Ministry of Higher Education & Scientific Research

Foundation of Technical Education

Technical College/ Mosul

Dept. of Ref. & Air-Cond. Eng. Technology

Mechanical Drawing

&

Descriptive Geometry

For

Second year students

Objectives : The teaching objectives are to train students: to read the technical drawings, symbols, technical terms, standard specifications, draw the simple and complex assembly drawings, and use the computer in mechanical drawing. Also to teaching the basic principal for the descriptive geometry.

Week	Syllabus
1st	Introduction, Simplifications, Conventions and Symbols.
2nd	Screw threads, forms of screw thread, international metric threads (ISO screw), Common types of fasteners.
3rd	Method of drawing (Hexagonal & Square headed bolts and nuts.
4th	Exercises.
5th	Keys, types of keys, spline shaft and hub.
6th	Rivets and riveted joints, types of riveted joints, Conventional rivet symbo. --.
7th	Welding, type of weld joints, welding symbols standard, location and dimension of weld.
8th	Pulleys, types of pulleys.
9th	Gears classification of gears, spur gear, definitions, formulas and calculations.
10th	Gear tooth profile, working drawing.
11th	Bevel gear, calculations, working drawing.
12th	Helical gear, worms and worm gear, rack and pinion.
13th	Gear boxes.
14th	Assembly and details of common mechanical unit, (Vice).
15th	Screw Jack (Assembly and details).
16th	Bett tightener (Assembly and details).
17th	Stock Bracket for cold saw machine (Assembly and details).
18th	Coupling, Types of coupling, rigid and flexible coupling.

19th	**Muff, old ham's and universal coupling.**
20th	**Bearings, types of bearings, sliding contact bearings.**
21th	**Rolling contact bearings.**
22th	**Clutches, types of clutches.**
23th	**Brakes, types of brakes.**
24th	**Pipes and pipe joints, piping fittings, pipe symbols standard.**
25th	**Two line piping drawing.**
26th	**One line piping drawing.**
27th	**Valves, types of valves, drawing of gate valves.**
28th	**Drawing of global valves.**
29th	**Introduction to (CAD), components of computer aided drawing(CAD), relationship between CAD & CAM in modern design and manufacturing facilities.**
30th	**Main advantages of (CAD) difference between plotting and drawing.**

The first week

1. **Introduction, Simplifications, Conventions and Symbols.**
2. **Class: second year**
3. **Subject: general introduction for engineering Drawing, and Simplifications for the correct manner for drawing the drawing fundamentals through the standard Conventions, also the Standard symbol used in Refrigeration & Air Conditioning.**
4. **Central idea: To make the students understanding all about the different subjects for engineering drawing. Also to teaching the students the correct manner to draw the different subjects in refrigeration and air conditioning drawings through the standard conventions also teaching all symbols used.**
5. **Goals: To teach the students the correct drawing in mechanical drawings for different scientific subjects also to show the students all used symbols in refrigeration and air conditioning drawings through the standard conventions and all the drawing fundamentals.**
6. **Pre test:**
   a) **What is your expecting about the fundamentals for engineering drawing?**
   b) **What is your expecting about the basic required components for drawing.**
   c) **What is your expecting about the types of lines.**
   d) **What is the mean mechanical of drawing?**

Drawing :

A drawing is a graphic representation of a real thing. To draw something as a figure by means of lines expressing some ideas on the paper is the drawing. The purpose of the drawing is to define and specify the shape and size of a particular object by means of lines, other information about the object, which be expressed by lines, are given side by side on the drawing in a simplest and shortest way. A good type of drawing gives full information about the object in a shortest and simplest way. Hence drawing is the shortest of shorthand.

A drawing worked out by an engineer, having engineering ideas, for the engineering purpose, is an engineering drawing. It is the universal graphic language of engineers, a world language, a language of use and ever increasing value. It is spoken, read and written in its own way. Every language has its own rules of grammar. Engineering drawing also has been devised according to certain rules. It has its grammar in the theory of projection, its idioms in conventionalized practices, its punctuations in the type of lines, its abbreviations, symbols, and its description in the construction. As the bad language is unpleasant to a master in die language, a wrong drawing will worry a trained eye of drawing. We have to learn to write a language so that we may be able to read it. If we known how to draw a drawing then we will be able to read and explain it. The knowledge of the drawing is the most important requirement of all the technical persons to work in an engineering occupation.

Machine Drawing is one of the parts of engineering drawing pertaining to the drawing of machines. Mechanical engineers are mainly concerned with the machine drawing.

Technical drawing is also a graphic language rightly applied to a drawing used to express technical ideas.

Sketching is the freehand expression of the graphic language. Sketching is the most important tool for the engineers engaged in technical work. Technical ideas can be expressed quickly and effectively by the sketches without the use of instruments.

An engineer expresses his ideas of mind on the paper through the medium of drawing. A complete working drawing of a job is prepared. It is then followed by the workers who give accurate shape of the raw materials according to the drawing. If the engineer commits a little error in the initial drawing work, it is carried over in the practical work by the workers resulting in loss of time, money, material and labor and finally the production efficiency of the factory will decrease. Therefore, it is extremely important for the engineers, designers, supervisors, draughtsman, mechanics and other workers engaged in production to have a thorough knowledge of engineering drawing.

Correct foundations for engineering drawing :

By means of drawing, the shape, size, finish, color and construction of any object can be described accurately and clearly in a simplest and shortest way. The best result can be obtained if we gain and develop some steps such as:

1. Understanding of original drawing.
2. Ability to think in three dimensions of the job seeing its different views.
3. A clear conception and appreciation of the shape, size, proportion and design.
4. Expressing power of ideas of mind on the, paper quickly and clearly by sketches.
5. Speed and accuracy of the drawing work using pencil and other drawing instruments.
6. Interest in the drawing work.

We should create interest in the drawing work so that we may learn it easily. Quick understanding of an original drawing, really visualizing of a finished job from a look at the drawing, the power of making quickly sketches all these can be achieved if we are interested in the drawing. Clear conception and appreciation of the job can be achieved by seeing the job and the drawing of the job. The shape, size and construction of the job can be easily understood by the drawing if we see the job at the same time. If we understand the drawing of the job, we can express our ideas by sketches. Accuracy and speed are developed by practice. Accuracy in the drawing must come first, quality must come before quantity. Pencil and all the drawing instruments should be kept in good conditions so that they may give maximum working efficiency. Every care should be taken to improve the quality of the drawing.

Classification Of Drawing:

The drawing may be classified into two distinct categories:

1. Artist drawing (Freehand or Model Drawing)
2. Engineering Drawing (Projection Drawing)

Artist' drawing is the drawing or art of a person who draws sketches of a job by his imagination or keeping the job before him. The artist tries to produce the job in the shape of a picture. He is so perfect in his art that tic can prepare the picture of a job by imagination without measuring the size and picture looks quite proportionate. He requires only his pen or pencil and paper to prepare the picture. Dimensions and other details are not given in it, however, one can appreciate the shape and size of the jot), It is not a simple drawing. One requires a great practice to prepare it. Everybody can understand and like this pictorial drawing.

Engineering drawing has already been described in Art. It cannot be understood by every person; even the artist cannot understand it. It is the graphic language of engineers and those trained to read and write, it can understand it. Dimensions and other details are also given in this drawing without which it is incomplete. Different views of a job are drawn for the clarification.

Drawing Instruments:

A neat and correct drawing is prepared with the help of good drawing instruments, the list of which is given below:

1. Drawing board and stand.
2. Tee Square (T-Square) or Mini Drafter.
3. Set-squares, protractor and clinograph.
4. Instrument Box.
5. French curves or irregular curves.
6. Pencils.
7. Rubber or eraser and erasing shield.
8. Blade, pocket knife or-pencil sharpener.
9. Drawing pins, adhesive tape or clips.
10. Drawing paper or drawing sheet, tracing paper, tracing cloth.
11. Handkerchief, duster or dusting brush.
12. Sand paper No. 0
13. Scales (cardboard scales or engineering scales).
14. Drawing ink.

To record information on paper or another surface, instruments and equipments are needed. Engineering drawing is entirely a graphic language hence instruments are essentially needed. Even for freehand drawing, pencils, erasers and sometimes coordinate paper are used. To secure most satisfactory result in drawing, the instruments should be of high grade, and correct to give accuracy and working efficiency.

Types of lines include the following:

visible – are continuous lines used to depict edges directly visible from a particular angle.

hidden – are short-dashed lines that may be used to represent edges that are not directly visible.

center – are alternately long- and short-dashed lines that may be used to represent the axes of circular features.

cutting plane – are thin, medium-dashed lines, or thick alternately long- and double short-dashed that may be used to define sections for section views.

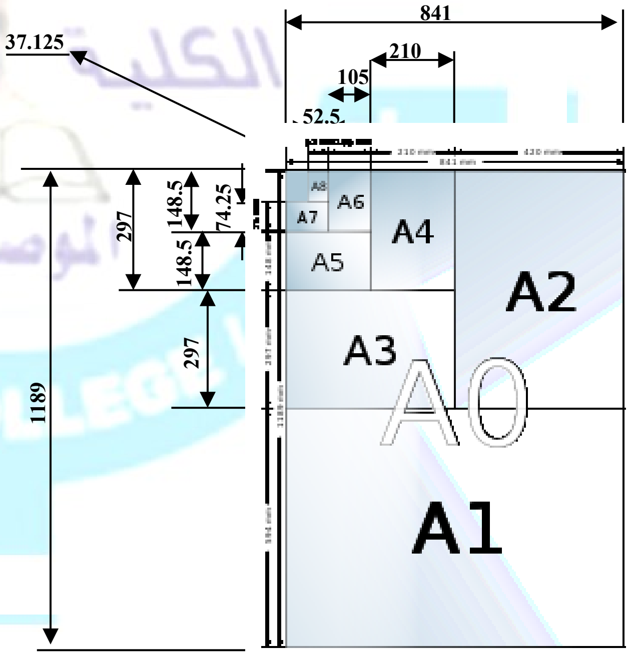
section – are thin lines in a pattern (pattern determined by the material being "cut" or "sectioned") used to indicate surfaces in section views resulting from "cutting." Section lines are commonly referred to as "cross-hatching."

Sizes of drawings :

Sizes of drawings typically comply with either of two different standards, ISO (World Standard) or U.S. customary, the ISO according to the following tables:

ISO paper sizes

ISO A Drawing Sizes	
A4	210 X 297
A3	297 X 420
A2	420 X 594
A1	594 X 841
A0	841 X 1189



ISO paper sizes

Layout of Drawing Sheets :

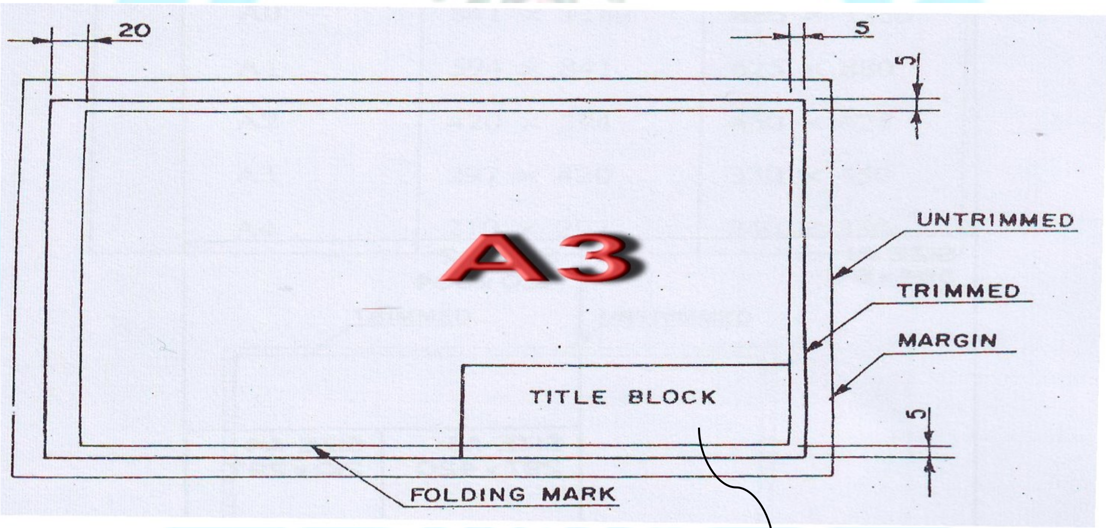
Layout should facilitate the reading of drawing and make it possible for essential references to be located easily, especially when drawings are prepared by several offices. A standard arrangement ensures that all necessary information is included and sufficient extra margin is left to facilitate filing and binding wherever necessary.

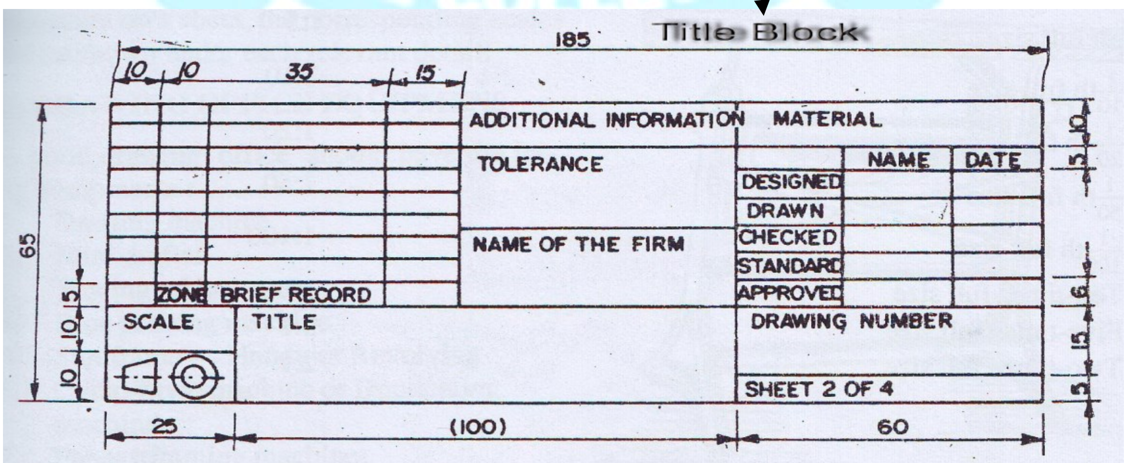
Margin: The provision of a margin will enable prints to be trimmed. Prints after trimming will be to the sizes of trimmed sheets. The margins for different sizes of drawing sheets are shown in Fig below the dimensions are derived from the standard sizes of the drawing sheet.

Title Block: The title block is an important feature in a drawing and should be placed at the bottom hand corner of the sheet where it is readily seen when the prints are folded in the prescribed manner. Recommended that shape should be provided for the following basic information in the title block :

1. Name of title of drawing.
2. Drawing and sheet number.
3. Scale.
4. Symbol denoting the method of projection.
5. Name of the firm, and
6. Dated initials of staff designing, drawing, checking, and standards and approving.

The size of the title recommended is 185 x 65 mm. The size of the title block is uniform for all sizes. -I layouts of title block are shown in Fig below





General Engineering Drawing. The **scales** recommended for use in general drawings are given below :

(a) Engineering Scales - (IS : 1481-1961):

Full scale	*Reducing scales*	*Enlarging scales*
1:1	1:2	10:1
	1:2.5	5:1
	1:5	2:1
	1:10	
	1:20	
	1:50	
	1:100	
	1:200	

(b) Architectural Scales (IS : 1491 — 1959)

I : 1, 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500 and 1:1000

(c) Scales for Roads, Bridges, Railways, etc

1:1, 1:2, 1:5, 1:10, 1 -20, 1:50, 1:100, 1:200, 1:500, 1:1000 and 1:2000

Indication. For indicating the scale in the appropriate division of the title block, the method indicated below should be adopted.

Scale 1:1 Scale 1:5 Scale 5:1

If more than one detail drawn to different scales occurs on a sheet, the corresponding scales should be shown under each relevant detail.

Scales :

Introduction:

Drawings of very big objects cannot be prepared in full size because they would be too big to accommodate on the drawing sheet. Drawings of very small objects also cannot be prepared in full size because they would be too small to draw and to read. Hence a convenient scale is chosen to prepare the drawings of big as well as small objects in proportionately smaller or larger size. So the scales are used to prepare a drawing -at a full size, reduced size, or enlarged size.

Classification Of Scales :

Scales may be divided into the following categories:.

1. Plain scale.
2. Diagonal Scale.
3. Vernier scale.
4. Comparative scale.
5. Scale of chords.
6. Isometric scale.

Plain Scales :

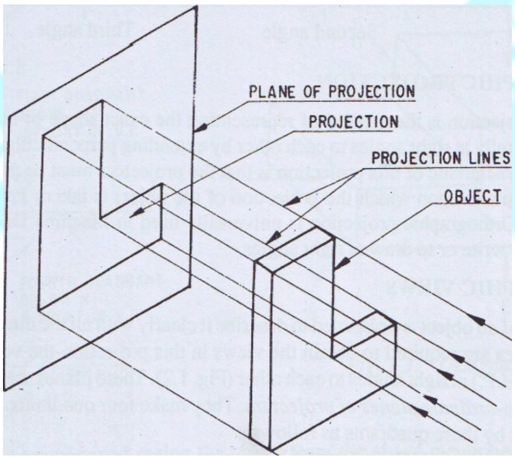
A plain scale represents either two units or only one unit and its fraction. It consists of a line divided into suitable number of equal parts or unit, the first of which is sub-divided into smaller parts. Ina a plain scale,

1. the zero is placed at the end of the first main division, i.e., between the units and its sub-units.
2. From the zero mark, the uni[t]s are numbered to the right and its sub-divisions to the left.
3. units of the divisions and stab-divisions arc stated below at the respective ends.
4. R.F. of the sc-ale. must be mentioned with it.
5. The length of the scale is obtained by the following formula:
6. Length of the scare = R.F. x maximum length to be measured by the scale.
7. If the maximum length to be measured by the scale is not given, take the length of the scale near about 15 cm.

Projection Methods :

As we know that engineering drawing is the graphic representation of a real thing, an engineer must stand the fundamental principles or grammar of the language and must be able to execute, the work reasonable skill. Practically, the drawing of an object is made up of a set of different views of the object taken by the observer from different positions and arranged to each other in a definite way by means projections.

Straight lines are drawn from the various points on the contour of an object to meet a plane, the obtained on the plane is called the Projection of the object. The object is said to be projected on the In other words, we can say that the projection of an object on a plane is the shadow of the object.

