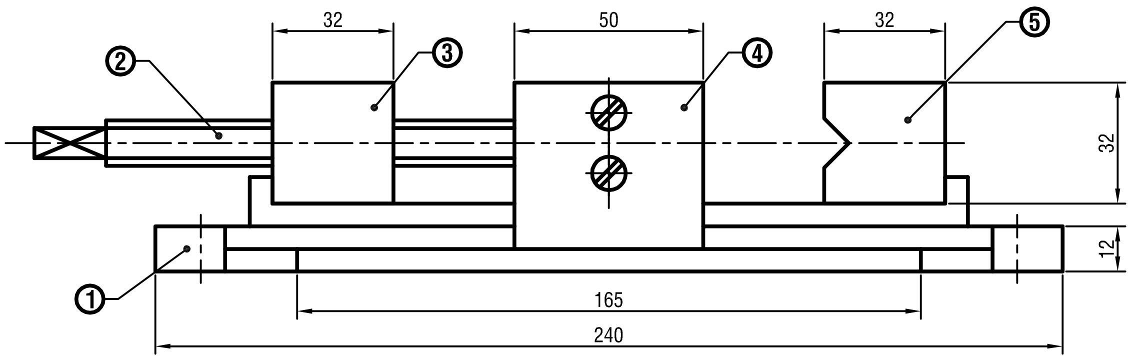
Example : 8

☞ **Assemble and draw the following views of MACHINE VICE shown in the sketch. Also add bill of materials.**

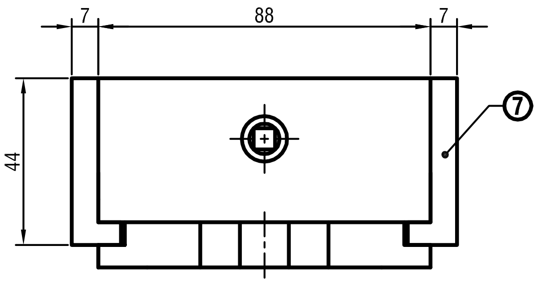
A. (a) Front view (b) Top view (c) Side view

B. (a) Sectional elevation (b) Plan

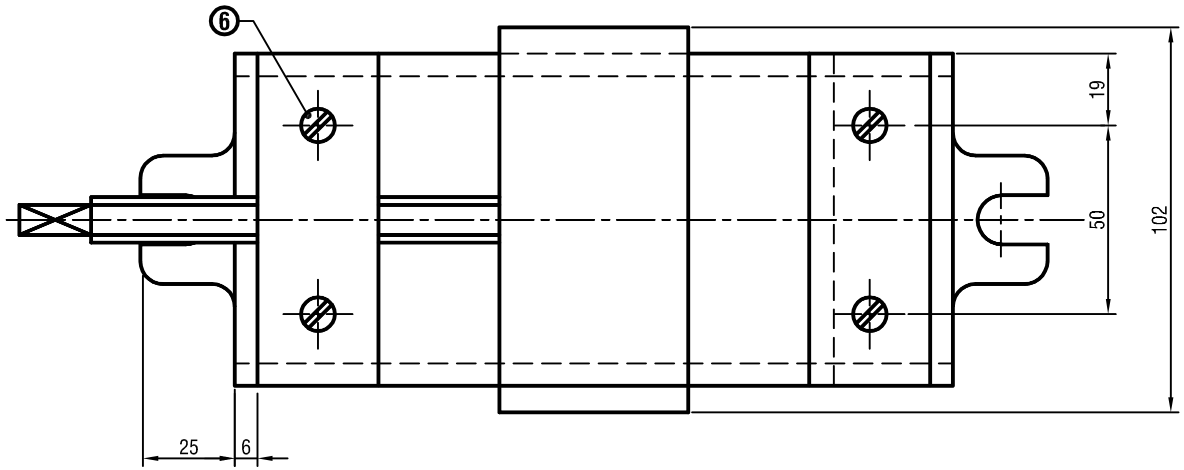
Solution : 8 (A)



FRONT VIEW



LEFT SIDE VIEW



TOP VIEW

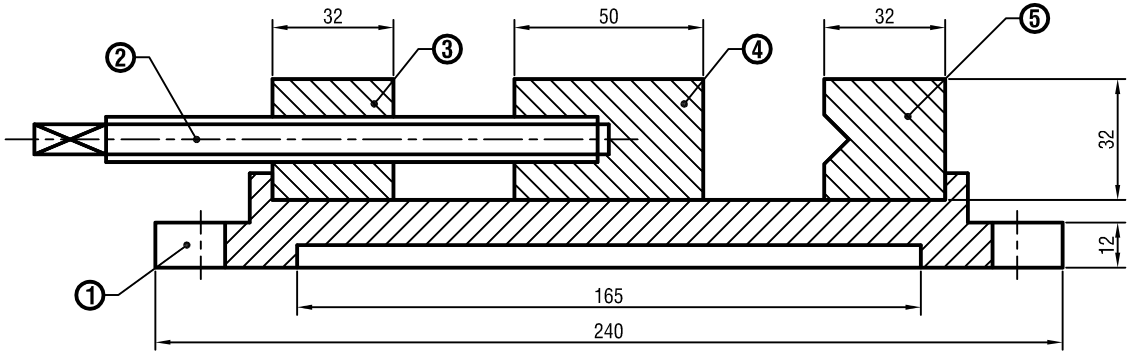
ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
7	END PLATE	MILD STEEL	1
6	SET SCREWS	MILD STEEL	6
5	FIXED JAW	CAST IRON	1
4	SLIDING JAW	CAST IRON	1
3	BLOCK	CAST IRON	1
2	SCREW	MILD STEEL	1
1	BASE	CAST IRON	1

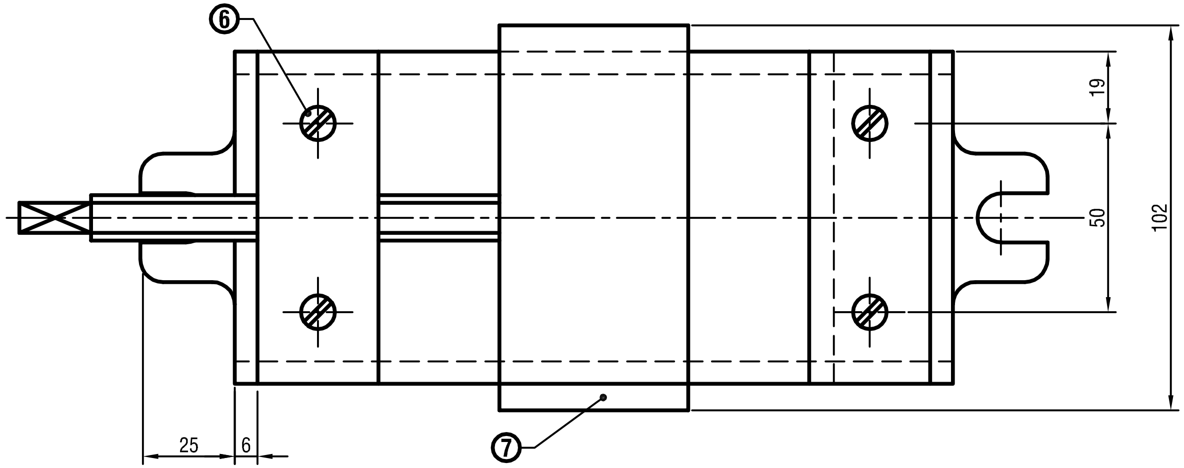
MACHINE VICE

SCALE 1:2

Solution : 8 (B)



SECTIONAL ELEVATION



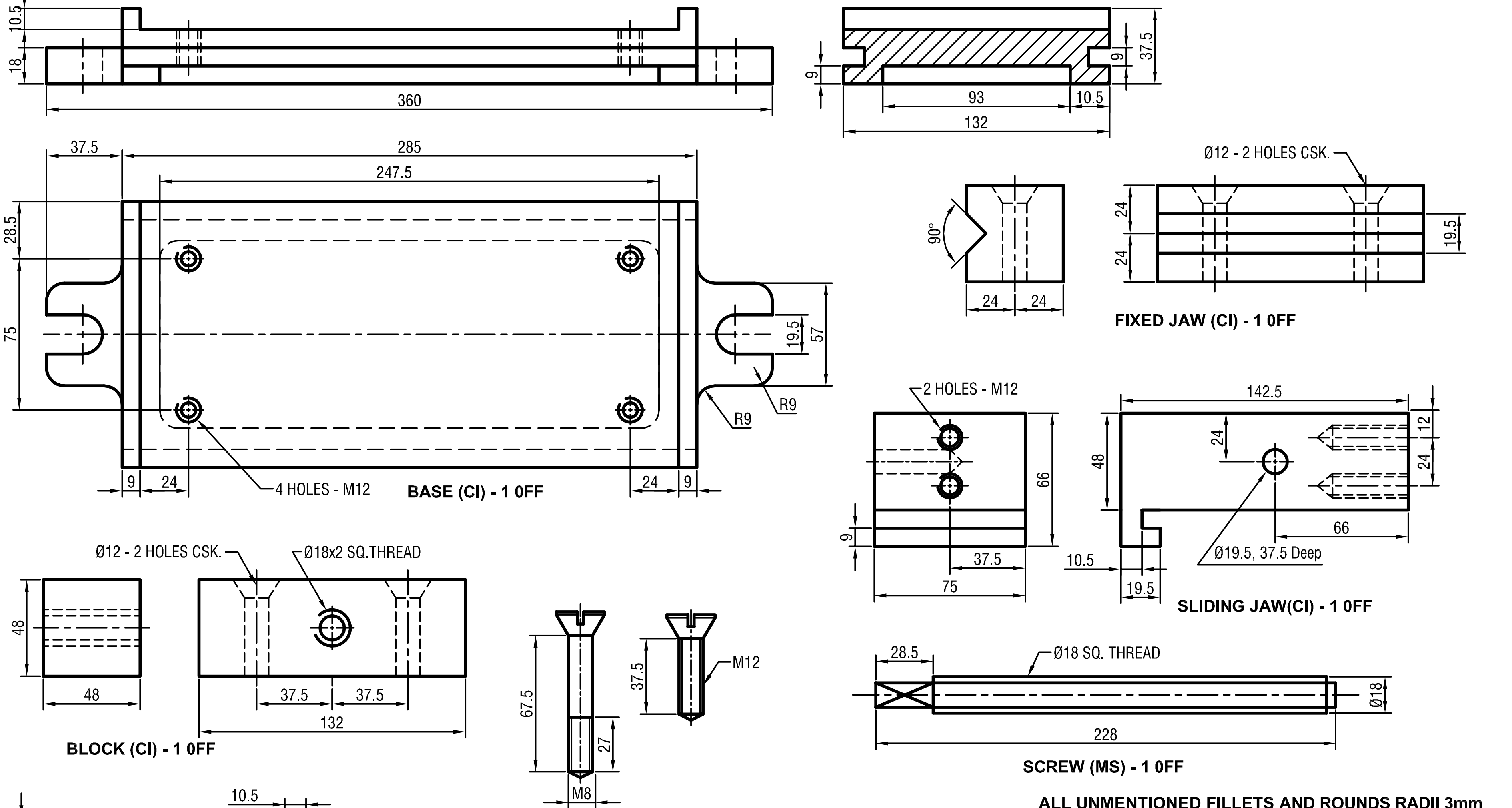
PLAN

ALL DIMENSIONS ARE IN mm

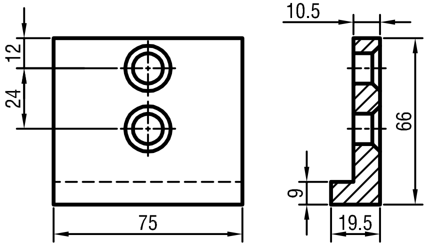
PART NO.	NAME	MATERIAL	NO.OFF
7	END PLATE	MILD STEEL	1
6	SET SCREWS	MILD STEEL	6
5	FIXED JAW	CAST IRON	1
4	SLIDING JAW	CAST IRON	1
3	BLOCK	CAST IRON	1
2	SCREW	MILD STEEL	1
1	BASE	CAST IRON	1