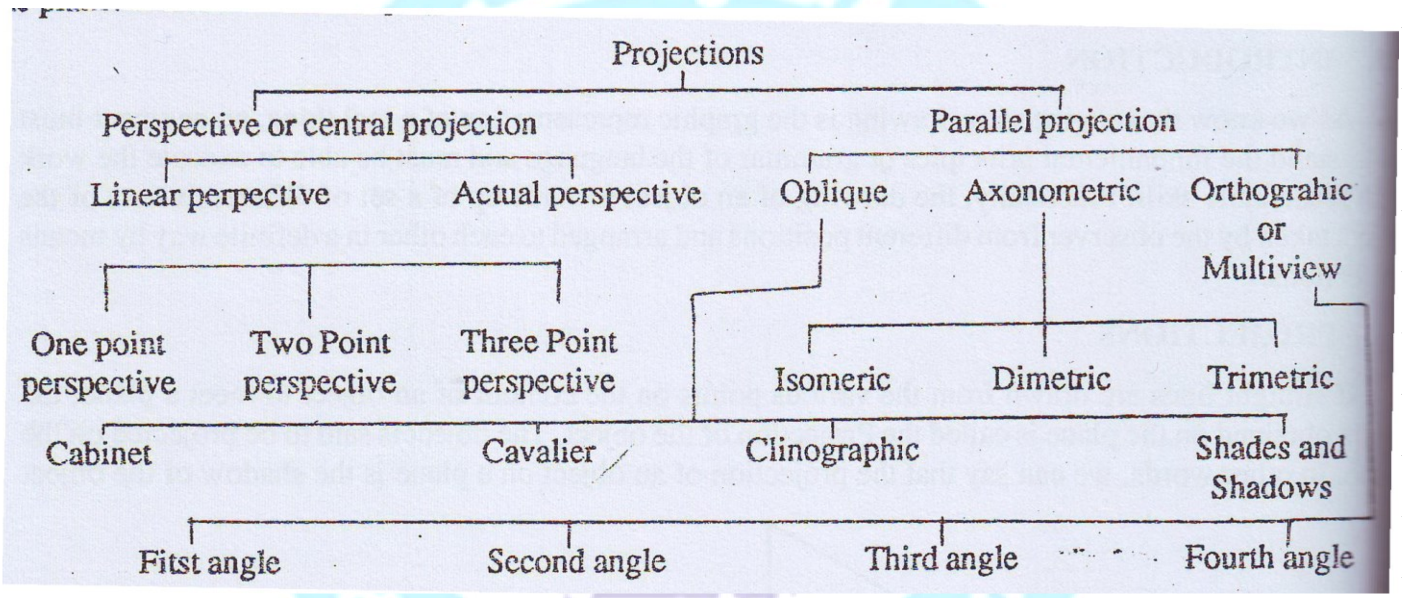


On the plane showing each and every edge line of the object. The imaginary lines drawn from the object plane are called projectors or projection lines. The plane on which the projection of the object is called Plane of projection. Suppose an object is placed in front of a screen and light thrown object (assuming the light ray's to be parallel to each other and perpendicular to the screen) then a true of the object is obtained on the screen. This shadow is the projection of the object on the plane of screen showing the contour lines of the object. Different views of an object can be &-awn by projections. Thus, every drawing of an object will have four imaginary things:

1. Object,
2. Projectors,
3. Plane of projection. and
4. Observer's eye or station point.

Classification of projections :

The projection or drawing upon the plane is produced by the piercing points of the projectors in the plane of projection; the projections are classified according to the method of taking tho projections on the plane. A classification of projections is shown below:



Orthographic Projection :

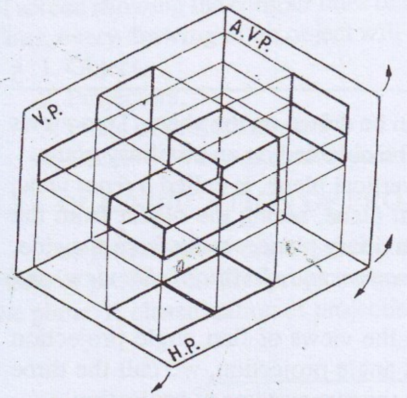
Orthographic, projection is the method of representing the exact shape of an object in two or m, views on planes generally at right angles to each other by extending perpendiculars from the object planes. The main characteristic of this projection is that the projectors must be parallel to each other and perpendicular to the plane upon which the projection of the object is taken. Projectors are assumed come from infinity. Orthographic projection is universally used in Machine Drawing. The word "Orthographic" means to write or to draw at right angles.

First angle Projection :

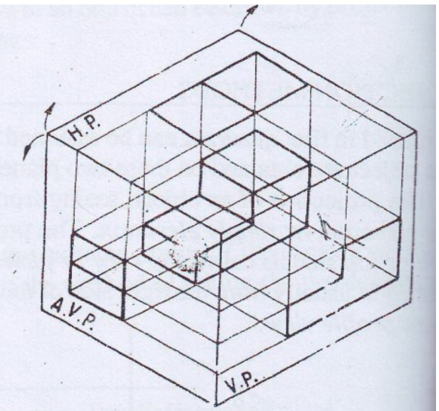
In the first angle system of projection the object is assumed to be placed in fast angle and projections are taken on V.P, H.P AND A.V.P. as follows:

1. Elevation - projected on V.P.
2. Plan-projected on H.P.
3. End view - projected on auxiliary vertical plane (right or left).

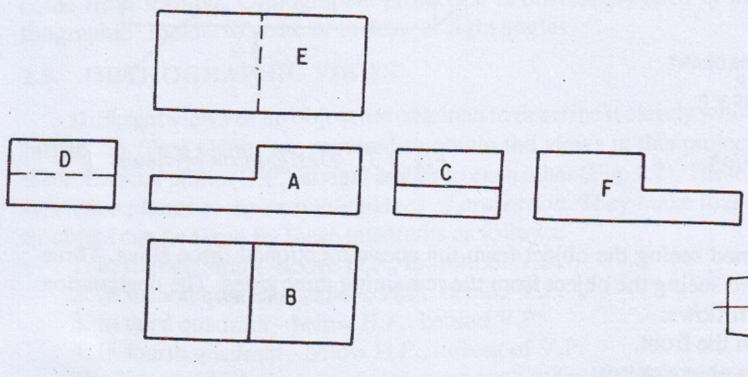
After taking the three views of the object, the horizontal and auxiliarly planes are rotated away from the object so shat they may come in the same vertical plane. Now, all the three views are in one plane surface and can be drawn on the drawing sheet.



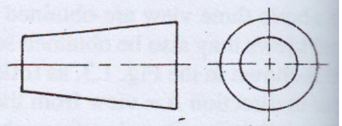
Object placed in first quadrant



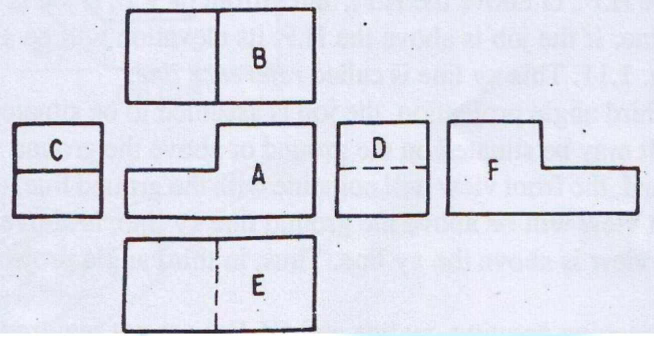
Object placed in third quadrant



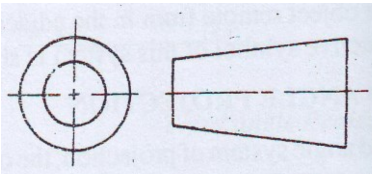
First angle Projection
Fig. 1.5.



Symbol of first angle projection.
Fig. 1.6



Third Angle Projection



Symbol of the third angle projection

Third Angle Projection :

In the third angle system of projection, the object is assumed to be placed in third angle and projections are taken on the V.P , H.P , A.V.P as follows:

1. Front view - Projected on V.P
2. Top view – Projected on H.P
3. Side view – projected on auxiliary plane (right or left).

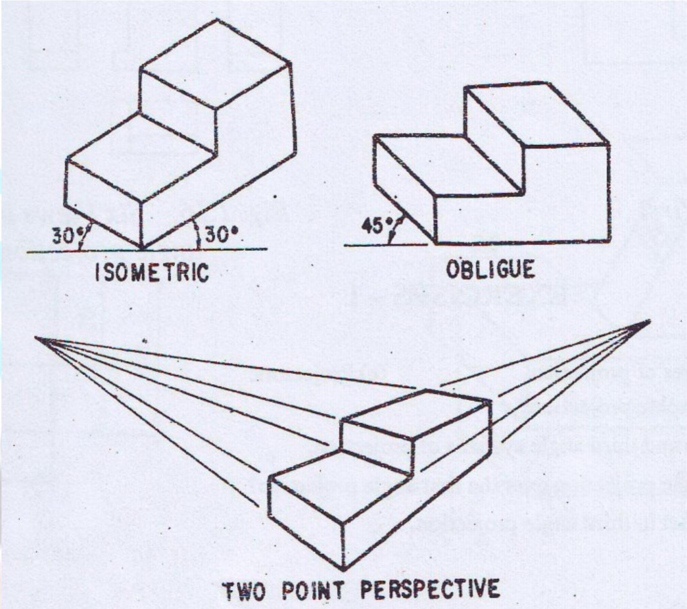
The planes of projection are assumed to be transparent to see the object through them and lie between the object and the observer. The auxiliary Plane is kept perpendicular to both the H.P. And V.P on the right or left side of the object.

Pictorial drawing :

It is the drawing of picture, a graphic language of engineers to represent a real thing by means of picture views. It shows the appearance of the object by one view only.

There are three methods of pictorial projections are commonly used in engineering drawing:

1. **Isometric projection.**
2. **Oblique projection.**
3. **Perspective projection.**



Dimensioning :

A drawing of an object is prepared to define its shape and to specify its size. The shape description is based on projection and size description on dimensioning. Dimensioning is the art by which the dimensions of an object arc written on its drawing. Every drawing must give its complete size description stating length, width, thickness, diameters of holes, grooves, angles, etc. and such other details relating to its construction. To give all those measurements and information describing the size of the object in the drawing is called dimensioning.

Placing of Dimensions :

Dimensions should be placed on the view which shows the relevant features most clearly. The two recommended systems of placing the dimensions are

(a) Aligned System. In this system, all dimensions are so placed that they may be read from the bottom or the right hand edge of the drawing sheet, and all dimensions should be placed above the dimension lines.

As far as possible, dimension lines should be drawn in accordance with Unidirectional System. In this system, all dimensions are so placed that they may be read from the bottom edge of the drawing sheet. In this system, they are no restriction controlling the direction of dimension lines. This system is advantageous on large drawings, where it is inconvenient to read dimensions from the right hand side.

General Principal of Dimensions:

1. As far as possible, all the dimensions for one particular operation shall be specified in one view only, such as diameter and depth of drilled hole, or size and depth of a threaded hole, etc.
2. Normally dimensions should be placed outside the views, but if it is not possible it may be placed within the view as shown in, however, dimensions should not be placed within a view unless drawing becomes clear by doing so. Dimensions should not be placed too close to each other or to the parts being dimensioned.
3. Dimensions are to be given from visible outlines, rather than from hidden lines, Dimensions are to be given from a base line, a centre line of a hole or cylindrical part an important hole or a finished surface which may N^{o}, readily established, based on design requirements and the relationship to other parts.
4. Dimensions for different operations on a part, for example, drilling and bending, should be given separately as **in**, if permissible by its design.
5. An axis or a contour line should never be used as a dimension line but may be used as a projection line.
6. The intersection of dimension line should be avoided as far as possible if, however, the intersection of two dimension lines is unavoidable, the, lines should not be broken. Dimension lines may be broken for inserting the dimension in the case of unidirectional dimensioning.
7. Overall dimensions should be placed outside the intermediate dimensions. Where **an** overall dimension is shown, one of the intermediate dimensions is redundant and should not be Dimensioned.

7. Post test:

a) **What is the definition of "Engineering Drawing", what is the foundations for Engineering drawing?**

b) **What is the types of lines? Also what is the basic conditions for section lines?**

c) **What is the projection, types of projections, first angle and 3rd angle projection?**

d) **What is the ISO Code of practice?**

e) **List the types of sheet layout with their dimensions?**

f) **Plot the title block with dimensions.**

g) **List the types dimensions.**

8. References:

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The Second week to fourth week

Screw threads, forms of screw thread, international metric threads (ISO screw), Common types of fasteners.

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Method of drawing (Hexagonal & Square headed bolts and nuts)

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Exercise

1. **Screw threads , Nuts, Forms and types of screw threads and types of nuts, ISO. Also Method of drawing (Hexagonal & Square headed bolts and nuts), with an exercise for these objects**
2. **Class: second year**
3. **Subject: general introduction for screw threads Drawing, and the basic definitions for screw threads also the correct manner for screw threads drawing. The common types for screw threads also the common types for bolts and nuts. With Method of drawing (Hexagonal & Square headed bolts and nuts)**
4. **Central idea: To make the students understanding all about the screw threads and their definitions also to teach the students all common types for screw threads and the common types for bolts and nuts with over view in details.. Also to teaching the mechanical drawing for all mentioned objects. Especially the method of drawing (Hexagonal & Square headed bolts and nuts)**
5. **Goals: To teach the students the correct drawing in mechanical drawings for common types of screw threads and bolt and nuts with overview for all these objects scientific subjects with enabling the students from drawing mechanical drawing for all mentioned objects.**
6. **Pre test:**

    a) **What is your expecting about the screw threads, and the definitions for screw threads characteristic ?**

    b) **What is your expecting about the common types for screw threads.**

    c) **What is the common types for bolts.**

    d) **What is the the common types for nuts?**

Screw thread :

Screw thread, used to convert torque into the linear force in the flood gate. The operator rotates the two long vertical bolts (via bevel gear).

Internal and external threads illustrated using a common nut and bolt. The screw and nut pair can be used to convert torque into linear force. As the screw (or bolt) is rotated, the screw moves along its axis through the fixed nut, or the non-rotating nut moves along the lead-screw.

A screw thread is a helical or tapered structure used to convert between rotational and linear movement or force.

Screw threads have several applications:

Fastening :

Fasteners such as wood screws, machine screws, nuts and bolts.

Connecting threaded pipes and hoses to each other and to caps and fixtures.

Gear reduction via worm drives

Moving objects linearly by converting rotary motion to linear motion, as in a screw jack.

Measuring by correlating linear motion to rotary motion (and simultaneously amplifying it), as in a micrometer.

Both moving objects linearly and simultaneously measuring the movement, combining the two aforementioned functions, as in a leadscrew.

In all of these applications, the screw thread has two main functions:

It converts rotary motion into linear.

It prevents linear motion without the corresponding rotation.

In most applications, the thread pitch of a screw is chosen so that friction is sufficient to prevent linear motion being converted to rotary, that is so the screw does not slip even when linear force is applied so long as no external rotational force is present. This characteristic is essential to the vast majority of its uses.

A screw thread may be thought of as an inclined plane wrapped around a cylinder or cone. The tightening of a fastener's screw thread is comparable to driving a wedge into a gap until it sticks fast through friction and slight plastic deformation.

Standard threads :

Standards for machine screw threads have evolved since the early nineteenth century to facilitate compatibility between different manufacturers and users. Many of these standards also specified corresponding bolt head and nut sizes, to facilitate compatibility between spanners and other driving tools.

Nearly all threads are oriented so that a bolt or nut, seen from above, is tightened (the item turned moves away from the viewer) by turning it in a clockwise direction, and loosened (the item moves towards the viewer) by turning anticlockwise. This is known as a right-handed thread. Threads oriented in the opposite direction are known as left-handed. There are also self-tapping screw threads where no nut is required.

Left-handed threads are used:

Where the rotation of a shaft would cause a conventional right-handed nut to loosen rather than to tighten due to fretting induced precession, e.g. on a left-hand bicycle pedal.

In combination with right-handed threads in turnbuckles.

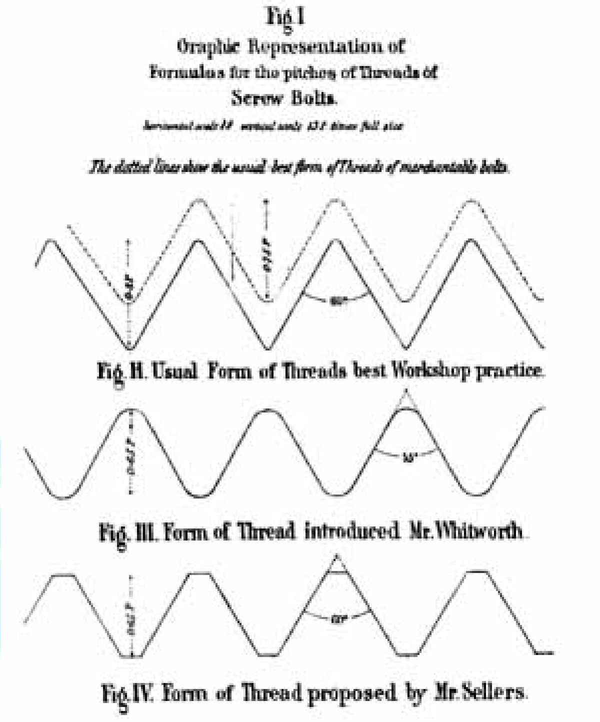
In some gas supply connections to prevent dangerous misconnections, for example in gas welding the flammable gas supply uses left-handed threads.

In some instances, for example early Biro (ballpoint) pens, to provide a "secret" method of disassembly.

In some applications of a leadscrew, for example the cross slide of a lathe, where it is desirable for the cross slide to move away from the operator when the leadscrew is turned clockwise.

Unless stated otherwise, all standards below specify right-handed threads.

History of standardization:

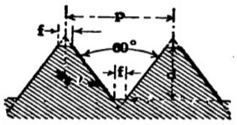


Graphic representation of formulas for the pitches of threads of screw bolts

The first historically important intra-company standardization of screw threads began with Henry Maudslay around 1800, when the modern screw-cutting lathe made interchangeable screws a practical commodity. During the next 40 years, standardization continued to occur on the intra-company and inter-company level. In 1841, Joseph Whitworth created a design that, through its adoption by many British railroad companies, became a national standard for the United Kingdom called British Standard Whitworth. During the 1840s through 1860s, this standard was often used in the United States and Canada as well, in addition to myriad intra- and inter-company standards. In April 1864, William Sellers presented a paper to the Franklin Institute in Philadelphia, proposing a new standard to replace the U.S.'s poorly standardized screw thread practice. Sellers simplified the Whitworth design by adopting a thread profile of 60° and a flattened tip (in contrast to Whitworth's 55° angle and rounded tip).[1][2] The 60° angle was already in common use in America,[3] but Sellers's system promised to make it and all other details of threadform consistent.

The Sellers thread, easier for ordinary machinists to produce, became an important standard in the U.S. during the late 1860s and early 1870s, when it was chosen as a standard for work done under U.S. government contracts, and it was also adopted as a standard by highly influential railroad industry corporations such as the Baldwin Locomotive Works and the Pennsylvania Railroad. Other corporations adopted it, and it soon became a national standard for the U.S.,[4] later becoming generally known as the United States Standard. Over the next 30 years the standard was further defined and extended and evolved into a set of standards including National Coarse (NC), National Fine (NF), and National Pipe Taper (NPT).

TABLE OF INTERNATIONAL STANDARD SCREW THREADS
DIMENSIONS IN MILLIMETERS



Formula { p = Pitch; d = Depth = p x .64952; f = Flat = $\frac{p}{8}$

Diam. of Screw	Pitch	Diam. of Screw	Pitch	Diam. of Screw	Pitch	Diam. of Screw	Pitch
6	1.00	18	2.50	39	4.00	68	6.00
7	1.00	20	2.50	42	4.50	72	6.50
8	1.25	22	2.50	45	4.50	76	6.50
9	1.25	24	3.00	48	5.00	80	7.00
10	1.50	27	3.00	52	5.00	88	7.50
11	1.50	30	3.50	56	5.50	96	8.00
12	1.75	33	3.50	60	5.50	116	9.00
14	2.00	36	4.00	64	6.00	136	10.00
16	2.00						

The ' International Standard" is the same, with modifications noted, as that now in general use in France.

International Standard Threads:

At the "Congress International pour L 'Unification des Filet ages", held in Zurich, October 24, 1898, the following resolutions were adopted:

1. The Congress has undertaken the task of unifying the threads of machine screws. It recommends to all those who wish to adopt the metric system of threads to make use of the proposed system. This system is the one which has been established by the "Society for the Encouragement of National Industries," with the following modification adopted by this Congress.
2. The clearance at the bottom of thread shall not exceed TI_C part of the bight of the original triangle. The shape of the bottom of the thread resulting from said clearance is left to the judgment of the manufacturers. However, the Congress recommends rounded profile for said bottom.
3. The table for Standard Diameters accepted is the one which has been proposed by the Swiss Committee of Action. (This table is given above.) It is to be noticed especially that r.25 mm. pitch is adopted for 8 mm. diameter, and 1.75 mm- pitch for 12 mm. diameter. The pitches of sizes between standard sated in the table are to be the same a-, for the next smaller standard diameter.