MACHINE VICE

SCALE 1:2



SET SCREWS (MS) - 6 0FF



END PLATE(MS) - 1 0FF

DETAILS OF MACHINE VICE

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

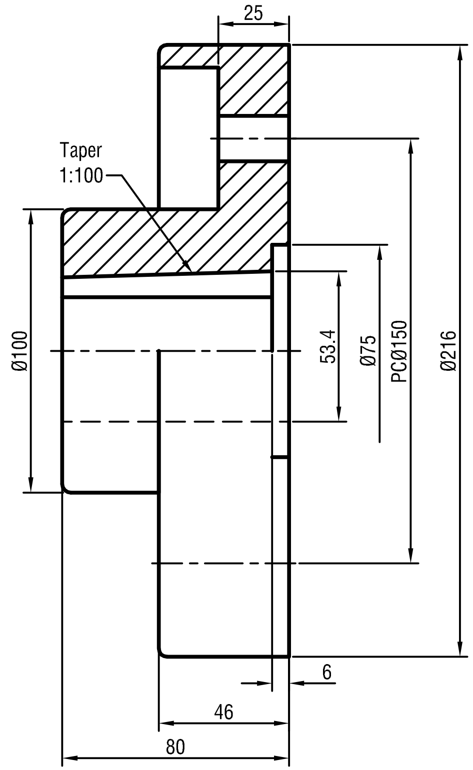
ALL DIMENSIONS ARE IN mm

Exercise : 8

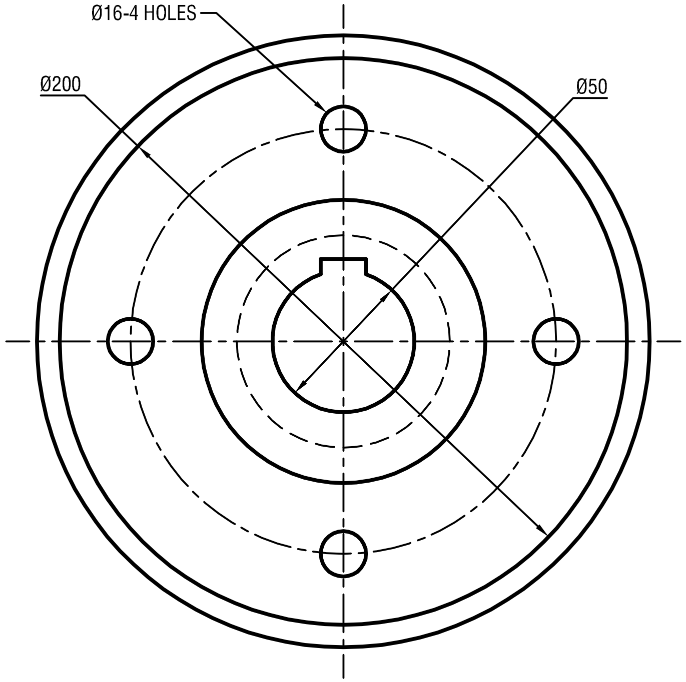
☞ **Assemble and draw the following views of MACHINE VICE shown in the sketch. Also add bill of materials.**

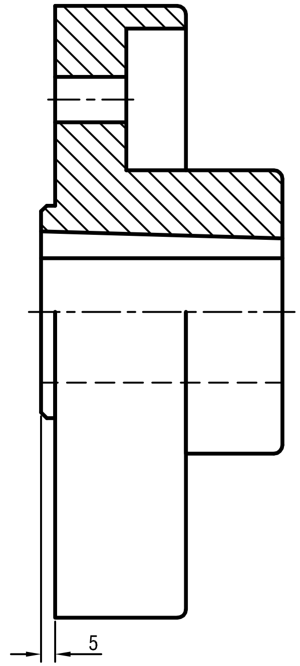
A. (a) Front view (b) Top view (c) Side view

B. (a) Sectional elevation (b) Plan

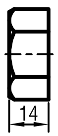


FLANGE-1(CAST IRON) - 1 0FF

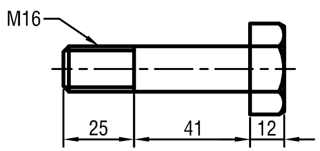




FLANGE-2(CAST IRON) - 1 0FF



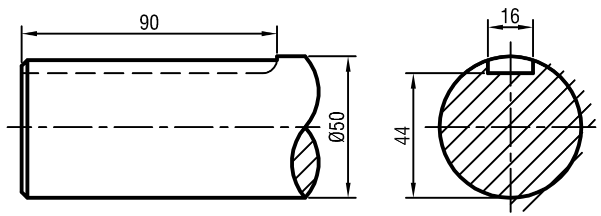
HEX. NUT
(STEEL) - 4 0FF



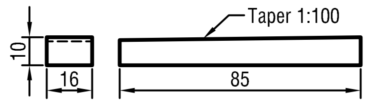
HEX. BOLT
(STEEL) - 4 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm



SHAFT(STEEL) - 2 0FF



TAPER KEY(STEEL) - 2 0FF

DETAILS OF PROTECTED TYPE FLANGED COUPLING

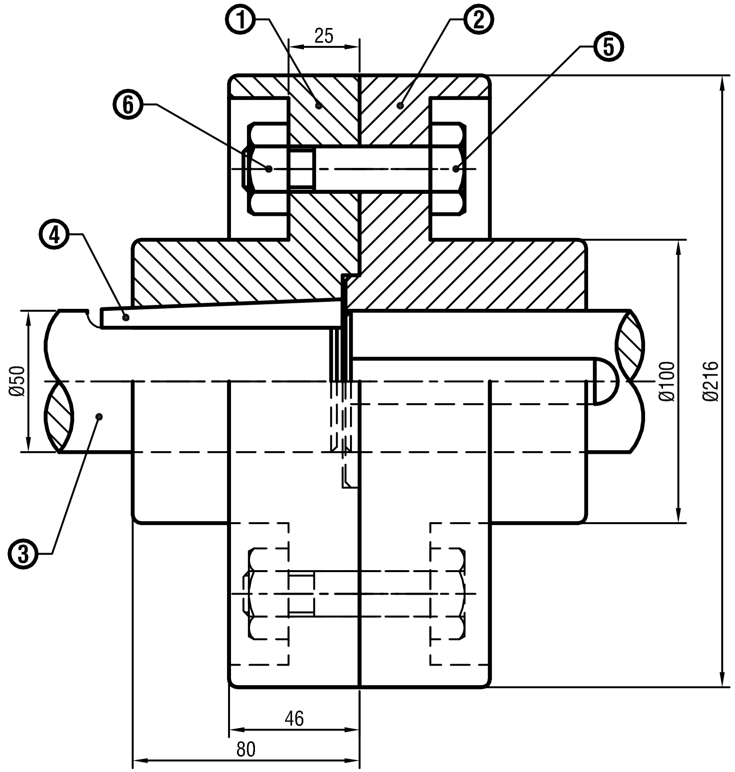
Example : 9

☞ **Assemble and draw the following views of PROTECTED TYPE FLANGED COUPLING shown in the sketch. Also add bill of materials.**