For a good summary of screw thread standards in current use in 1914, see Colvin FH, Stanley FA (eds) (1914): American Machinists' Handbook, 2nd ed. New York and London: McGraw-Hill, pp. 16-22.

During this era, in continental Europe, the British and American threadforms were well known, but also various metric thread standards were evolving, which usually employed 60° profiles. Some of these evolved into national or quasi-national standards. They were mostly unified in 1898 by the International

Congress for the standardization of screw threads at Zurich, which defined the new international metric thread standards as having the same profile as the Sellers thread, but with metric sizes. Efforts were made in the early 20th century to convince the governments of the U.S., UK, and Canada to adopt these international thread standards and the metric system in general, but they were defeated with arguments that the capital cost of the necessary retooling would damage corporations and hamper the economy. (The mixed use of dualling inch and metric standards has since cost much, much more, but the bearing of these costs has been more distributed across national and global economies rather than being borne up front by particular governments or corporations, which helps explain the lobbying efforts.)

During the late 19th and early 20th centuries, engineers found that ensuring the reliable interchangeability of screw threads was a multi-faceted and challenging task that was not as simple as just standardizing the major diameter and pitch for a certain thread. It was during this era that more complicated analyses made clear the importance of variables such as pitch diameter and surface finish. Classes of fit were standardized, and new ways of generating and inspecting screw threads were developed (such as production thread-grinding machines and optical comparators).

Problems with lack of interchangeability among American, Canadian, and British parts during World War II led to an effort to unify the inch-based standards among these closely allied nations, and the Unified Thread Standard was adopted by the Screw Thread Standardization Committees of Canada, the United Kingdom, and the United States on November 18, 1949 in Washington, D.C., with the hope that they would be adopted universally. (The original UTS standard may be found in ASA (now ANSI) publication, Vol. 1, 1949.) UTS consists of Unified Coarse (UNC), Unified Fine (UNF), Unified Extra Fine (UNEF) and Unified Special (UNS). The standard was not widely taken up in the UK, where many companies continued to use the UK's own British Association (BA) standard.

However, internationally, the metric system was eclipsing inch-based measurement units. In 1947, the International Organization for Standardization (interlingually known as ISO) had been founded; and in 1960, the metric-based International System of Units (abbreviated SI from the French Système international) was created. With continental Europe and much of the rest of the world turning to SI and the ISO metric screw thread, the UK gradually leaned in the same direction. The ISO metric screw thread is now the standard that has been adopted worldwide and has mostly displaced all former standards, including UTS. In the U.S., where UTS is still prevalent, over 40% of products contain at least some ISO metric screw threads. The UK has completely abandoned its commitment to UTS in favour of the ISO metric threads, and Canada is in between. Globalization of industries produces market pressure in favor of phasing out minority standards. A good example is the automotive industry; U.S. auto parts factories long ago developed the ability to conform to the ISO standards, and today very few parts for new cars retain inch-based sizes, regardless of being made in the U.S.

ISO standard threads:

The most common threads in use are the ISO metric screw threads (M) and BSP threads also called G threads for pipes.

These were standardized by the International Organization for Standardization in 1947. Before that, there were separate metric thread standards used in France, Germany, and Japan, and the Swiss had a set of threads for watches.

Differentiation between bolt and screw :

Carriage bolt with square nut.

Structural bolt DIN 6914 with DIN 6916 washer and UNI 5587 nut.

A universally accepted distinction between a screw and a bolt does not exist.

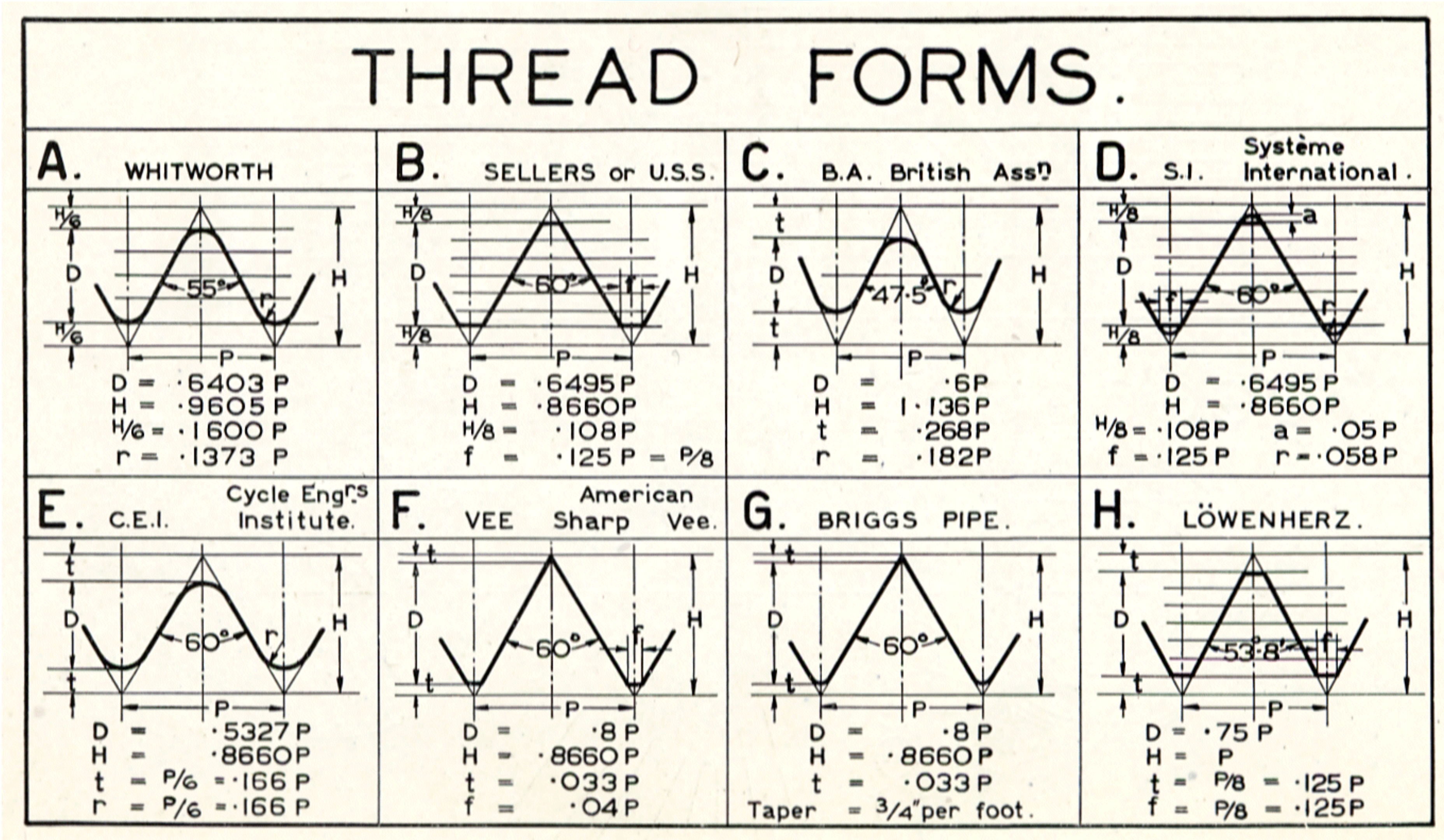
In common usage the term "screw" refers to smaller (less than 1/4 inch) threaded fasteners, especially threaded fasteners with tapered shafts and the term "bolt" refers to larger threaded fasteners that do not have tapered shafts. The term "machine screw" is commonly used to refer to smaller threaded fasteners that do not have a tapered shaft.

Various methods of distinguishing bolts and screws exist or have existed. These methods conflict at times and can be confusing. Old SAE and USS standards made a distinction between a bolt and a cap screw based on whether a portion of the shaft was un-threaded or not. Cap screws had shafts that were threaded up to the head and bolts had partially threaded shafts. Today a bolt that has a completely threaded shaft might be referred to as a "tap bolt".

ASME B18.2.1 defines a bolt as "an externally threaded fastener designed for insertion through the holes in assembled parts, and is normally intended to be tightened or released by torquing a nut". Using this definition to determine whether a particular threaded fastener is a screw or a bolt requires that an assumption be made about the intended purpose of the threaded fastener and as a practical matter doesn't seem to be followed by most threaded fastener manufacturers. It also conflicts with common usage such as the term, "head bolt", which is a threaded fastener that mates with a tapped hole in an engine block and is not intended to mate with a nut.

It is possible to find other distinctions than those described above, but regardless of the particular distinction favored by an individual or standards body the use of the term "screw" or "bolt" varies. More specific terms for threaded fastener types that include the word “screw” or "bolt" (such as "machine screw" or "carriage bolt") have more consistent usage and are the common way to specify a particular kind of fastener.

The US government made an effort to formalize the difference between a bolt and a screw because different tariffs apply to each. The document seems to have no significant effect on common usage and does not eliminate the ambiguous nature of the distinction for some fasteners. It is available


THREAD FORMS.
A. WHITWORTH
H/6 D H/6 55° r H P
D = ·6403 P
H = ·9605 P
H/6 = ·1600 P
r = ·1373 P
B. SELLERS or U.S.S.
H/8 D H/8 60° f H P
D = ·6495 P
H = ·8660 P
H/8 = ·108 P
f = ·125 P = P/8
C. B.A. British Assn.
t D t 47·5° r H P
D = ·6 P
H = 1·136 P
t = ·268 P
r = ·182 P
D. S.I. Système International.
H/8 a D f 60° r H H/8 P
D = ·6495 P
H = ·8660 P
H/8 = ·108 P a = ·05 P
f = ·125 P r = ·058 P
E. C.E.I. Cycle Engrs. Institute.
t D t 60° r H P
D = ·5327 P
H = ·8660 P
t = P/6 = ·166 P
r = P/6 = ·166 P
F. VEE American Sharp Vee.
t D t 60° f H P
D = ·8 P
H = ·8660 P
t = ·033 P
f = ·04 P
G. BRIGGS PIPE.
t D t 60° H P
D = ·8 P
H = ·8660 P
t = ·033 P
Taper = 3/4" per foot.
H. LÖWENHERZ.
t D t 53°8' f H P
D = ·75 P
H = P
t = P/8 = ·125 P
f = P/8 = ·125 P

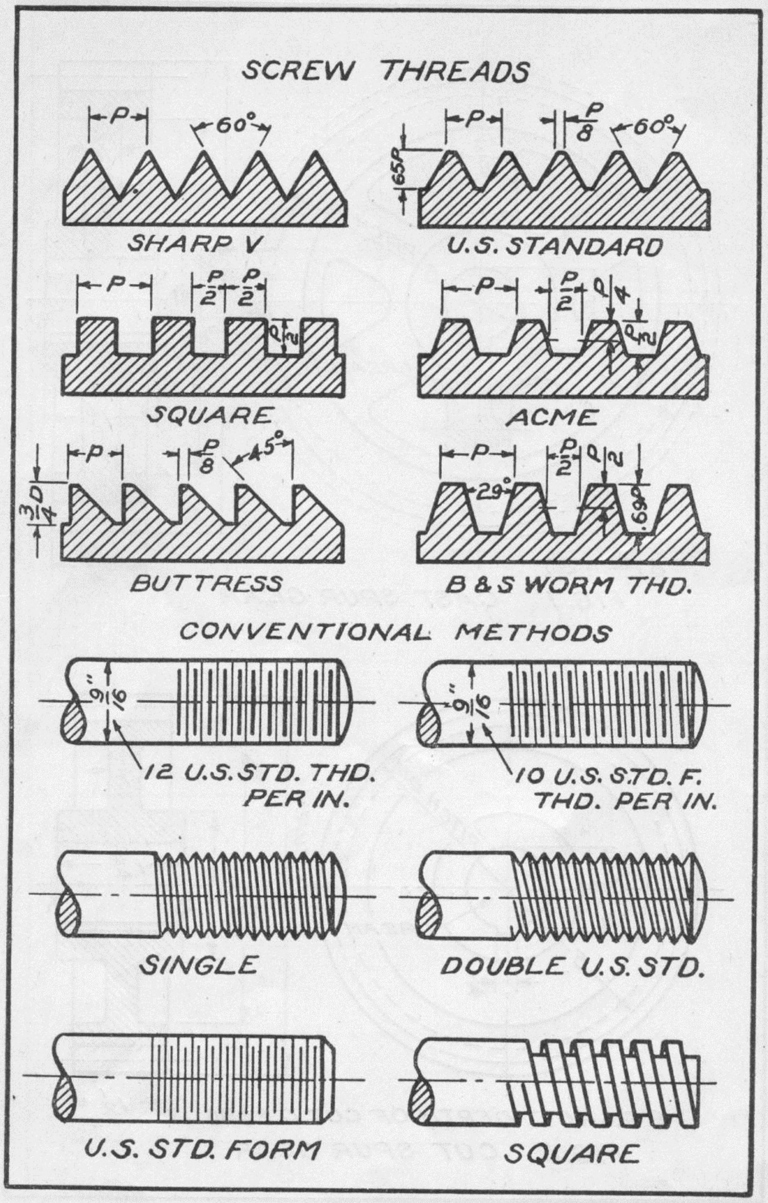


PLATE 13

28

Other current standards :

In particular applications, largely for reasons of backwards compatibility, threads other than the ISO metric threads remain commonly used. These include:

Unified Thread Standard, (UTS), which is still in common use in the United States and Canada. This standard includes:

Unified Coarse (UNC)

Unified Fine (UNF)

Unified Extra Fine (UNEF)

Unified Special (UNS)

National pipe thread (NPT)

British Standard Whitworth (BSW), and for other Whitworth threads including:

British Standard Fine (BSF)

Cycle Engineers' Institute (CEI)

British standard pipe thread (BSP)

British Standard Pipe Taper (BSPT)

British Association screw threads (BA), primarily electronic/electrical, moving coil meters and to mount optical lenses

Camera case screws, used to mount a camera on a photographic tripod:

¼″ British Standard Whitworth (BSW) used on almost all small cameras

⅜″ BSW for larger (and some older small) cameras

Royal Microscopical Society (RMS) thread, a special 0.8"-36 thread used for microscope objective lenses.

Microphone stands:

⅝″ 27 threads per inch (tpi) Unified Special thread (UNS, USA and the rest of the world)

¼″ BSW (not common in the USA, used in the rest of the world)

⅜″ BSW (not common in the USA, used in the rest of the world)

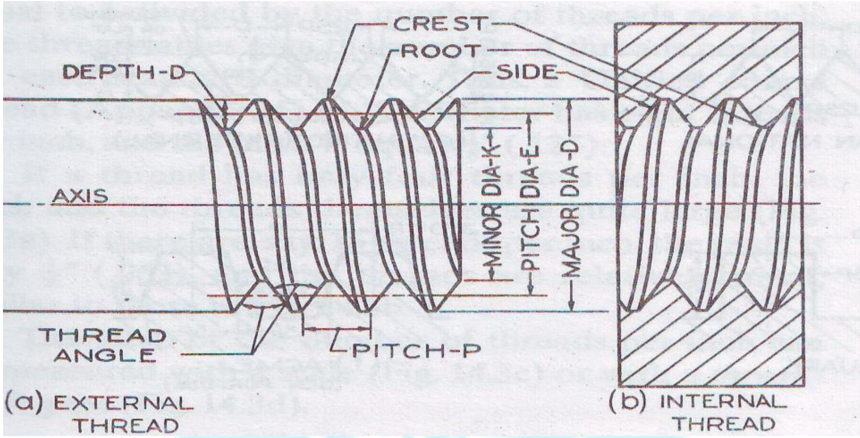
Stage lighting suspension bolts (in some countries only; some have gone entirely metric, others such as Australia have reverted to the BSW threads, or have never fully converted):

⅜″ BSW for lighter luminaries

½″ BSW for heavier luminaries

Panzergewinde (Pg) (also: Stahlpanzerrohr-Gewinde) is an old German 80° thread (DIN 40430) that remained in use until 2000 in some electrical installation accessories in Germany.

The Screw Threads Definitions :



Screw Threads A ridge of uniform section in the form of a helix on the external or internal surface of a cylinder.
External threads A thread on the outside of a member, as on a shaft.
Internal threads A thread on the inside of a member, as in a hole.
Major diameter The largest diameter of a screw thread (applies to both internal and external threads).
Minor diameter The smallest diameter of a screw thread (applies to both internal and external threads).
Pitch The distance from a point on a screw thread to a corresponding point on the next thread measured parallel to the axis. The pitch P is equal to 1 divided by the number of threads per inch.
Pitch diameter The diameter of an imaginary cylinder passing through the threads to make equal the widths of the threads and the widths of the spaces cut by the cylinder.
lead The distance a screw thread advances axially in one turn.
Angle of thread The angle included between the sides of the thread measured in a plane through the axis of the screw.

Crest The top surface joining the two sides of a thread.

Root The bottom surface joining the sides of two adjacent threads.

Side The surface of the thread that connects the crest with the root.

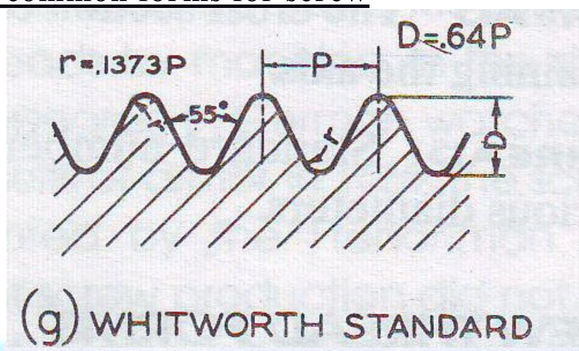
Axis OF Screw The longitudinal center line through the screw.
Depth of thread The distance between the crest and the root of the thread measured normal to the axis.
From of thread The cross section of thread cut by a plane containing the axis.
Series of threads Standard number of threads per inch for various diameters.

Various forms of threads are used to hold parts together, to adjust parts with reference to each other, or to transmit power (Fig. 14.2). The 60° Sharp-V thread was originally called the United States Standard thread, or the Sellers thread. For purposes of certain adjustments, the Sharp-V thread is useful with the increased friction resulting from the full thread face. It is also used on brass pipe work.

The following illustration considered the common forms for screw threads:

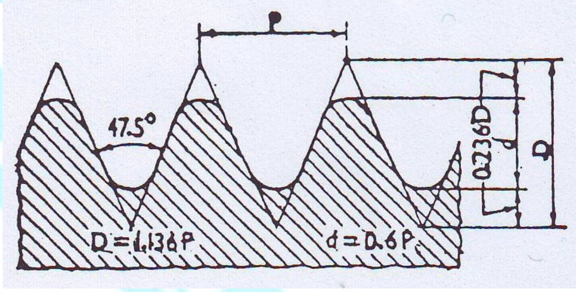
1. Witworth threads or B.S.W:

Was the British standard and has been replaced by the Unified thread. Its uses correspond to those of the American National thread.



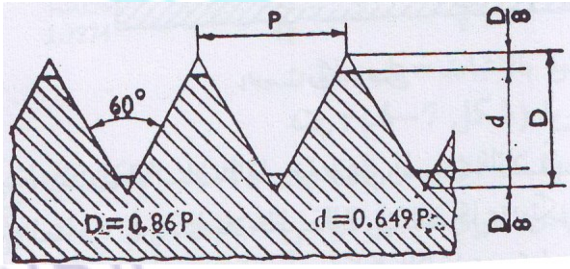
2. British association threads:

used for small screwed wormed machine threads.



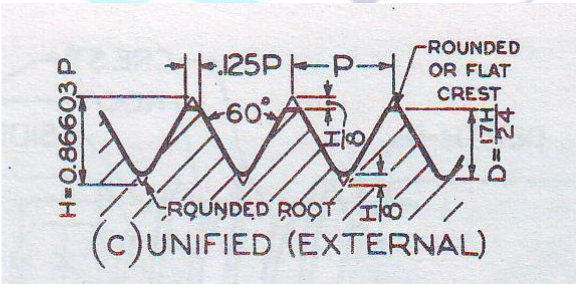
3. Seller thread

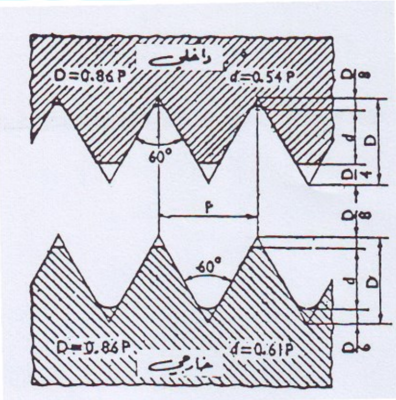
this type is considered as a standard type in united state of America.



4. Unified thread

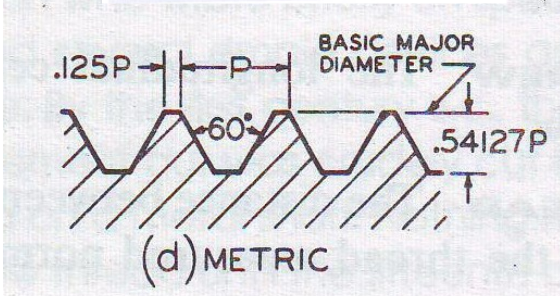
is the standard thread agreed upon by the United States, Canada, and Great Britain in 1948, and has replaced the American National form. The crest of the external thread may be flat or rounded, and the root is rounded; otherwise, the thread form is essentially the same as the American National



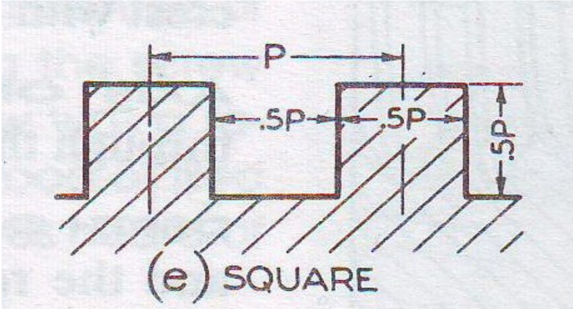


5. Metric thread

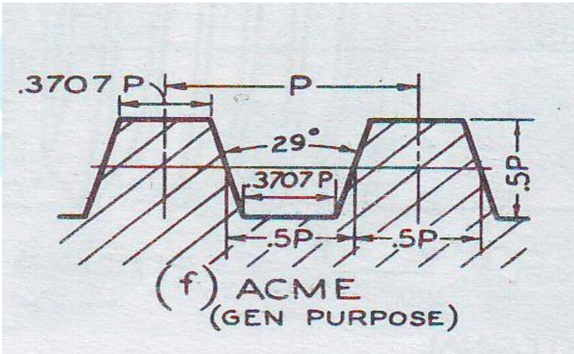
is the standard screw thread agreed upon for international screw thread fasteners. The crest and root are flat, but the external thread is often rounded if formed by a rolling process. The form is similar to the American National and Unified threads but with less depth of thread.



Square thread



is theoretically the ideal thread for power transmission, since its face is nearly at right angles to the axis, but due to the difficulty of cutting it with dies and because of other inherent disadvantages (such as the fact that split nuts will not readily disengage), the square thread has been displaced to a large extent by the Acme thread. The square thread is not standardized.

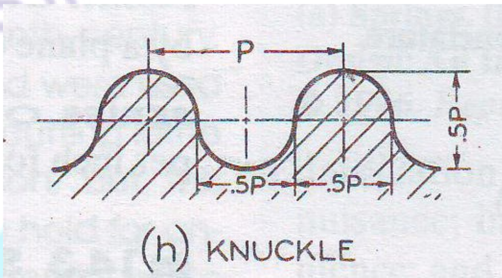


6. Acme thread

is a modification of the square thread and has largely replaced it. It is stronger than the square thread, is easier to cut, and has the advantage of easy disengagement from a split nut, as on the lead screw of a lathe.

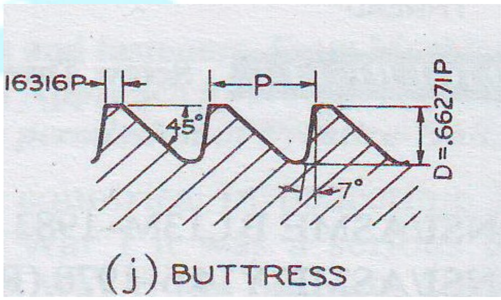
7. Knuckle thread

Is usually rolled from sheet metal but is sometimes cast; in modified forms it is used in electric bulbs and sockets, bottle tops, etc.



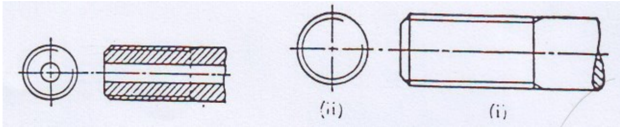
8. Buttress thread

is designed to transmit power in one direction only and is used in large guns, in jacks and in other mechanisms having similar high-strength requirements.

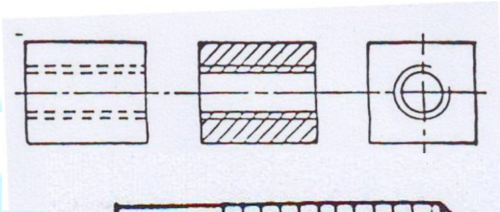


Conventional representation of thread:
First method:

1. Out thread

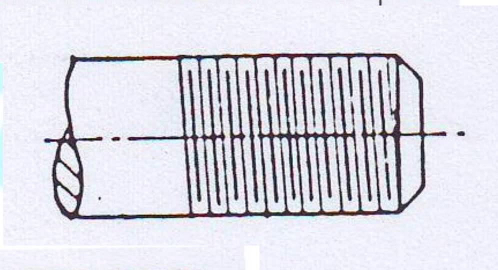


2. In thread

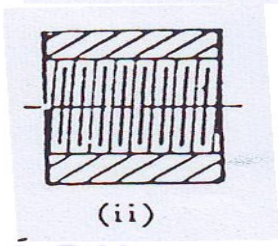


Second method:

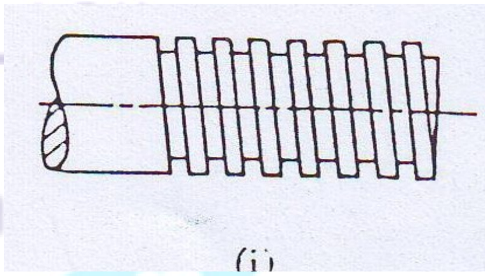
1. V- out thread



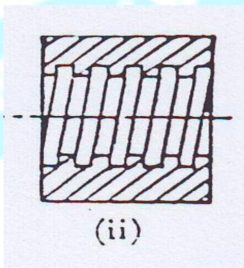
2. V- in thread



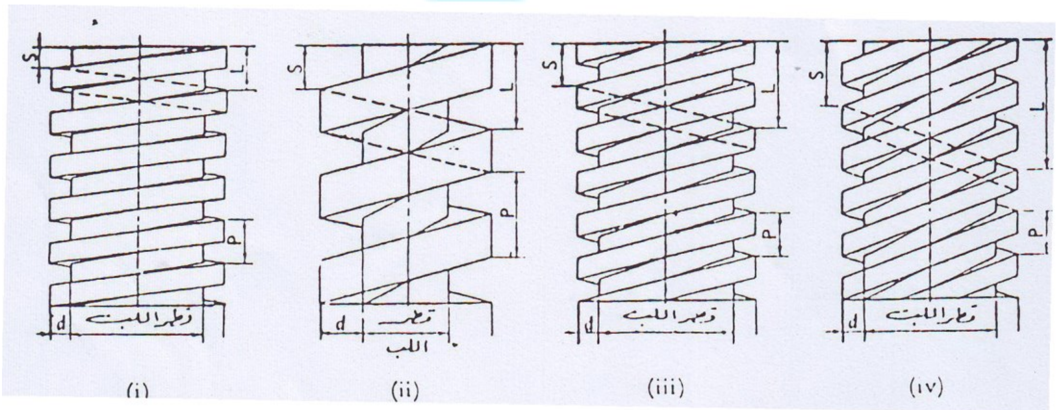
3. Square out thread



4. Square in thread



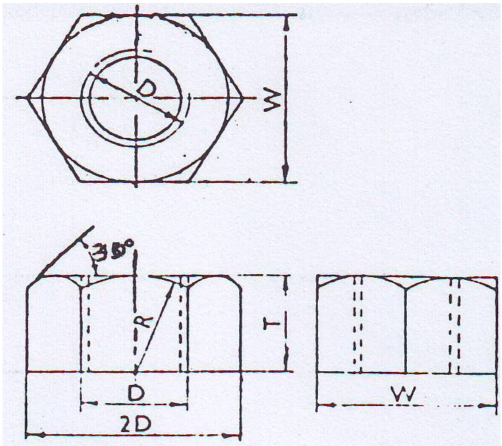
5. Multiple start thread



6. Right hand and lift hand

NUTS

1- Hexagonal Nut



Diameter = D

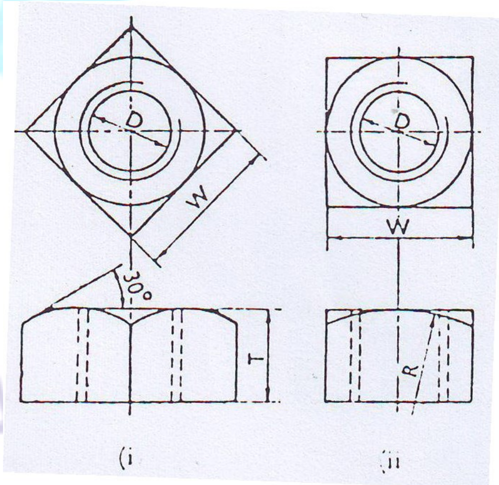
Thickness = T =D

Width = W = 1.5D + 3mm

Angle = 30 °

R = 1.4 D

2- Square Nut



Diameter = D

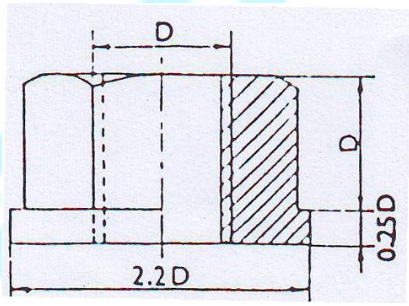
Thickness = T =D

Width = W = 1.5D + 3mm

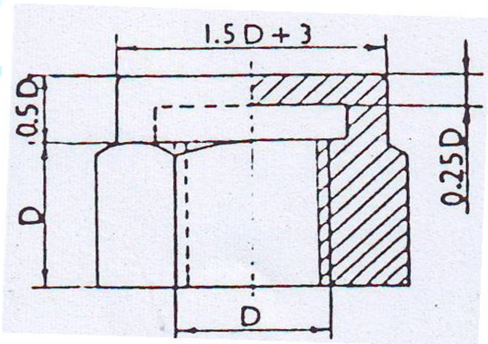
Angle = 30 °

R = 2D

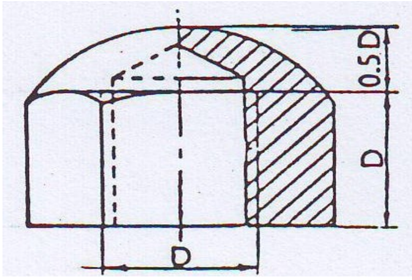
3- Flanged Nut



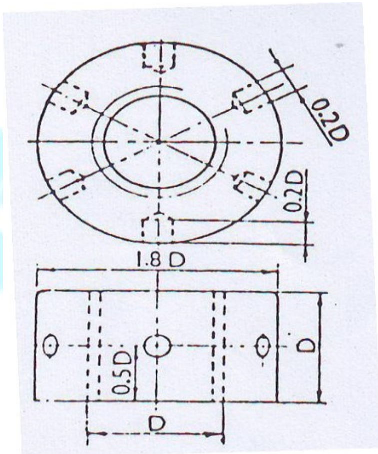
4- Cap Nut



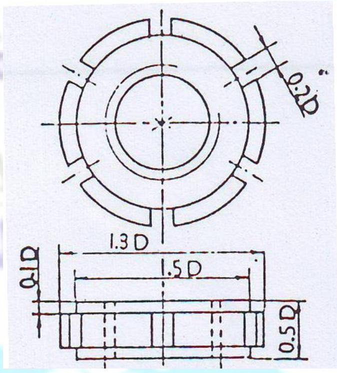
5- Dome Nut



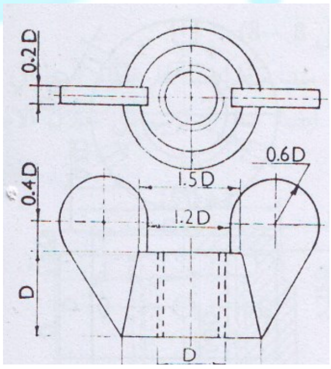
6- Cylindrical or capstan Nut



7- Ring Nut



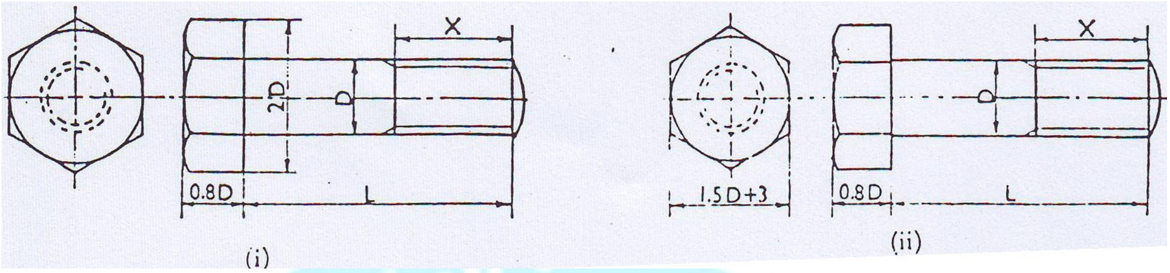
8- Wing Nut



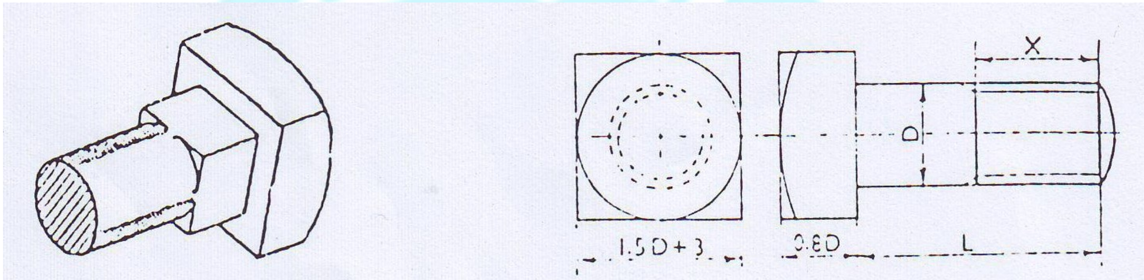
Bolts

Bolt consist of to parts which are; a head and a shank:

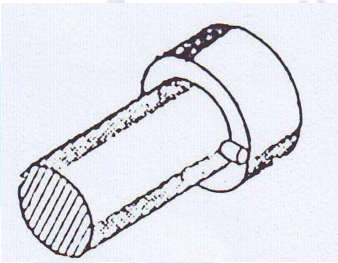
1. Hexagonal – headed bolt

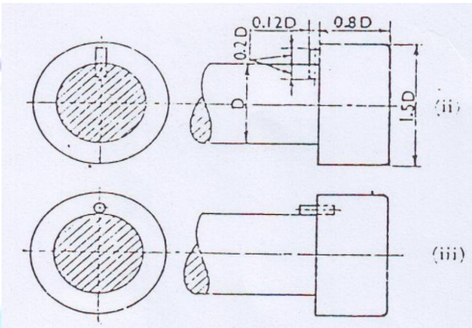


2. Square – headed bolt

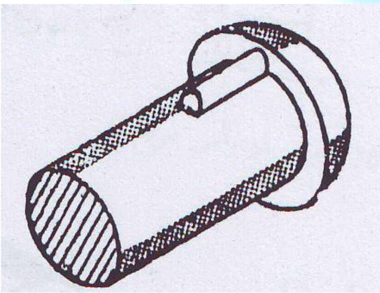


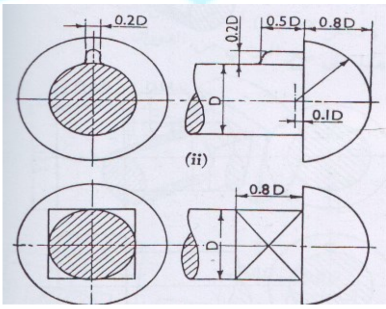
3. Cylindrical or Cheese- headed bolt



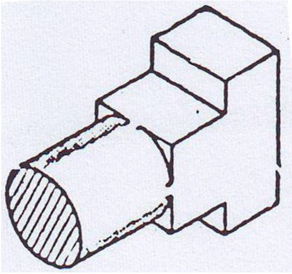


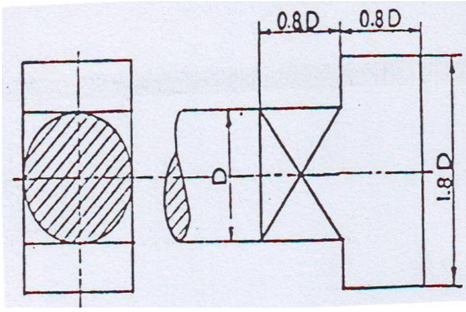
4. Cup – headed or round headed bolt



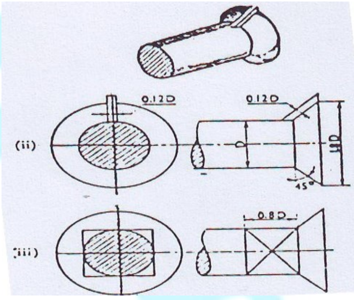


5. T – headed bolt

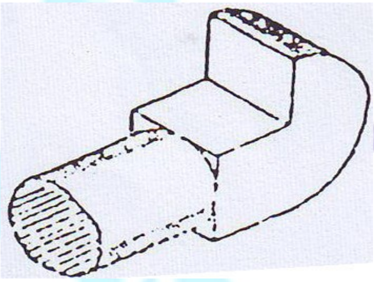


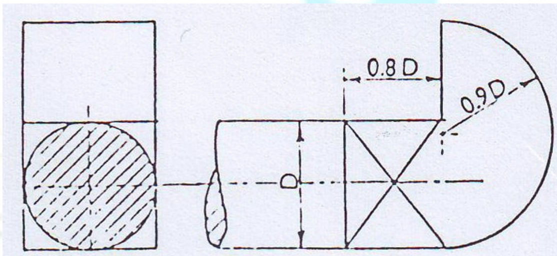


6. Counter sunk-headed bolt

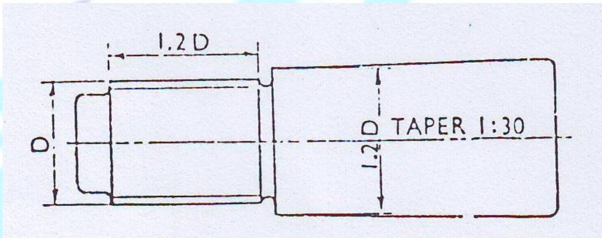


7. Hook bolt

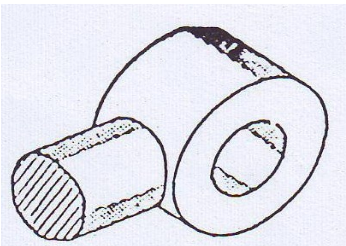


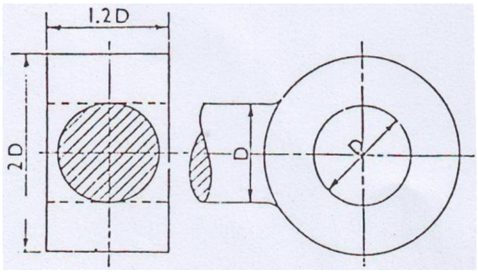


8. Headless tapered bolt

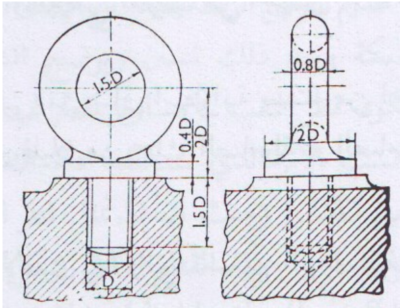


9. Eye – bolt

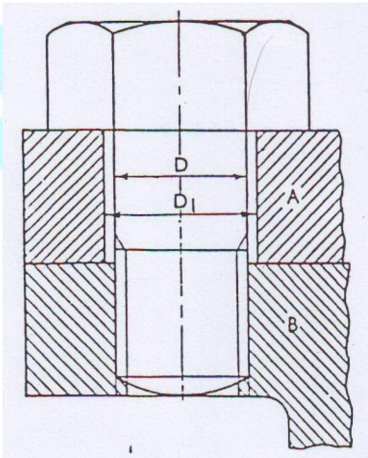




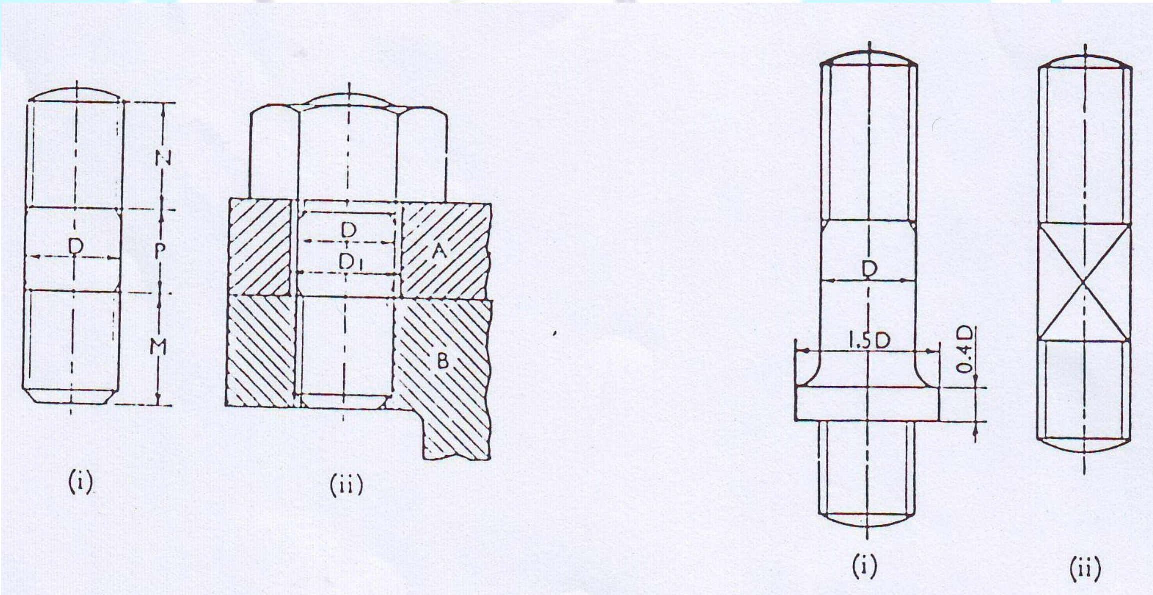
10.Lifting-eye bolt



11.Tap bolt or cap screw



12. Stud- bolt or stud



7. Post test:

h) What is the definition of "Screw Threads",

i) What are the common types of screw threads? Draw all types?

j) Also what are the common types of nuts?

k) What are the common types of bolts?

8. References:

1. R.B. Gupta, "Engineering Drawing and Graphics", effective 1993&other engg.exams.
2. N.D. Bhatt, "Machine Drawing", Twenty-Second Edition, (1991).
3. (1988) in Henry H. Ryffel (ed.): Machinery's Handbook 23rd Edition. New York: Industrial Press Inc. ISBN 0-8311-1200-X.
4. (2000) Witold Rybczynsky. One Good Turn: A Natural History of the Screwdriver and the Screw. Toronto: Harper Collins. ISBN 0-00-638603-2
5. ^ World Fastener Review, Industrial Press, 2006
6. ^ Stephanie Dalley and John Peter Oleson (January 2003). "Sennacherib, Archimedes, and the Water Screw: The Context of Invention in the Ancient World", Technology and Culture 44 (1).

The Fifth week

Keys, types of keys, spline shaft and hub.

1. **Keys, types of keys, spline shaft and hub with an explanation in details.**
2. **Class: second year**
3. **Subject: general introduction for Keys, types of keys, spline shaft and hub Drawing, and the basic definitions for Keys also the correct manner for Keys drawing. The common types for Keys also an explanation in details**
4. **Central idea: To make the students understanding all about the Keys, types of keys, spline shaft and hub concept, and the basic definitions for Keys also the correct manner for Keys drawing. The common types for Keys also an explanation in details Also to teaching the mechanical drawing for all mentioned objects.**
5. **Goals: To teach the students the correct drawing in mechanical drawings for common types of keys with overview for all types for these objects scientific subjects with enabling the students to design and draw mechanical drawing for all mentioned objects.**
6. **Pre test:**

   e) **What is your expecting about the keys, and the definitions for keys characteristic ?**

   f) **What is your expecting about the common types for keys.**

   g) **For what manner keys used.**

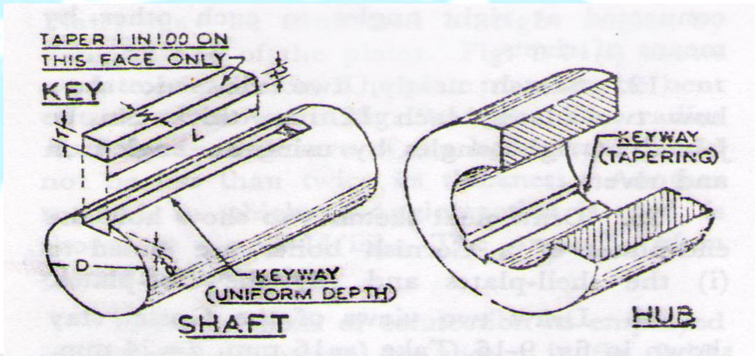
KEYS, COTTER – JOINTS, PIN – JOINTS

KEYS : Means used to connected two pieces , for ex. A shaft and a pulley in such away that there is no relation movement between them.

Keys may be divided into two main type:

1. <u>Taper keys(fig.1):</u>

- Uniform in width but tapered in thickness.
- The standard tapered is 1 in 100 .
- Prevent relative rotation and axial movement between the two pieces .



Key and keyways
FIG. 1

1.1 Sunk taper keys(fig.2) :

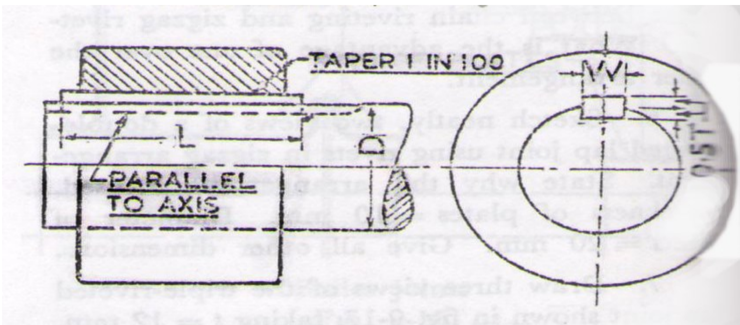
- May be either of rectangular or square cross- section.
- It is sunk in the shaft to a depth of on-half its nominal thickness.

approximate proportion of a sunk taper key of rectangular cross-section: (D)is the diameter of the shaft.

W=1/4 D + 2 mm …..(*Width of the key*)

T= 2/3 W …(*Thickness of the key*)

W = T (in the case of sunk key of square cross-section).

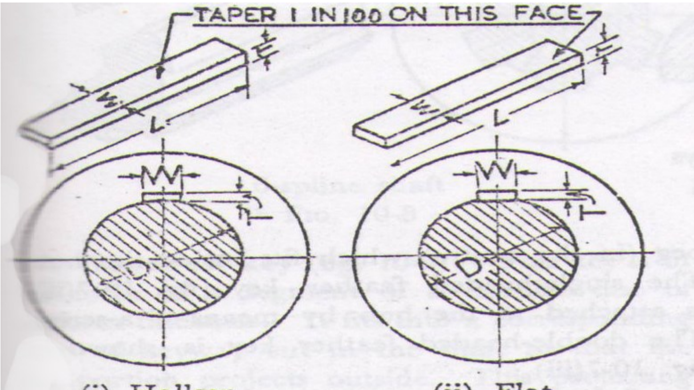


Sunk taper key
(First-angle projection)
FIG. 2

1.2 Saddle taper keys: there are two type

a) Hollow saddle keys(fig3i): has its under side hollow to fit the curved surface of the shaft, used when the power to be transmitted is small. W= 1/4 + 2mm and T = 1/3W

b) Flat saddle keys (Fig3ii): sits on a flat surface provided on the shaft, the resistance to slipping her is greater than the hollow saddle keys, and greater power to be transmitted.



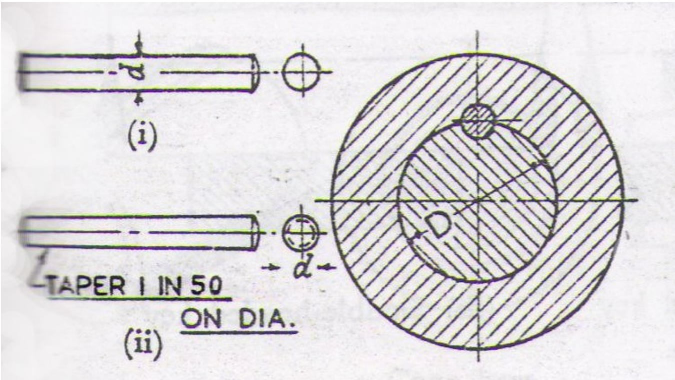
Saddle keys
FIG. 3

1.3 Round taper keys or pin taper keys (fig 4i) :

- It is a circular cross- section , and the diameter of the key is(d) .
- d = 1/6 D (D) is the diameter of the shaft .
- Driven in a hollow drilled partly in the shaft and partly in the mating piece.

1.4 Taper pin (4ii) :

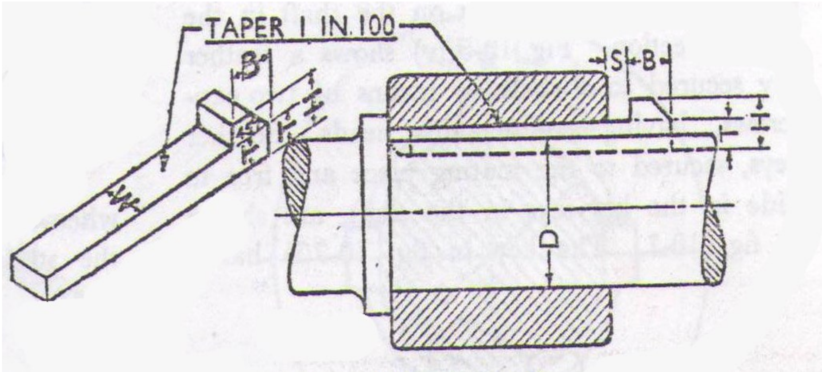
- Taper key of a circular cross- section .
- Has a standard tapered 1 in 50 on diameter
- (D) is diameter of shaft, (d) is diameter of key. d = 1/6 D



(i) Round key (ii) Taper pin
FIG. 4

1.4 Gib- head taper keys (fig.5) :

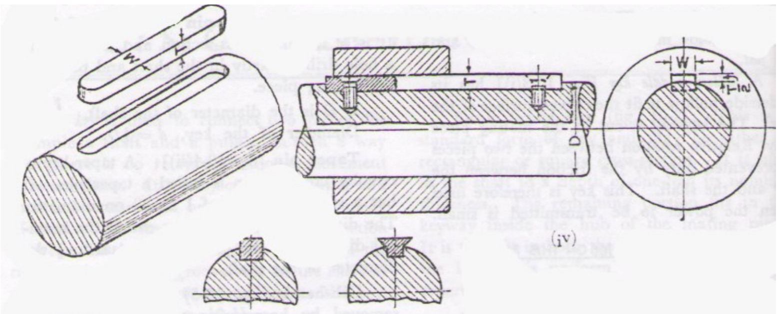
- Provided with the head to facilitate its remove .
- Remove by the hammering at its thinner end .
- H= 1.75T and B=1.5T and angle of chamfer=45^o



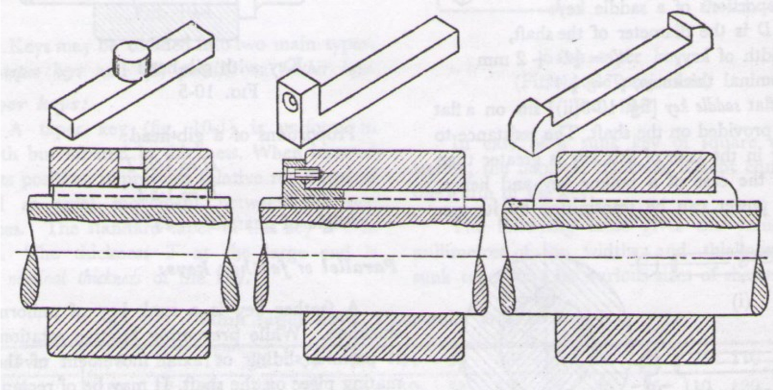
Key with gib-head
FIG. 5

2. **<u>Parallel or feather keys(fig. 6)(fig. 7):</u>**

- Is a sunk key of uniform thickness.
- Preventing relative rotation, permits sliding or axial movement of the mating piece on the shaft.
- It may be rectangular(fig.6i), square(fig.6ii), or dovetail(fig.6iii)
- Has a peg key(in the center),single and double-headed key(fig7)



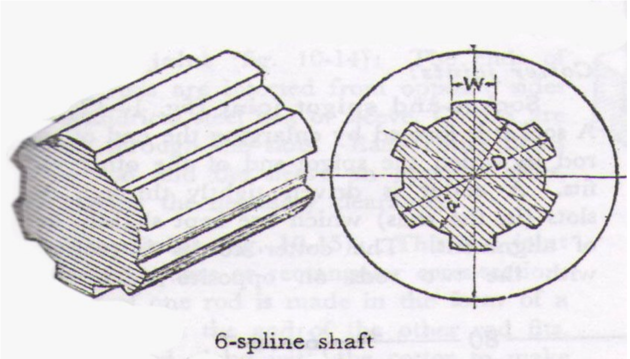
Feather keys
FIG. 6



(i) Peg key (ii) Single-headed key (iii) Double-headed key
Feather keys
FIG. 7

2.1 Spline shafts (fig. 8):

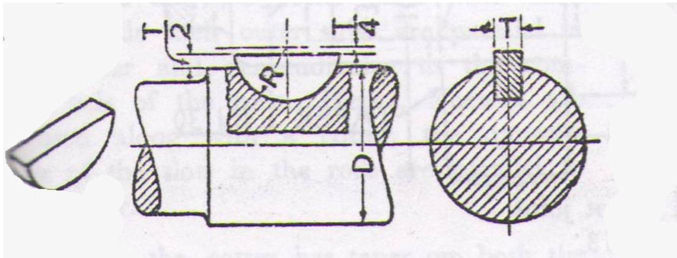
- Provided with the a corresponding number of keyways to mate with the spline shaft.
- Used when a single key is not sufficient to withstand the stresses.



6-spline shaft
FIG. 8

2.2 Woodruff key(fig. 9):

- This key is in the form of a segment of a circular disc of a uniform thickness.
- The shaft is weakened due to the comparatively greater depth of the keyway cut in it.

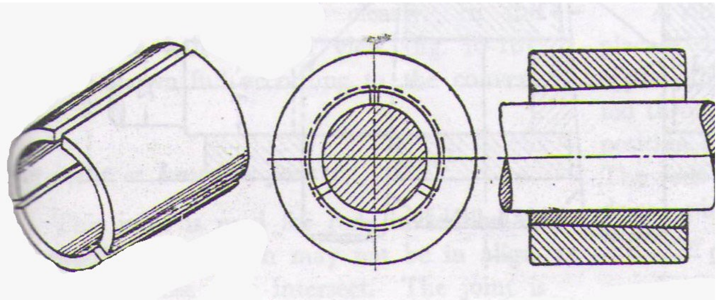


$$T = \frac{D}{6} \qquad R = 2T = \frac{D}{3}$$

Woodruff key
FIG. 9

2.3 Cone key (fig. 10):

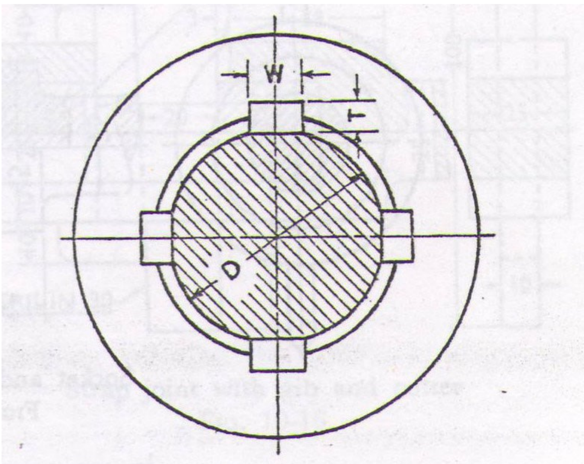
- There are three no. of segments, of a hollow bush.
- A pulley can be fitted on shafts of different diameter by varying the thickness of the cone keys.



Cone keys
FIG. 10

2.4 Staking-on (fig. 11):

- Fitted by the process of staking-on .
- No. of flat saddle key with gib-heads are used .



Staking-on
FIG. 11

COTTER: Is a flat, wedge-shaped piece of steel of rectangular cross-section (fig.12i) .

- Used to connected rigidly two rods subjected to tensile or compressive forces and is inserted at right angle to the axes of the rods.
- Uniform thickness but tapering width(1 in 30)on one side only.
- The thickness of the cotter [(T) = W/4] at the center.