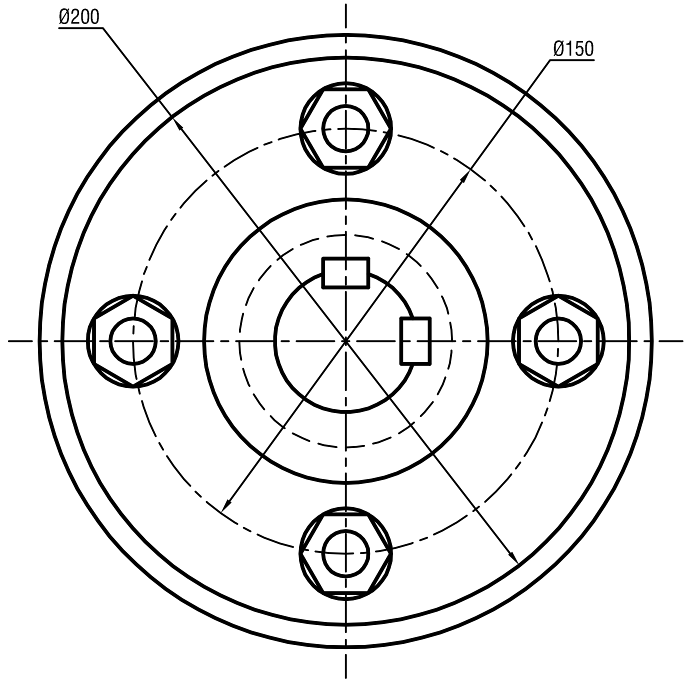
A. (a) Half sectional front view (b) Side view

B. (a) Sectional elevation (b) Side view

Solution : 9 (A)



HALF SECTIONAL FRONT VIEW



LEFT SIDE VIEW

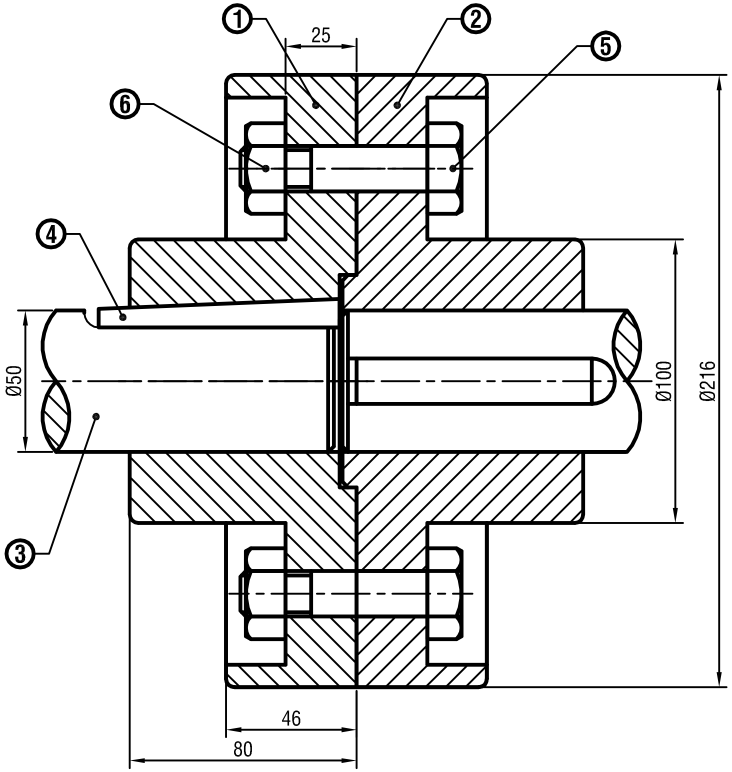
ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
6	HEX. NUT	STEEL	4
5	HEX. BOLT	STEEL	4
4	TAPER KEY	STEEL	2
3	SHAFT	STEEL	2
2	FLANGE-2	CAST IRON	1
1	FLANGE-1	CAST IRON	1

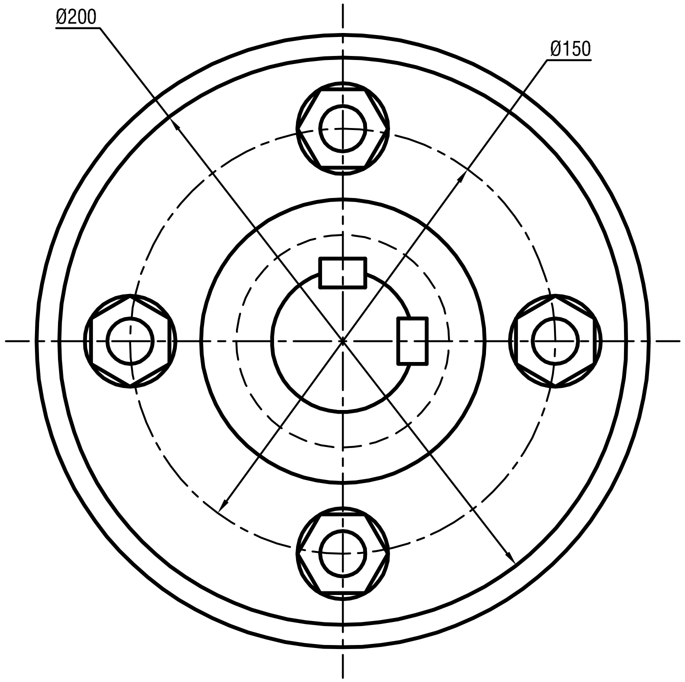
FLANGED COUPLING

SCALE 1:2.5

Solution : 9 (B)



SECTIONAL ELEVATION



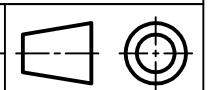
LEFT SIDE VIEW

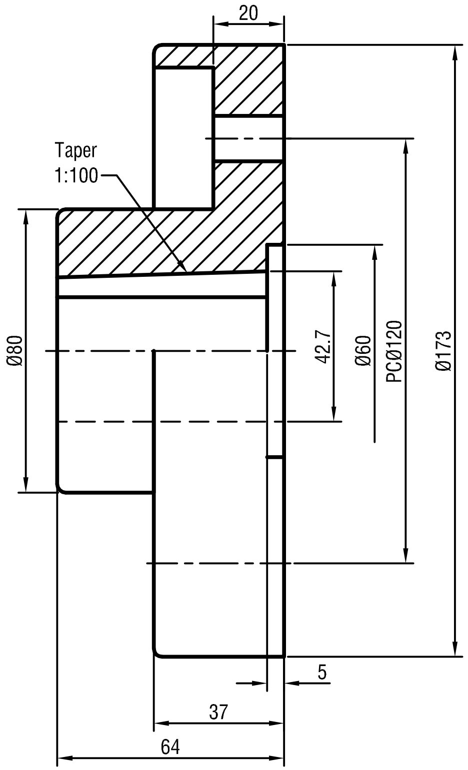
ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
6	HEX. NUT	STEEL	4
5	HEX. BOLT	STEEL	4
4	TAPER KEY	STEEL	2
3	SHAFT	STEEL	2
2	FLANGE-2	CAST IRON	1
1	FLANGE-1	CAST IRON	1

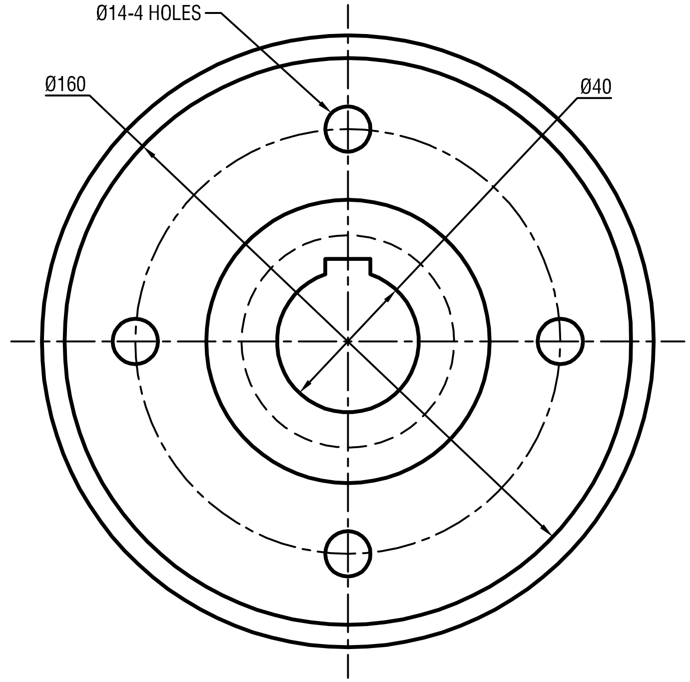
FLANGED COUPLING

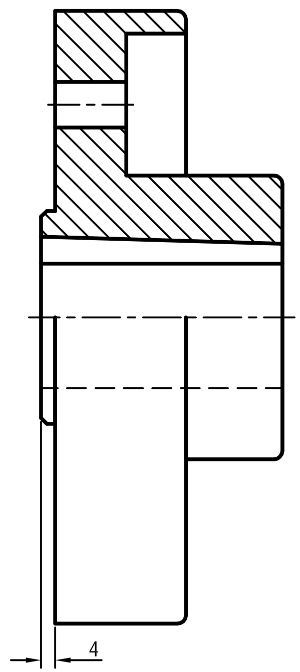
SCALE 1:2.5



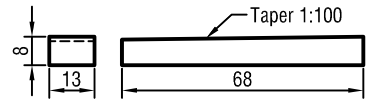


FLANGE-1(CAST IRON) - 1 0FF

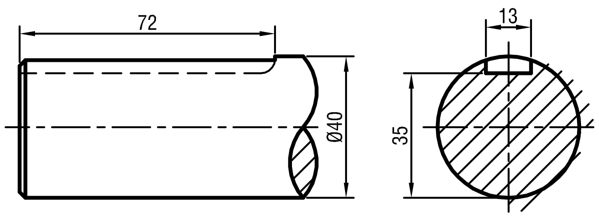




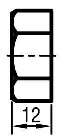
FLANGE-2(CAST IRON) - 1 0FF



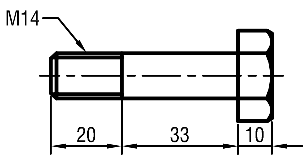
TAPER KEY(STEEL) - 2 0FF



SHAFT(STEEL) - 2 0FF



HEX. NUT
(STEEL) - 4 0FF



HEX. BOLT
(STEEL) - 4 0FF

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

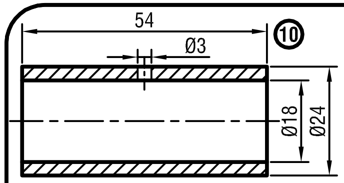
Exercise : 9

☞ **Assemble and draw the following views of PROTECTED TYPE FLANGED COUPLING shown in the sketch. Also add bill of materials.**

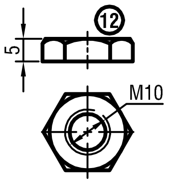
A. (a) Sectional front view (b) Side view

B. (a) Half sectional elevation (b) Side view

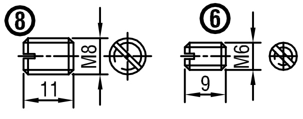
DETAILS OF PROTECTED TYPE FLANGED COUPLING