1. Cotter joints :

1.1 socket and spigot joints(fig. 12ii)(fig 13):

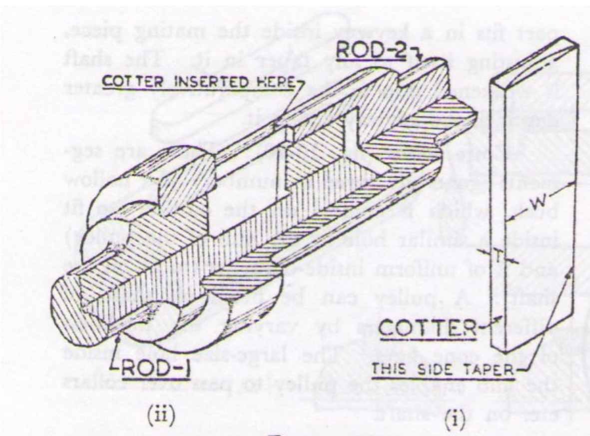
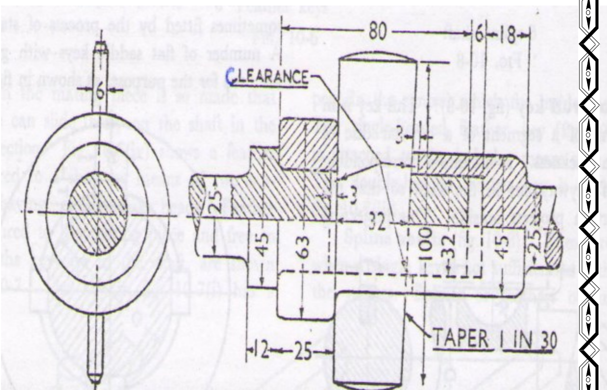
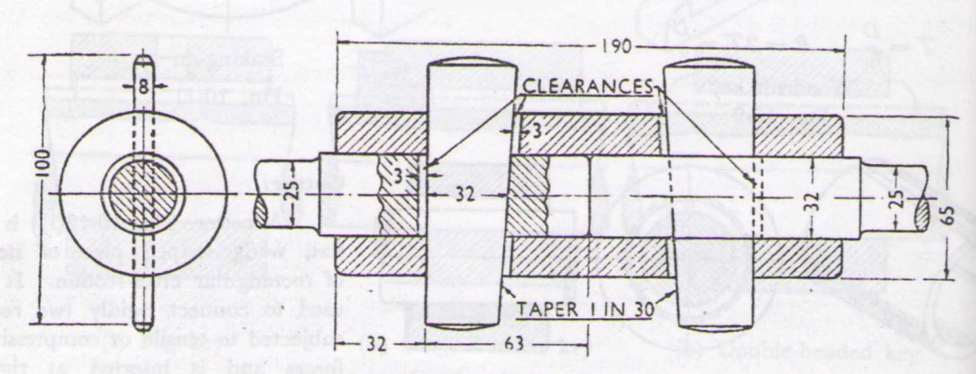


FIG. 12



Socket and spigot joint
FIG. 13

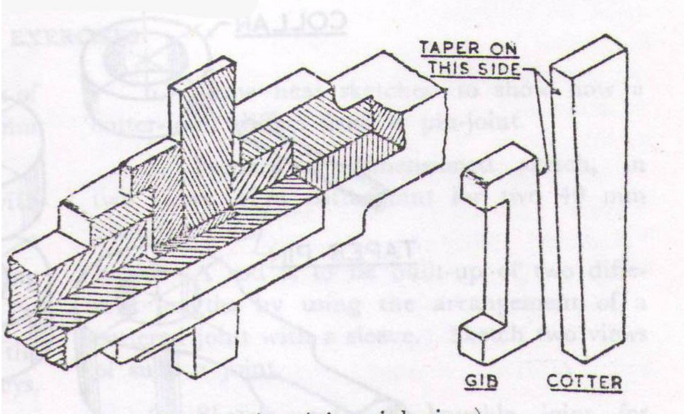
1.2 Sleeve joint(fig 14):



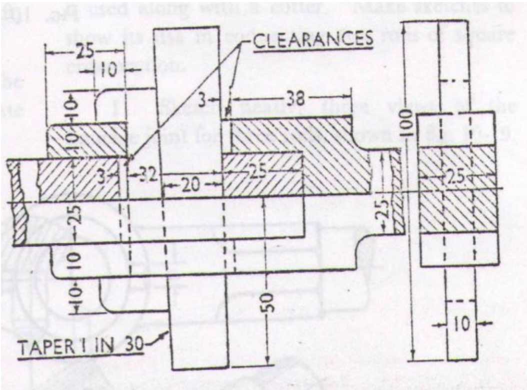
Cotter-joint with sleeve
FIG. 14

1.3 Strap joints(fig 15)(fig.16):

- Square or rectangular cross-section.
- A gib-head at its two end is used along with the cotter to make the joint.
- The depth and the width of the gib-head are usually kept equal to the thickness of the cotter .



Strap joint (pictorial view)
FIG. 15



Strap joint with gib and cotter
FIG. 16

Pin-joint or knuckle joint (fig.17) (fig.19): Used for rods in tension or compression and which may not be in alignment but whose axes intersect.

- The joint is not rigid .
- Permits angular movement between the rods.
- Commonly used when reciprocating motion is to be converted into a rotary motion or vice-versa.

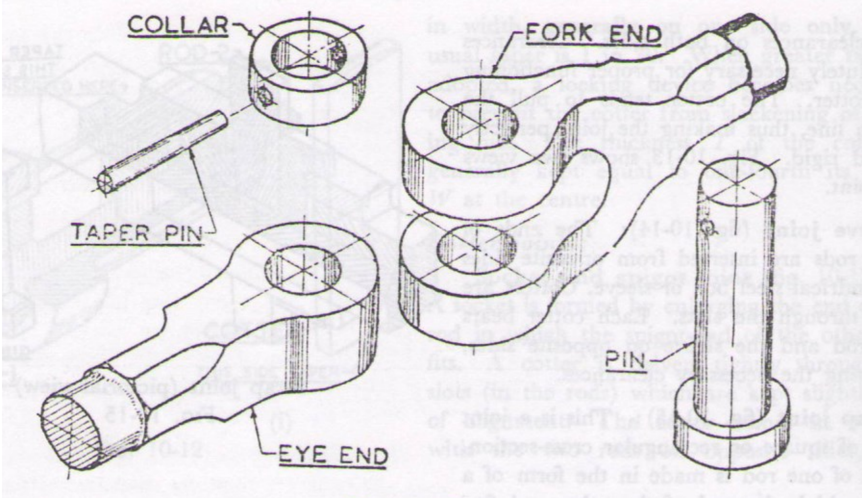
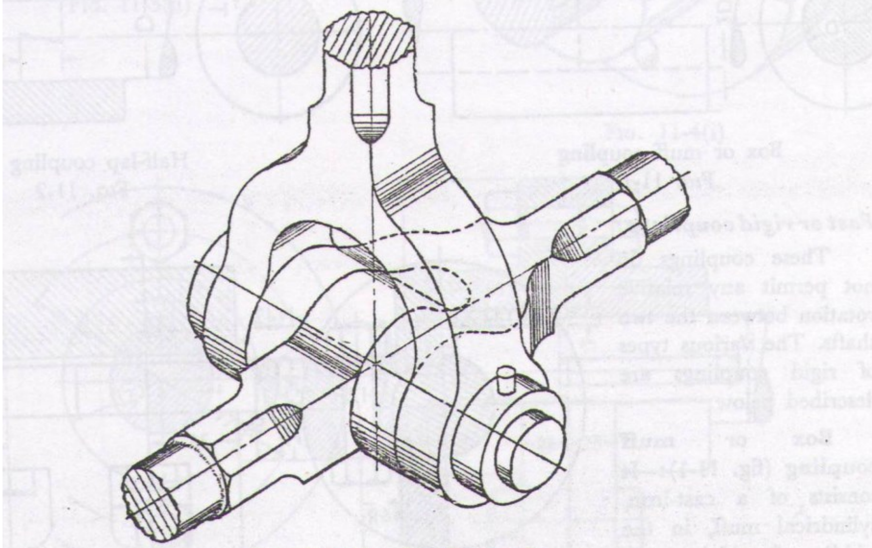


FIG. 17



Knuckle joint for three rods
FIG. 19

7. Post test:

a) **What is the definition of "Keys", "cotter", "cotter joints"**

b) **What are the common types of keys? Draw all types?**

c) **Also what are the common types of cotter? And draw?**

d) **Draw the Figure above with three projection using third angle projection? with front sectional view?**

8. References:

1. R.B. Gupta, "Engineering Drawing and Graphics", effective 1993&other engg.exams.
2. N.D. Bhatt, "Machine Drawing", Twenty-Second Edition, (1991).
3. (1988) in Henry H. Ryffel (ed.): Machinery's Handbook 23rd Edition. New York: Industrial Press Inc. ISBN 0-8311-1200-X.
4. (2000) Witold Rybczynsky. One Good Turn: A Natural History of the Screwdriver and the Screw. Toronto: Harper Collins. ISBN 0-00-638603-2
5. Warren Jacob Luzadder (1959). Fundamentals of engineering drawing for technical students and professional.
6. Mitchell/ Spencer, "Technical Drawing", Hill/Dygdon/ Novak., Tenth Edition, Prince hill.

The six week

Rivets and riveted joints, types of riveted joints, Conventional rivet symbol.

1. **Rivets and riveted joints, types of riveted joints, Conventional rivet symbol. With an explanation in details.**
2. **Class: second year**
3. **Subject:** **general introduction for rivets and riveted joints, types of riveted joints, Conventional rivet symbol, and the basic definitions for riveting also the correct manner for all types of rivets drawing, also an explanation in details for all types.**
4. **Central idea:** **To make the students understanding all about the riveting, types of rivets, and the basic definitions for riviting also the correct manner for all types of rivets drawing, also an explanation in details, also to teaching the mechanical drawing for all mentioned objects.**
5. **Goals:** **To teach the students the correct drawing in mechanical drawings for common types of rivets with overview for all types for these objects scientific subjects with enabling the students to design and draw mechanical drawing for all mentioned objects.**
6. **Pre test:**

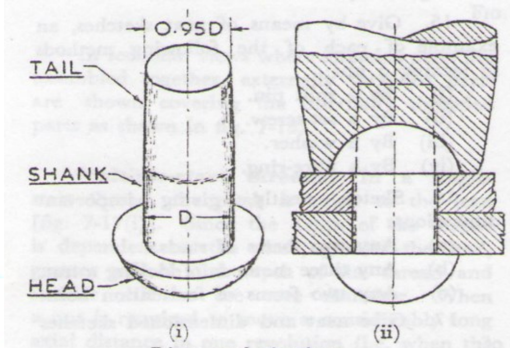
   h) **What is your expecting about the riveting , and the definitions for riveting process?**

   i) **What is your expecting about the common types for rivets.**

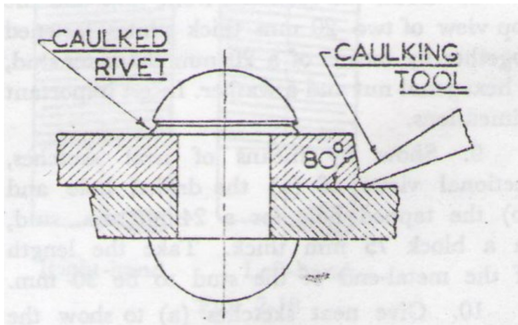
   j) **For what manner rivets used.**

RIVETS AND RIVETED JOINTS

Rivets : Are used to fasten permanently two or more plates or pieces of metal. Joints made with rivets are called riveted joints. They are commonly used in ship-building and for the construction of steel buildings, bridges, boilers, tanks etc. Rivets are usually made of mild steel or wrought iron.



(i) (ii)
Rivet and riveting
Fig. 9-1



Caulking
Fig. 9-2

In its initial form (fig.1) a rivets comprises of :-

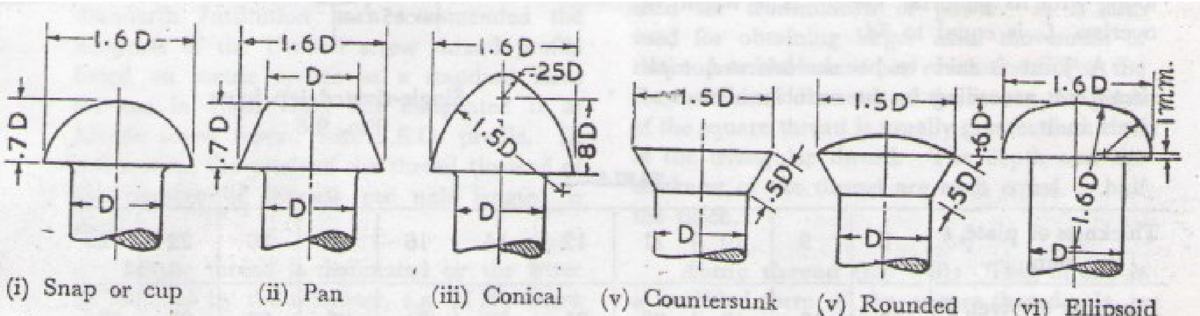
1. Head
2. Cylindrical body or shank
3. Slightly tapered tail (L_T=1.25D_R).

Riveting : The process of forming another rivet-head, after the rivet is placed in the holes previously drilled or punched through the plates.

- D_{hole} large than D_{Rivet} about (1-1.5) mm.
- The rivet is made red-hot and then inserted within the hole in the plates(for large size rivet)
- The head of the rivet is held fast against the adjoining plate, while the tail is hammered and another rivet-head is forged .
- The rough surface of the new head is smoothened with the aid of the a special tool having a cavity of the desired form of the head. (fig. 2).

Forms And Proportions Of Rivet Heads: Some of the various form of rivet heads used for general work are (fig. 4) :

1. Snap or cup head : is the most common form in use (fig.4 i) .
2. Pan : (fig.4 ii)
3. Conical : are generally used in boiler work (fig.4 iii).
4. Countersunk head : is used when the surface of the plate is required to be free from projecting heads (fig.4 iv).
5. Rounded countersunk : (fig.4 v)
6. Ellipsoid : (fig.4 vi)
7. are generally used in boiler work



Forms and proportions of rivet-heads

Failure Of The Riveted Joints : A riveted joint may fail in any of the following ways (fig. 5) :

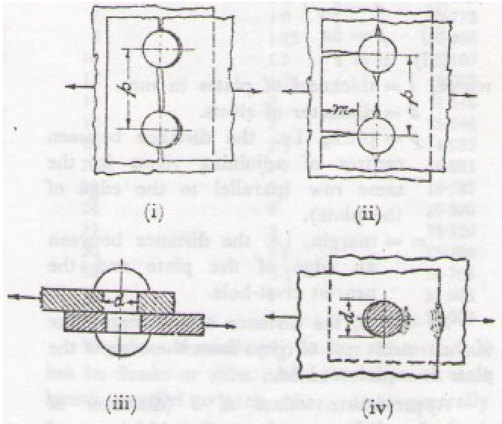


FIG. 9-5

1. Tearing of the plate between the holes if they are very near each other(fig. 5i).
2. Tearing of the plate between the edge of the plate and the rivet-hole, if the hole is too near the edge (fig. 5ii) .
3. Shearing of rivet if the diameter of the rivet is smaller than necessary (fig. 5iii).
4. Crushing of the plate or the rivet (fig. 5iv).

Dimensions Of A Riveted Joint : To prevent failure, the joint should be carefully designed, by using the following empirical formulae:

- $d = 6\sqrt{t}$
- $p = 3d$
- $m = d$

where : *t* = thickness of the plates in mm.

d = diameter of rivets .

p = pitch, the distance between the center of the adjoining rivets in the same row .

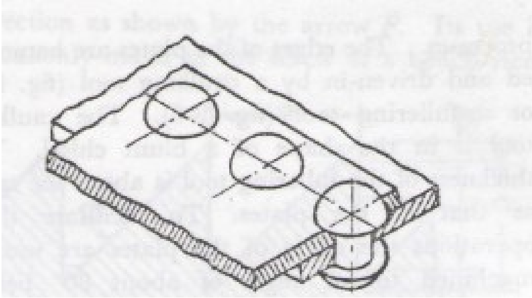
m = margin, the distance between an edge of the plate and the nearest rivet-hole.

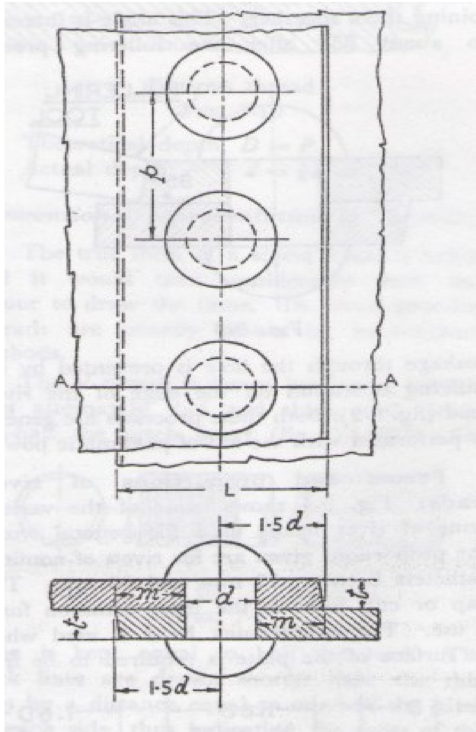
Table 1: Different value of diameter of the rivet(D_R) for different value of thickness of the plate (T_P) .

T_P	8	9	10	11	12	14	16	18	20	25
D_R	17	18	19	20	21	22	24	26	38	30

Types Of Riveted Joints :

1. Lap joint : In a lap joint, the plates to be connected overlap each other, the width of overlap L is equal to 3d (L = 3 d) .
   Single – riveted lap joint(fig. 6): When the joint is made with only one row of rivets .
   Double – riveted , triple riveted : When the joint is made with two row of rivets, according to the no. of rows of rivets in it.



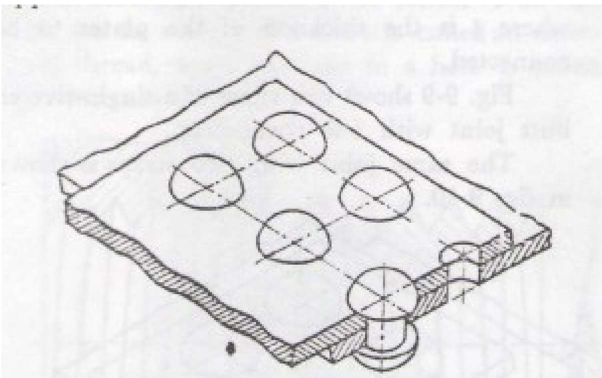


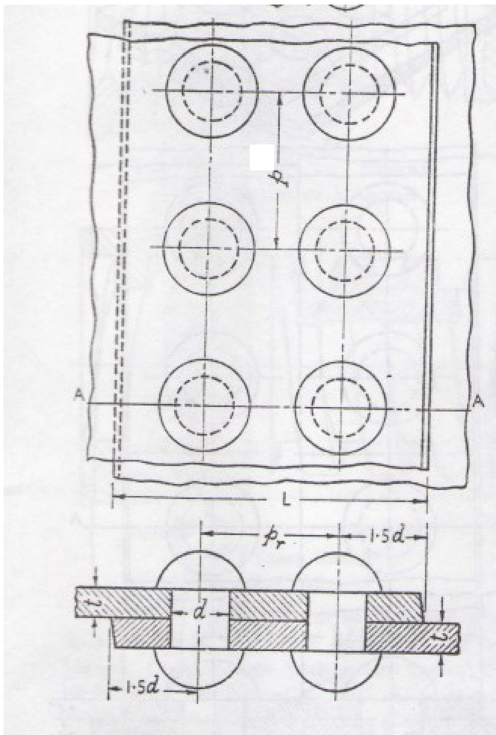
Single-riveted lap joint
FIG. 9-6

when two or more of rivets are required rivets may be arranged in :

i) Chain :Double-riveted chain lap joint (fig.7),

- $p_r \geq 0.8\ p$ (p_r is row pitch, the distance between the rows of the rivets) .
- $p_r = 2d+6$ .... (*in terms of d*)

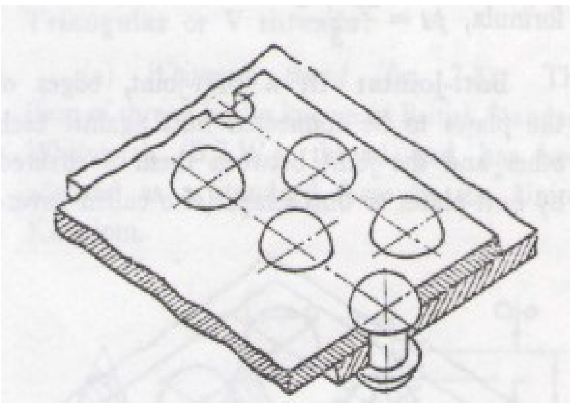


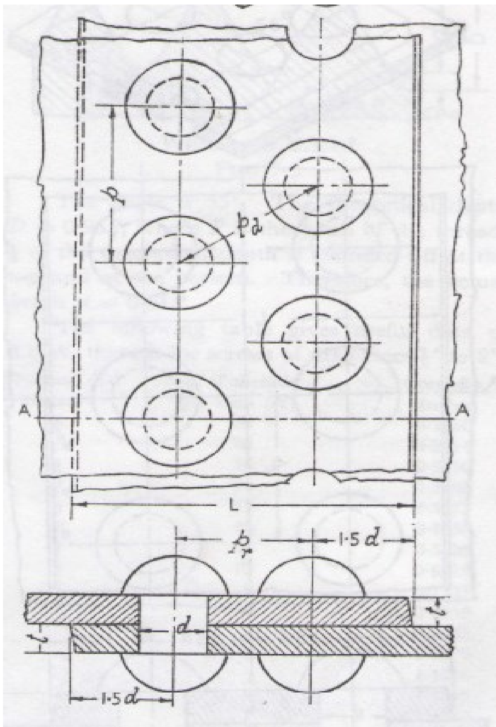


Double-riveed (chain) lap joint
FIG. 9-7

ii) Zigzag :Double-riveted zigzag lap joint(fig8)

- $p_r \geq 0.6p$
- p_r=2d .... (*in terms of d*)
- $P_d = \left[\dfrac{2p+d}{3}\right]$,(p_d is Diagonal pitch, the distance between the center of a rivet in one row and the center of the nearest rivet in the adjoining row).