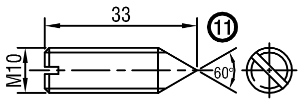
BUSH (BRASS) - 1 0FF



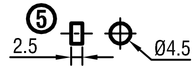
LOCK NUT(MS) - 2 0FF



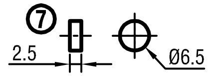
SET SCREW(MS) - 1 0FF



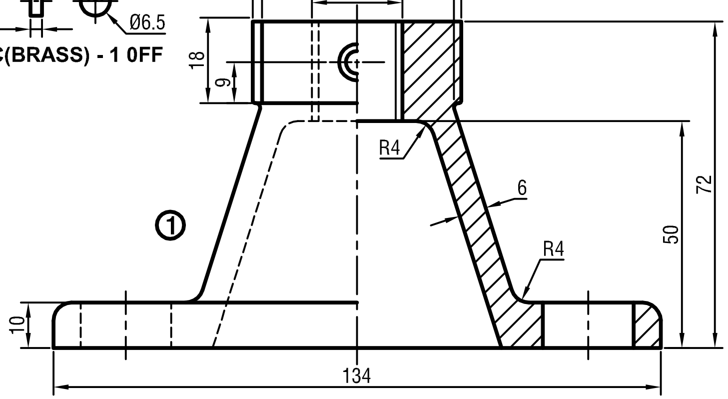
SET SCREW(MS) - 2 0FF

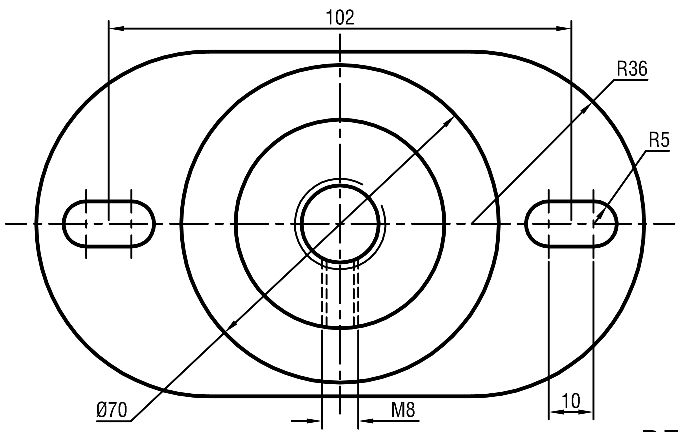


DISC(BRASS) - 1 0FF

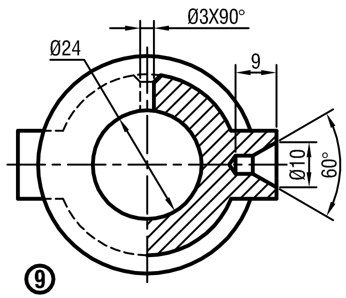


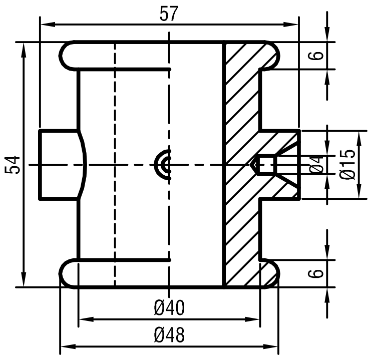
DISC(BRASS) - 1 0FF



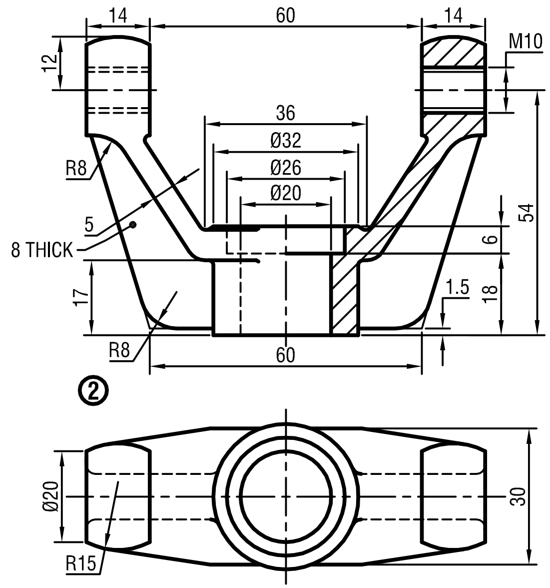


BASE (CI) - 1 0FF

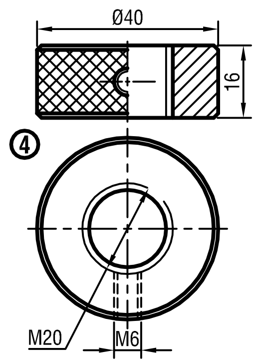




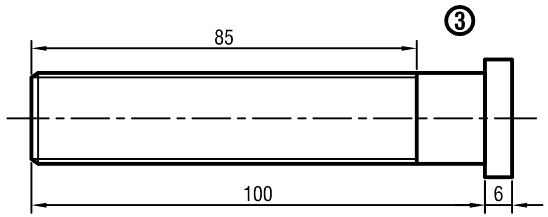
BEARING BLOCK(CI) - 1 0FF



FORK (CI) - 1 0FF



KNURLED NUT(MS) - 1 0FF



SPINDLE (MS) - 1 0FF

DETAILS OF SWIVEL BEARING

ALL UNMENTIONED FILLETS AND ROUNDS RADII 3mm

ALL DIMENSIONS ARE IN mm

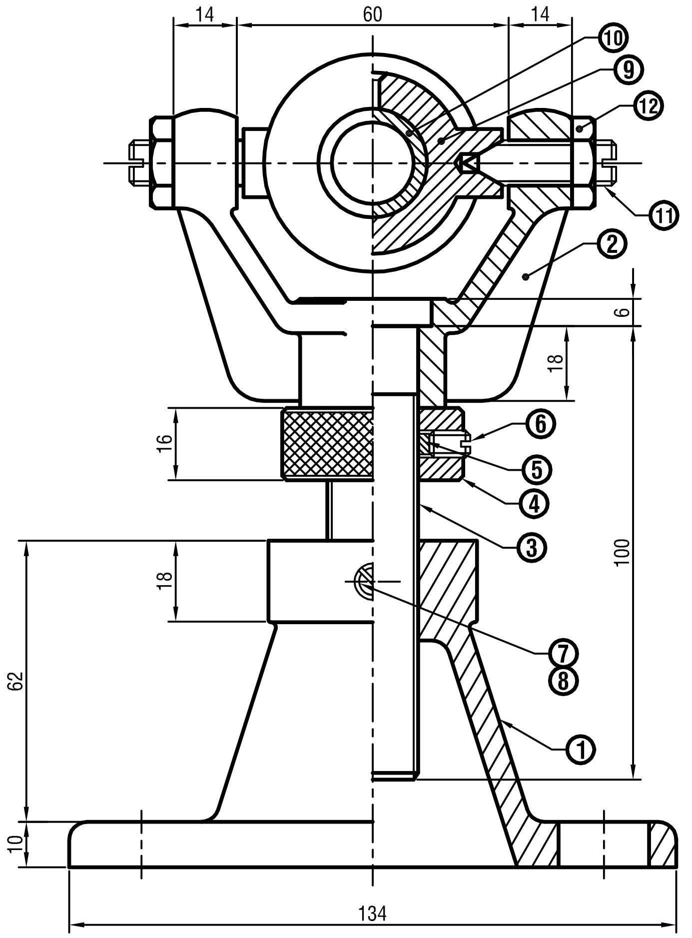
Exercise : 10

☞ **Assemble and draw the following views of SWIVEL BEARING shown in the sketch. Also add bill of materials.**

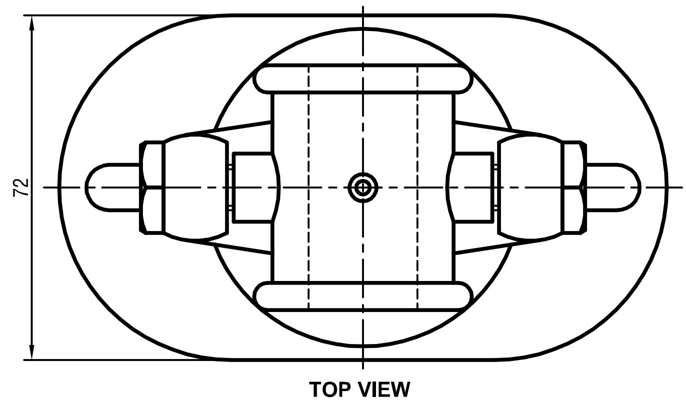
A. (a) Half sectional front view (b) Top view

B. (a) Sectional elevation (b) Top view (c) Side view

Solution : 10 (A)