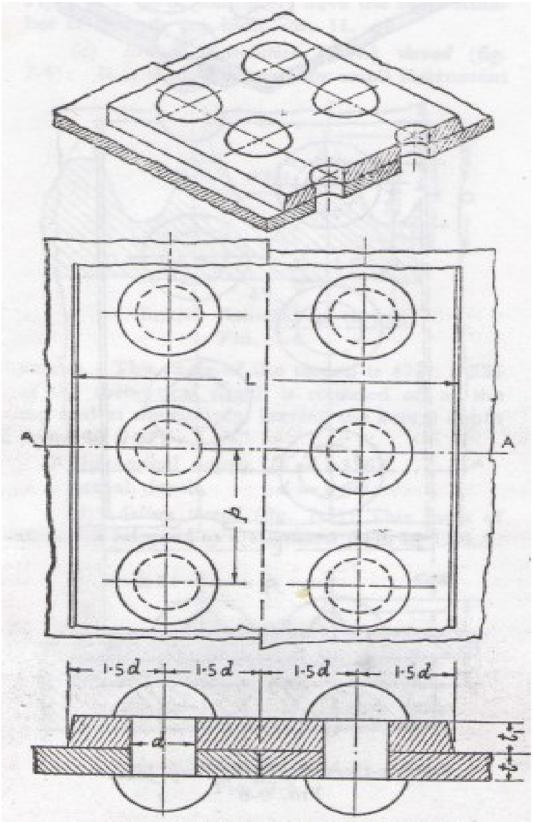
Double-riveted (zigzag) lap joint
FIG. 9-8

Butt-joints : In a butt-joint , edges of the plates to be connected butt against each other and the joint between them is covered by butt-plates or butt-straps(also called cover-plates or cover-straps)on one or both sides.

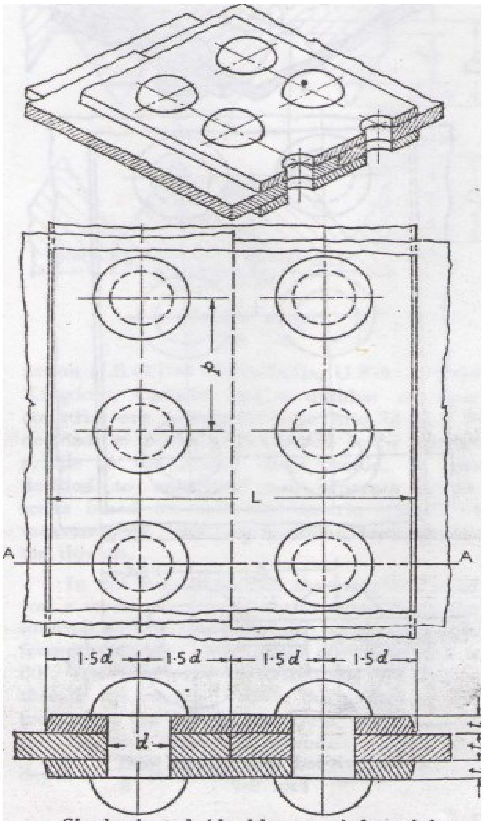
- When only one strap is used $t_1 = t$ to $1.125t$
- When two strap is used $t_2 = 0.7t$ to $0.8t$

t : is the thickness of the plates to be connected(t_{plate} or $t_{p.}$)

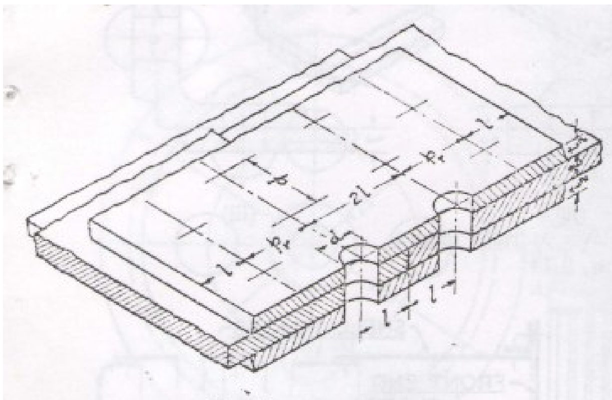
2.1 Single riveted butt joint with one cover-strap (fig. 9).
2.2 Single riveted butt joint with two strap (fig. 10).
2.3 Double–riveted butt joint with double strap(fig. 11).



Single-riveted (single strap) butt joint
FIG. 9-9



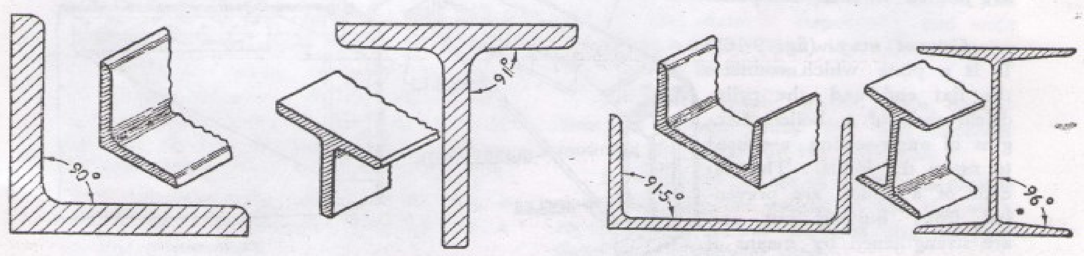
Single-riveted (double straps) butt joint
FIG. 9-10



Double-riveted butt joint
FIG. 9-11

Rolled Steel Sections (fig.13): These are largely used in steel structures. The common shapes are:

1. Angle (fig.13i).
2. Tee (fig.13ii).
3. Channel (fig.13iii).
4. H or Joist (fig.13iv).



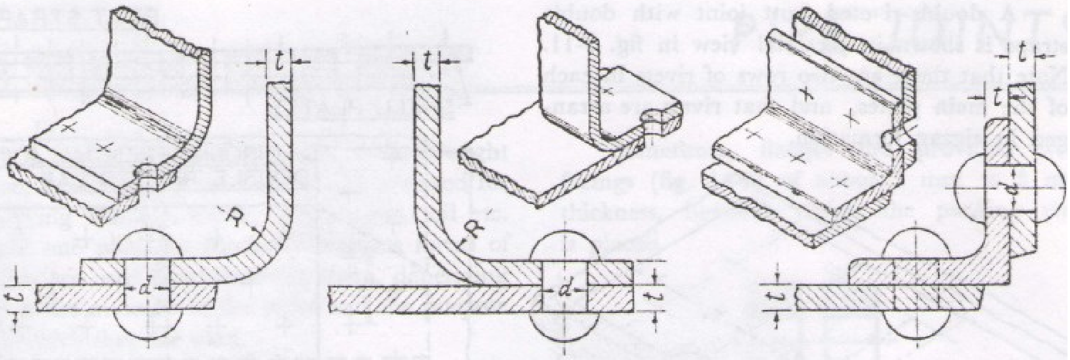
(i) Angle (ii) Tee (iii) Channel (iv) H or joist

Rolled-steel sections

FIG. 9-13

Connection Of Plates At Right Angles (fig. 14): Plates may be connected at right angles by flanging one of the plates

1. Plate bent inside (fig. 14i), R $\geq$ 2t .
2. Plate bent outside (fig. 14ii), R $\geq$ 2t .
3. An angle section is used, the angle is often placed outside(14iii)



(i) (ii) (iii)

Connection of plates at right angles

FIG. 9-14

Q) Draw the sectional Top view, and The Front view for 12 mm thick plates (t_p) of :

1. Single-Riveted Lap Joint
2. Double-Riveted(Chain)Lap Joint.
3. Double-Riveted(Zigzag)Lap Joint.
4. Single-Riveted(Single Strap)Butt Joint.
5. Single-Riveted(Double Strap)Butt Joint.

- $d=6\sqrt{t}$, $p=3d$, $m=d$
- Chain $p_r = 2d+6$
- Zigzag $p_r = 2d$
- $P_d = \left[\frac{2p+d}{3}\right]$
- One strap $t_1 = t$
- Two strap $t_2 = 0.7t$

7. Post test:

e) What is the definition of "riveting ", "rivets"?

f) What are the common types of rivets? Draw all types?

g) Also what are the common types of ivits? And draw?

8. References:

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9. (1988) in Henry H. Ryffel (ed.): Machinery's Handbook 23rd Edition. New York: Industrial Press Inc. ISBN 0-8311-1200-X.
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11. Warren Jacob Luzadder (1959). Fundamentals of engineering drawing for technical students and professional.
12. Mitchell/ Spencer, "Technical Drawing", Hill/Dygdon/ Novak., Tenth Edition, Prince hill.

The seven week

Welding, type of weld joints, welding symbols standard, location and dimension of weld.

1. **Welding, type of weld joints, welding symbols standard, location and dimension of weld. With an explanation in details.**

2. **Class: second year**

3. **Subject: general introduction for Welding, type of welding, welding symbols standard.**

1. **location and dimension of weld, and the basic definitions for welding also the correct manner for all types of welding symbol drawing, also an explanation in details for all types.**

2. **Central idea: To make the students understanding all about the welding, types of weld goints, and the basic definitions for welding also the correct manner for all types of welding symbol drawing, also an explanation in details, also to teaching the mechanical drawing for all mentioned objects.**

3. **Goals: To teach the students the correct drawing in mechanical drawings for common types of welding symbol with overview for all types for these objects scientific subjects with enabling the students to design and draw mechanical drawing for all mentioned objects.**

4. **Pre test:**

   k) **What is your expecting about the welding, and the definitions for welding process?**

   l) **What is your expecting about the common types for weld.**

   m) **For what manner welding used.**

Welding

Welding: Is the process of permanently joining metal by heating a joint to a suitable temperature with or without applying pressure and with or without using filler material. Advantage of welding over other methods of fastening include :

1. Simplified Fabrication
2. Economy
3. Increased Strength And Rigidity
4. Easy Of Repair
5. Creation Of Gas-And Liquid Tight Joint
6. Reduction In Weight And Size

Welding Processes

There are various types of welding processes; the three types are gas welding, arc welding, and resistance welding.

1. **Gas welding**
   - Involves the use of gas flames to melt and fuse metal joints.
   - Gas such as acetylene or hydrogen are mixed in a welding torch and burned with air or oxygen.
   - Most metal except for low and medium carbon steel.
2. **Arc welding**
   - Involves the use of an electric arc to heat and fuse joints, with pressure some times required in addition to heat.
   - Metals will suited to arc welding are wrought iron, low and medium carbon steels, stainless steel, copper, brass, bronze aluminum, and some nickel alloys.
3. **Resistance welding**
   - Comprises several process by which metals are fused both by the heat produced form the resistance of the parts to an electric current and by pressure.
   - All resistance welds are either lap-or butt-type welds

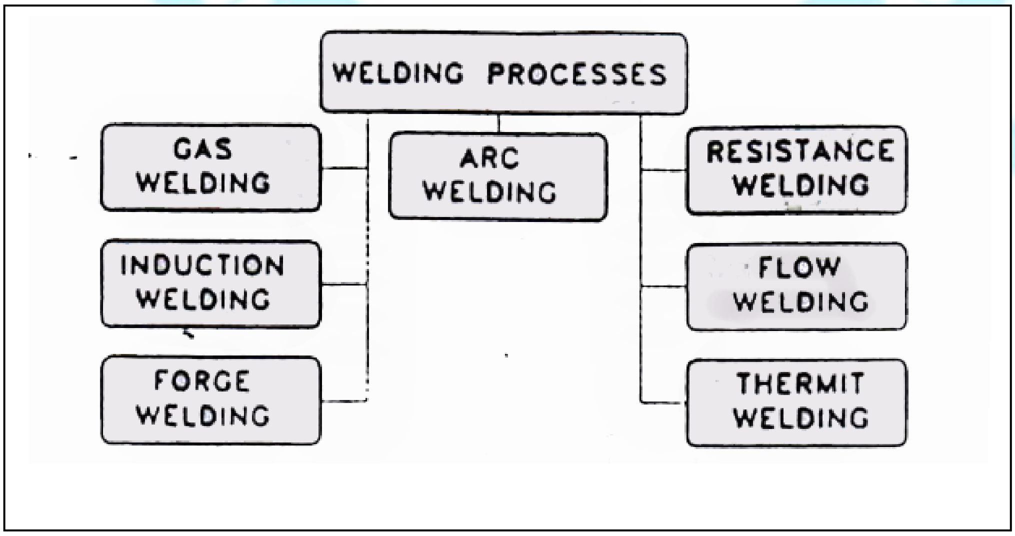


Fig 1 Various type of welding processes .

Weld Joints And Welds

Fig. 2 show the five standard weld joints, Fig 3 show the standard weld their corresponding ideographs.

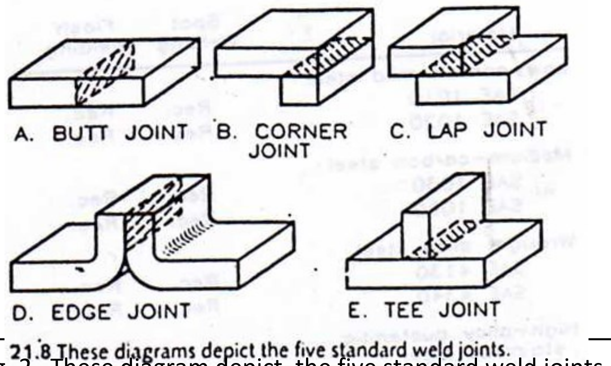


Fig. 2 These diagram depict the five standard weld joints

1. Butt joint : Can be jointed with a square groove, V- groove, bevel groove, U- groove and J- groove weld
2. Corner joint: Can be jointed with these welds and with the fillet weld.
3. Lap joint : Can be jointed with a bevel groove, J- groove, fillet, slot, plug, spot, projection, and seam weld
4. Edge joint : Uses the same welds as the lap joint, along with square groove, V- groove, U- groove, and seam welds
5. Tee joint: Can be jointed by bevel groove, J- groove, and fillet welds

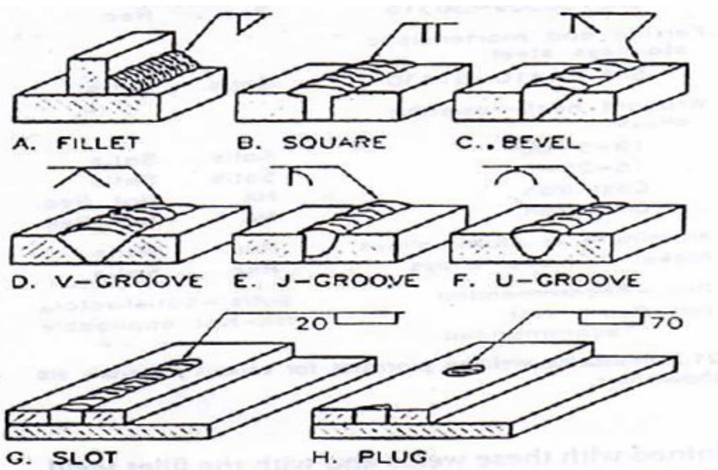


Fig. 3 These views illustrate standard weld and their corresponding ideographs

Welding Symbols

Symbols are used to convey welding specifications on a drawing as show in the fig3 .