HALF SECTIONAL FRONT VIEW



TOP VIEW

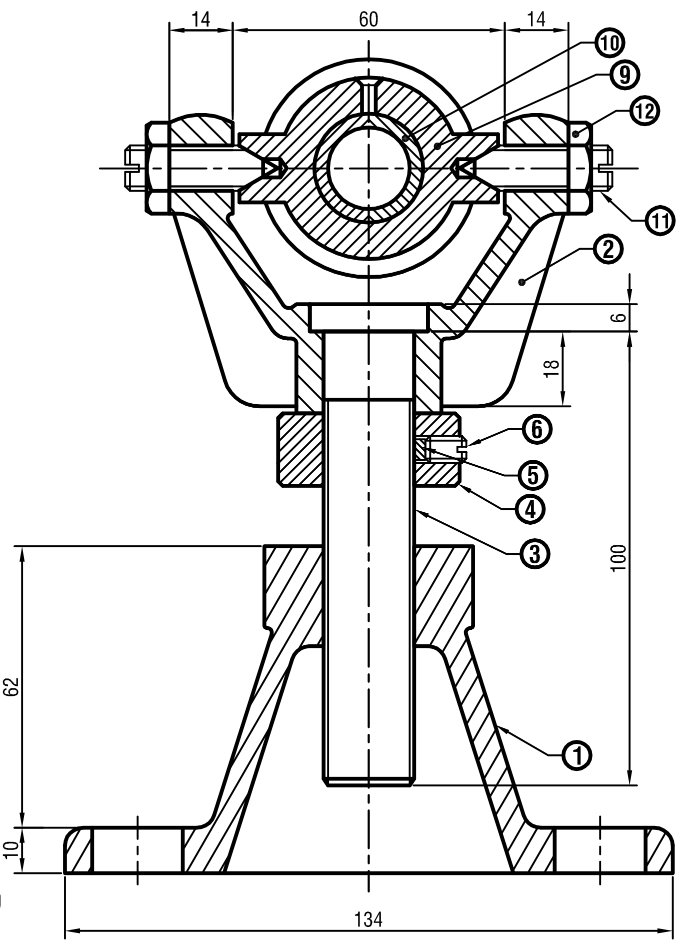
ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
12	LOCK NUT	MILD STEEL	2
11	SET SCREW	MILD STEEL	2
10	BUSH	BRASS	1
9	BEARING BLOCK	CAST IRON	1
8	SET SCREW	MILD STEEL	1
7	DISC	BRASS	1
6	SET SCREW	MILD STEEL	1
5	DISC	BRASS	1
4	KNURLED NUT	MILD STEEL	1
3	SPINDLE	MILD STEEL	1
2	FORK	CAST IRON	1
1	BASE	CAST IRON	1

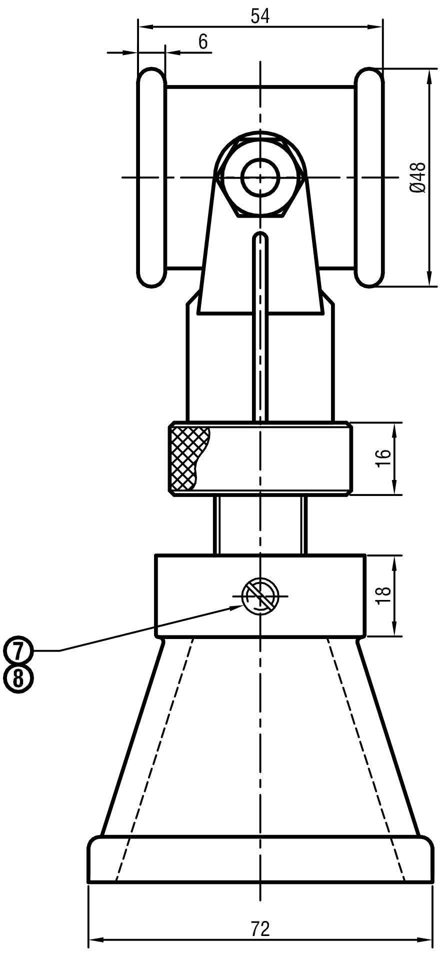
SWIVEL BEARING

SCALE 1:2

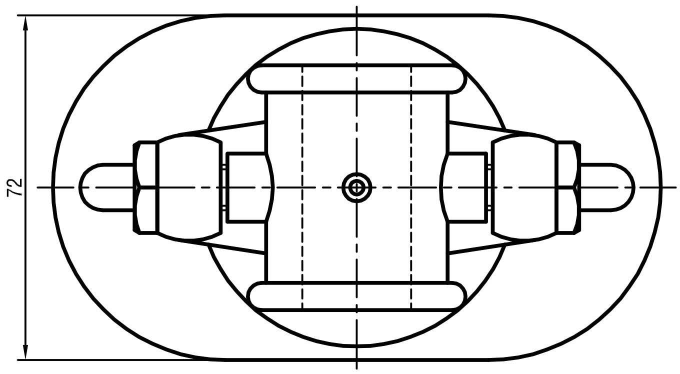
Solution : 10 (B)



SECTIONAL ELEVATION



LEFT SIDE VIEW



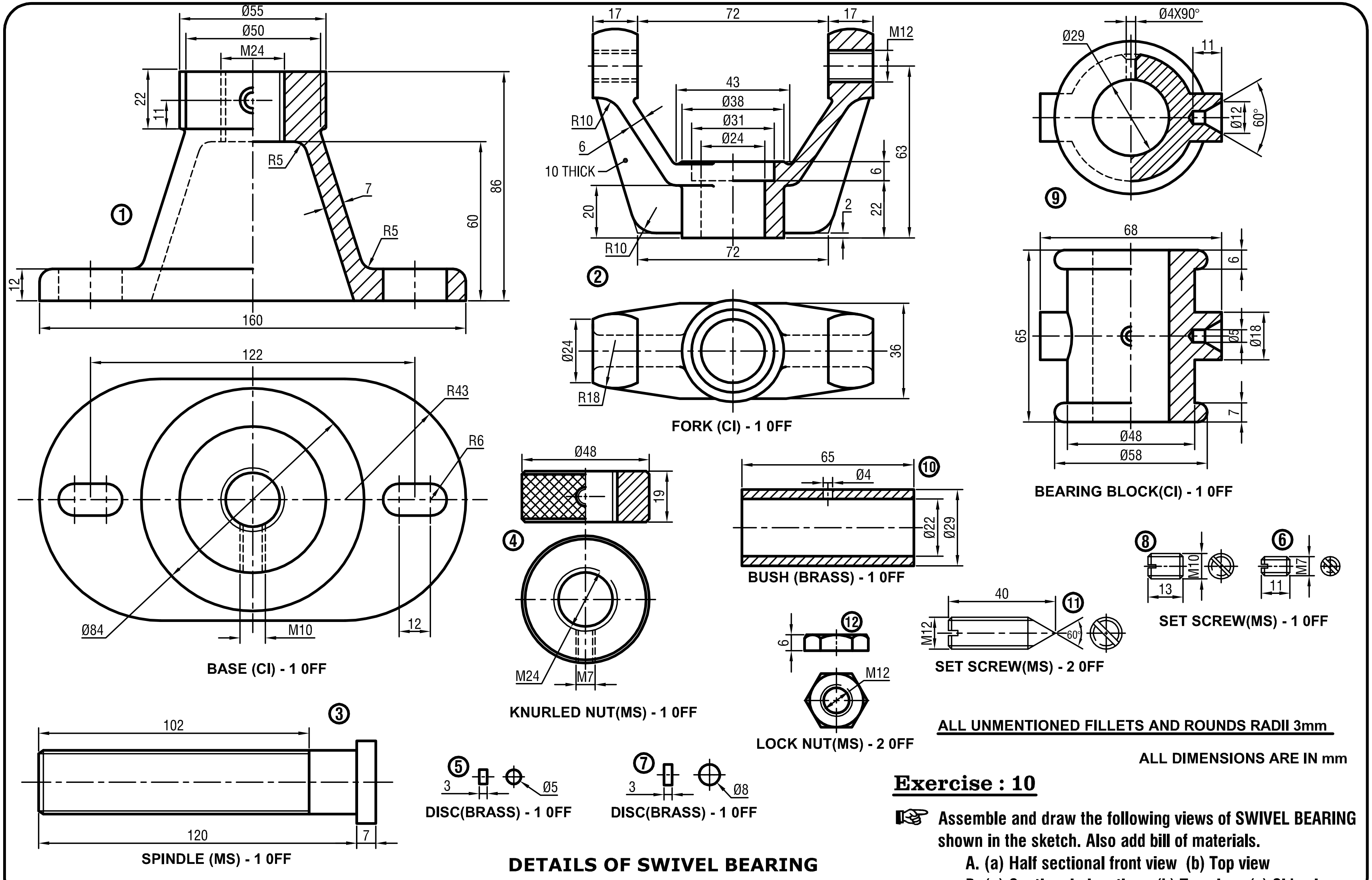
PLAN

ALL DIMENSIONS ARE IN mm

PART NO.	NAME	MATERIAL	NO.OFF
12	LOCK NUT	MILD STEEL	2
11	SET SCREW	MILD STEEL	2
10	BUSH	BRASS	1
9	BEARING BLOCK	CAST IRON	1
8	SET SCREW	MILD STEEL	1
7	DISC	BRASS	1
6	SET SCREW	MILD STEEL	1
5	DISC	BRASS	1
4	KNURLED NUT	MILD STEEL	1
3	SPINDLE	MILD STEEL	1
2	FORK	CAST IRON	1
1	BASE	CAST IRON	1

SWIVEL BEARING

SCALE 1:2



DETAILS OF SWIVEL BEARING

Exercise : 10

☞ Assemble and draw the following views of SWIVEL BEARING shown in the sketch. Also add bill of materials.

A. (a) Half sectional front view (b) Top view

B. (a) Sectional elevation (b) Top view (c) Side view

32033 - MACHINE DRAWING

DETAILED SYLLABUS

Unit – I: SECTIONAL VIEWS

Review of sectioning – Conventions showing the section – symbolic representation of cutting plane- types of section – full section, half section, offset section, revolved section, broken section, removed section – section lining.

Unit - II: LIMITS, FITS AND TOLERANCES

Tolerances – Allowances – Unilateral and Bilateral tolerances. Limits – Methods of tolerances – Indication of tolerances on linear dimension of drawings – Geometrical tolerances – application – Fits – Classifications of fits – Selection of fits – examples

Unit - III: SURFACE TEXTURE

Surface texture – importance – controlled and uncontrolled surfaces – Roughness – Waviness – lay – Machining symbols

Unit – IV: KEYS, SCREW THREADS AND THREADED FASTENERS

Types of fasteners – temporary fasteners – keys – classification of keys – Heavy duty keys – light duty keys. Screw thread – Nomenclature – different types of thread profiles – threads in sections – threaded fasteners – bolts – nuts – through bolt – tap bolt, stud bolt – set screw – cap screws – machine screws – foundation bolts

Unit – V: MANUAL DRAWING PRACTICE

Detailed drawings of following machine parts are given to students to assemble and draw the Elevations / Sectional elevations / Plan and Side views with dimensioning and bill of materials

1. Sleeve & Cotter Joint
2. Knuckle Joint
3. Screw Jack
4. Foot step bearing
5. Plummer Block
6. Universal Coupling
7. Simple Eccentric
8. Machine Vice
9. Protected type flanged coupling
10. Swivel Bearing

32033 – MACHINE DRAWING

MODEL QUESTION PAPER

Time: 3 Hrs **Max Marks : 75**

[N.B : (1) Answer any seven questions in Part – A and answer division (a) or division (b) in Part – B.

(2) Each question carry 5 marks in Part – A and 40 marks in Part – B.

(3) All the questions are to be answered in drawing sheet only.]

PART – A

1. Name different types of section. Explain (i) full section and (ii) half section.
2. List the important points to be considered while creating hatching lines.
3. Define hole basis and shaft basis system. Explain with sketch.
4. What are the types of fits? Illustrate transition fit using a neat sketch.
5. Explain surface roughness symbol and its notations.
6. Explain the direction of lay using symbols.
7. Explain the nomenclature of screw thread.
8. Illustrate the types of keys. Draw a gib headed key with its proportions.

PART – B

9. (a) Assemble and draw the following views of **connecting rod** shown in the sketch. Also add bill of materials.

Right half sectional elevation	: 20 Marks
Plan	: 15 Marks
Bill of Materials	: 05 Marks

(OR)

(b) Assemble and draw the following views of **knuckle joint** shown in the sketch. Also add bill of materials.

Full sectional front view	: 20 Marks
Top view	: 15 Marks
Bill of Materials	: 05 Marks

32033 – MACHINE DRAWING

BOARD EXAM QUESTION PAPER – OCTOBER 2016

Time: 3 Hrs **Max Marks : 75**

[N.B : (1) Answer any seven questions in Part – A and answer division (a) or division (b) in Part – B.

(2) Each question carry 5 marks in Part – A and 40 marks in Part – B.

(3) All the questions are to be answered in drawing sheet only.]

PART – A

1. Sketch the broken end of a solid shaft as per the conventional representation.
2. Illustrate revolved section.
3. How will you indicate tolerances on Linear dimension of drawings?
4. Draw the symbols for the following geometrical tolerances:
   (a) Parallelism (b) Squareness (c) Angularity
   (d) Straightness (e) Flatness.
5. What are controlled and uncontrolled surfaces?
6. Sketch the basic machining symbol for indicating surface roughness.
7. How are keys classified?
8. Mention the different types of thread profiles.

PART – B

9. (a) Assemble and draw the following views of **screw jack** shown in the sketch. Also add bill of materials.

Sectional elevation	: 20 Marks
Plan	: 15 Marks
Bill of Materials	: 05 Marks

(OR)

(b) Assemble and draw the following views of **swivel bearing** shown in the sketch. Also add bill of materials.

Sectional elevation	: 20 Marks
Plan	: 15 Marks
Bill of Materials	: 05 Marks