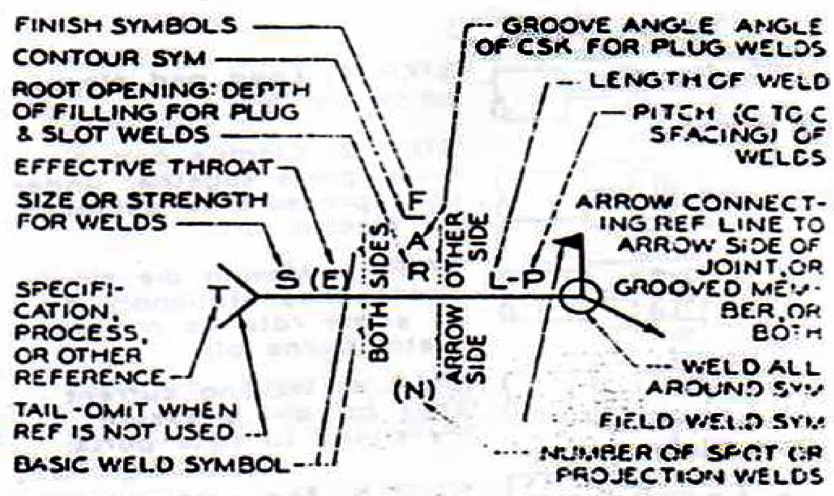
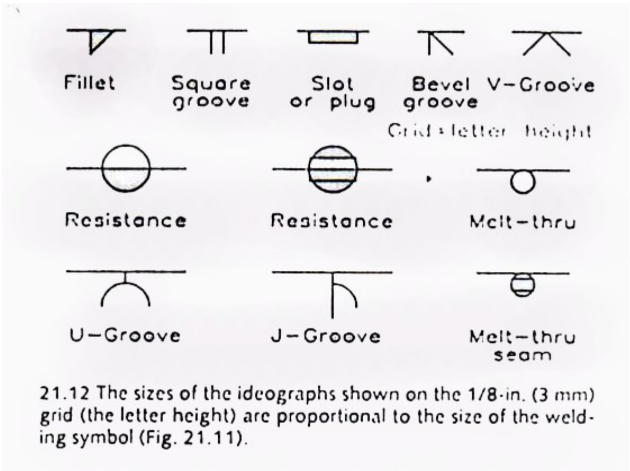
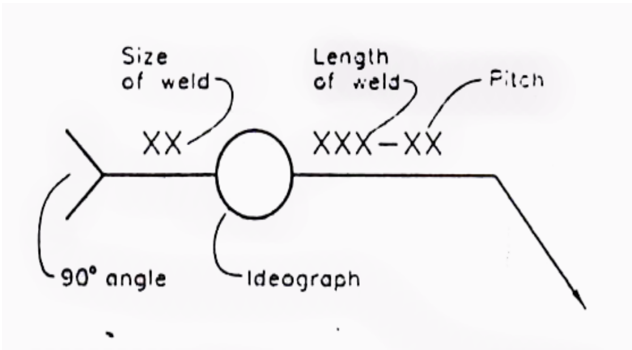


Fig 4 The welding symbol. Usually it is modified to a simpler form for use on drawing

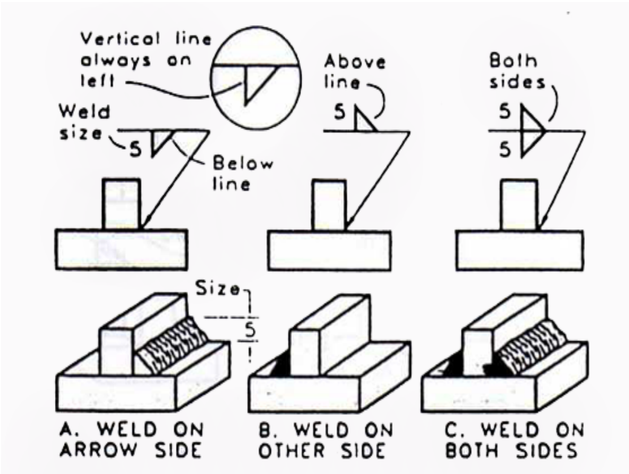


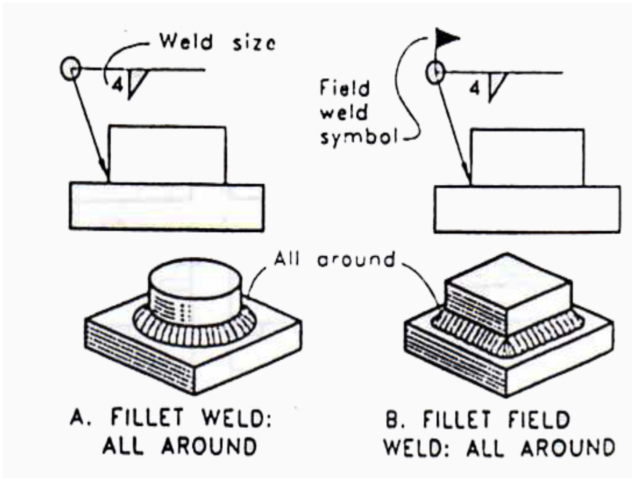
21.12 The sizes of the ideographs shown on the 1/8-in. (3 mm) grid (the letter height) are proportional to the size of the welding symbol (Fig. 21.11).

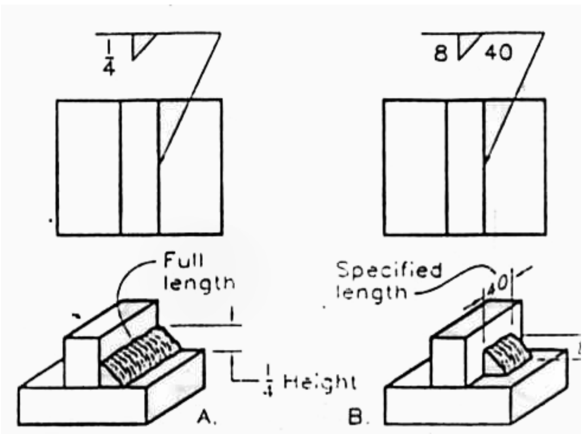


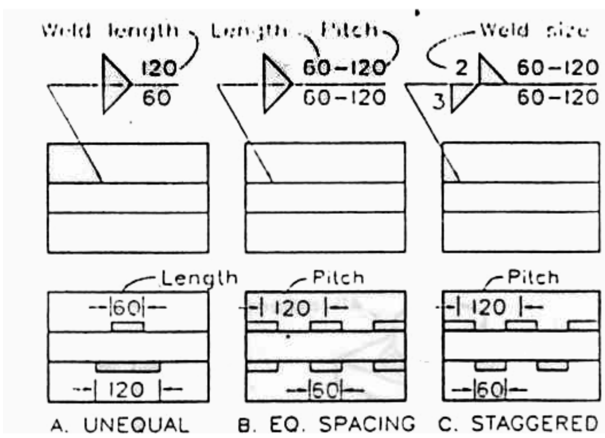
21.11 Welding symbol proportions are based on the letter height used on a drawing, usually 1/8 in. or 3 mm. This grid is equal to the letter height.

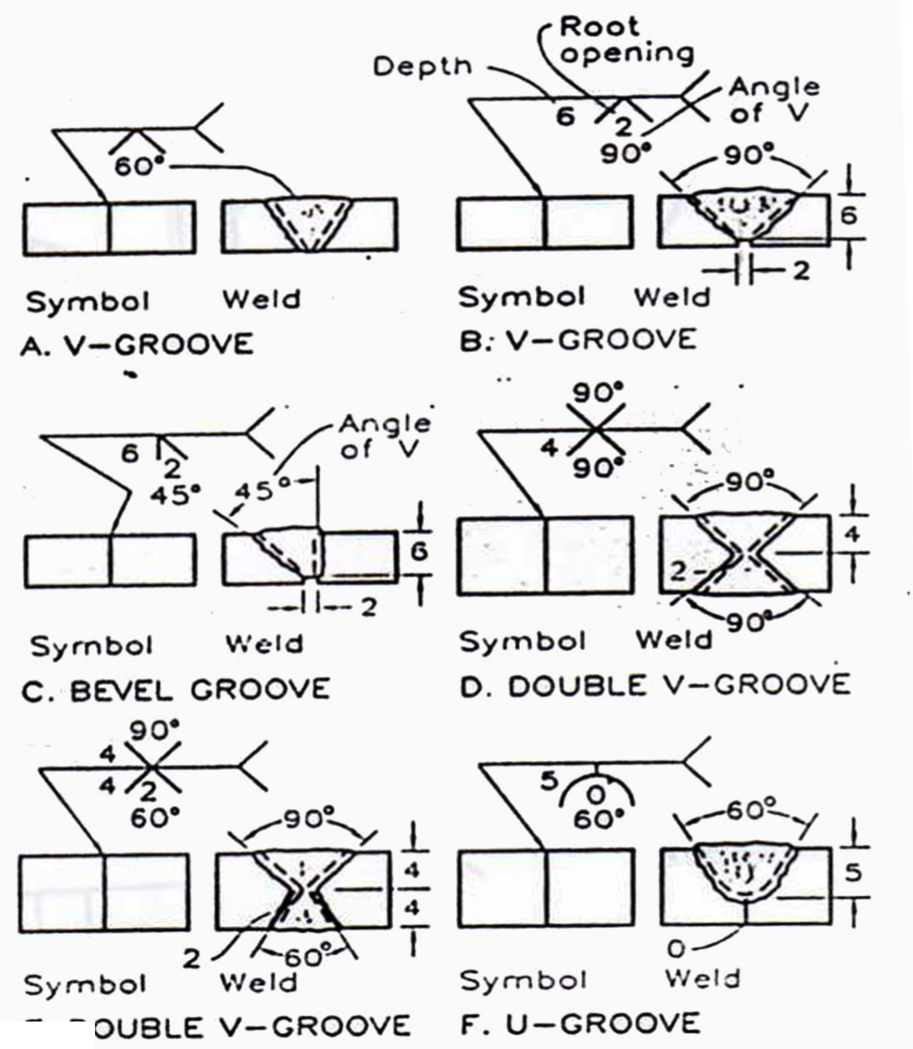
Application Of Symbols :



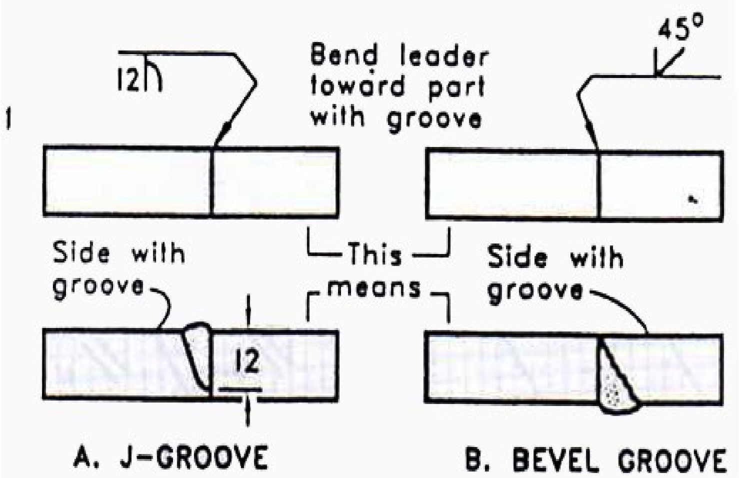








21.17 This drawing shows the various types of groove welds and their general specifications.



21.18 J-groove welds and bevel welds are specified by bent arrows pointing to the side of the joint to be grooved or beveled.

The eight week

Pulleys, types of pulleys.

1. **Pulleys, types of pulleys.**
2. **Class: second year**
3. **Subject: general introduction for Pulleys, types of pulleys.**
4. **location and dimension of Pulleys, and the basic definitions for Pulleys also the correct manner for all types of Pulleys drawing, also an explanation in details for all types.**
5. **Central idea:** **To make the students understanding all about the Pulleys, types of pulleys, and the basic definitions for Pulleys also the correct manner for all types of Pulleys drawing, also an explanation in details, and usage for these pulleys types also to teaching the mechanical drawing for all mentioned objects.**
6. **Goals:** **To teach the students the correct drawing in mechanical drawings for common types of pulleys with overview for all types for these objects scientific subjects with enabling the students to design and draw mechanical drawing for all mentioned objects.**
7. **Pre test:**
   a) **What is your expecting about the pulley, and the definitions for pulley?**
   b) **What is your expecting about the common types for pulley with usage for these all types.**

Pulleys

Pulleys : Are used for transmission of power from one shaft -co another by means of belts or ropes.

They are made of cast iron, wrought iron, steel or wood.

The three parts of a pulley are(fig.1):

- Hub or Boss.
- Arms .
- Rim.

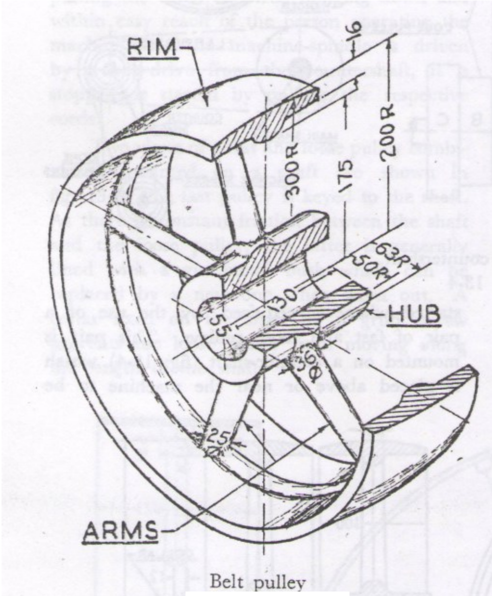


Fig.1

There are three methods of mounting a pulley on a shaft, viz. by means of : (fig 2)

(i) Keys .
(ii) Cone keys .
(iii) Set-Screw .

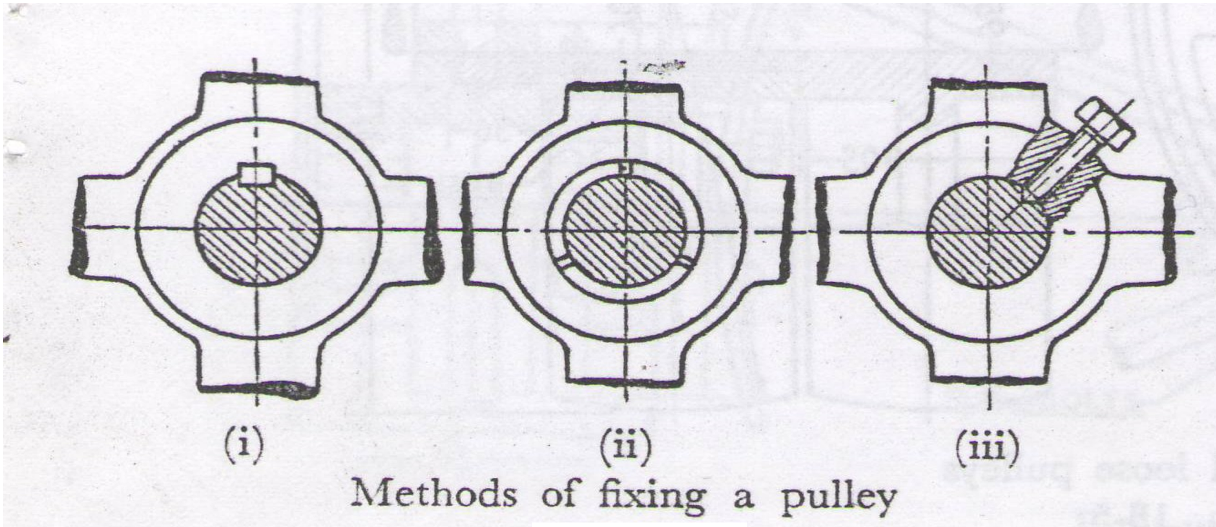


Fig.2

BELT PULLEYS:

Cast iron belt pulleys (fig 3):

- Has convex (curvature) rim, to keep the belt in the middle of the rim.
- The arms of a pulley may be of circular or elliptical cross-section but are larger at the hub than at the rim, and the arms are made curved.

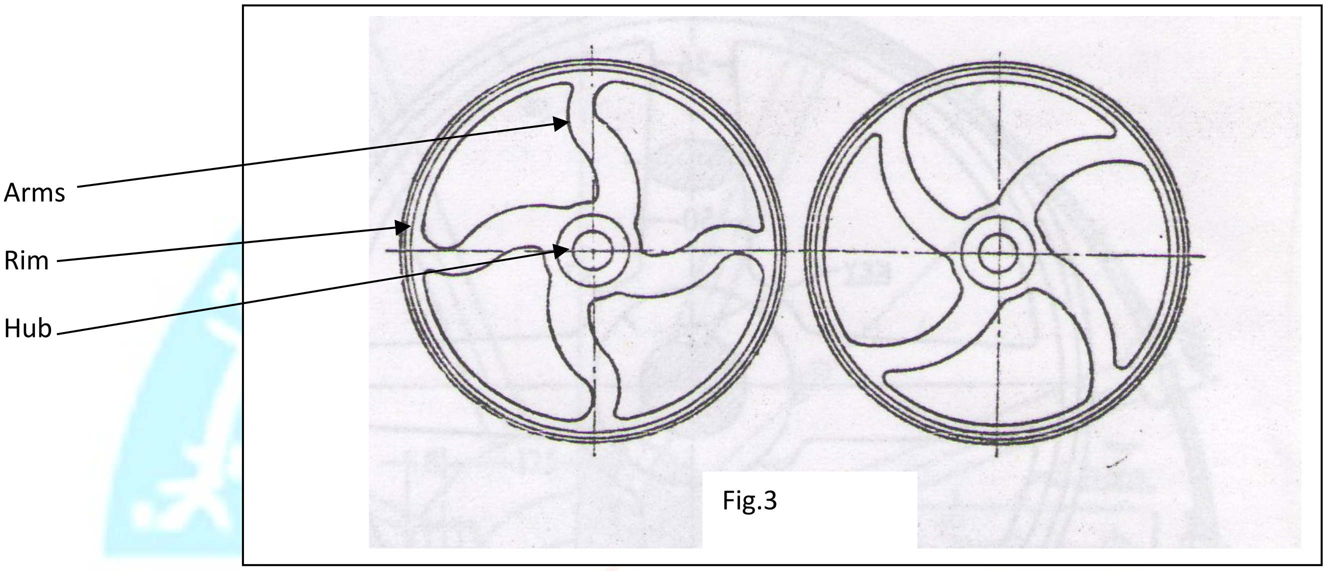
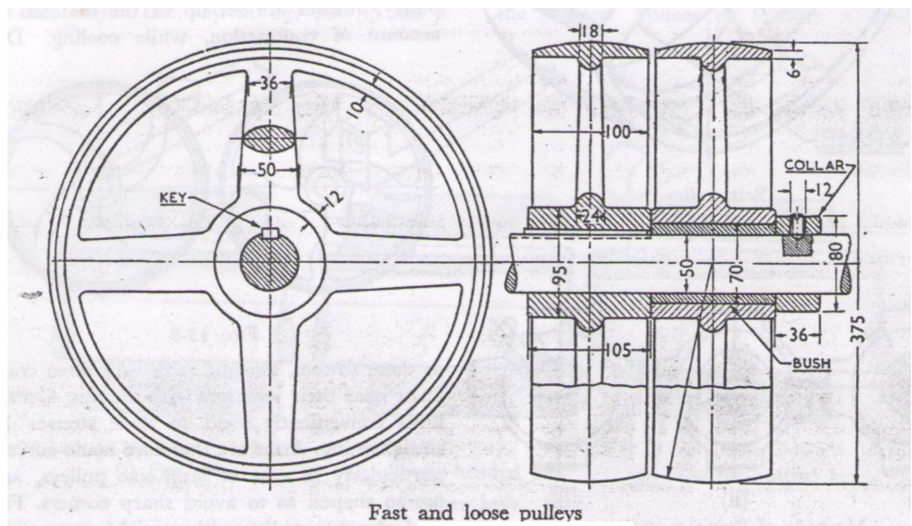


Fig.3

Fast and loose pulleys (fig.4).

- Fast pulley is a pulley rigidly attached to a shaft.
- Loss pulley is a pulley free to rotate on the shaft.



Fast and loose pulleys

Fig.4

Speed cones or stepped pulleys (fig.5)

- Made of cast iron
- Secured to a shafts by means of keys or set-screw.
- A machine-spindle can be driven at different speeds by fixing stepped pulleys on the spindle and on the countershaft in reverse positions.

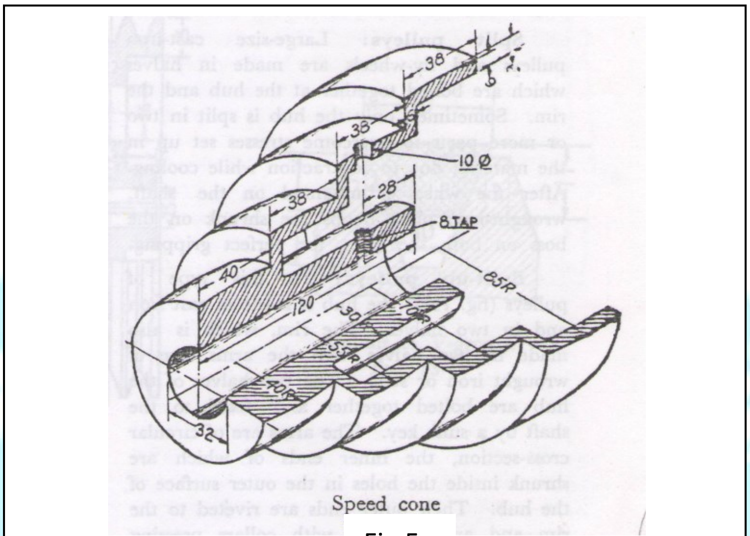


Fig.5

Split pulleys :

- Large-size cast iron pulleys and fly-wheel are made in halves which are bolted together at the hub and the rim.

Built-up pulleys(fig.6) :

- The hub is made of cast iron; the rim is made of wrought iron or steel.
- The hub and the rim are made in two halves.
- Use sunk key to fix the two halves of the hub on the shaft after bolted it.

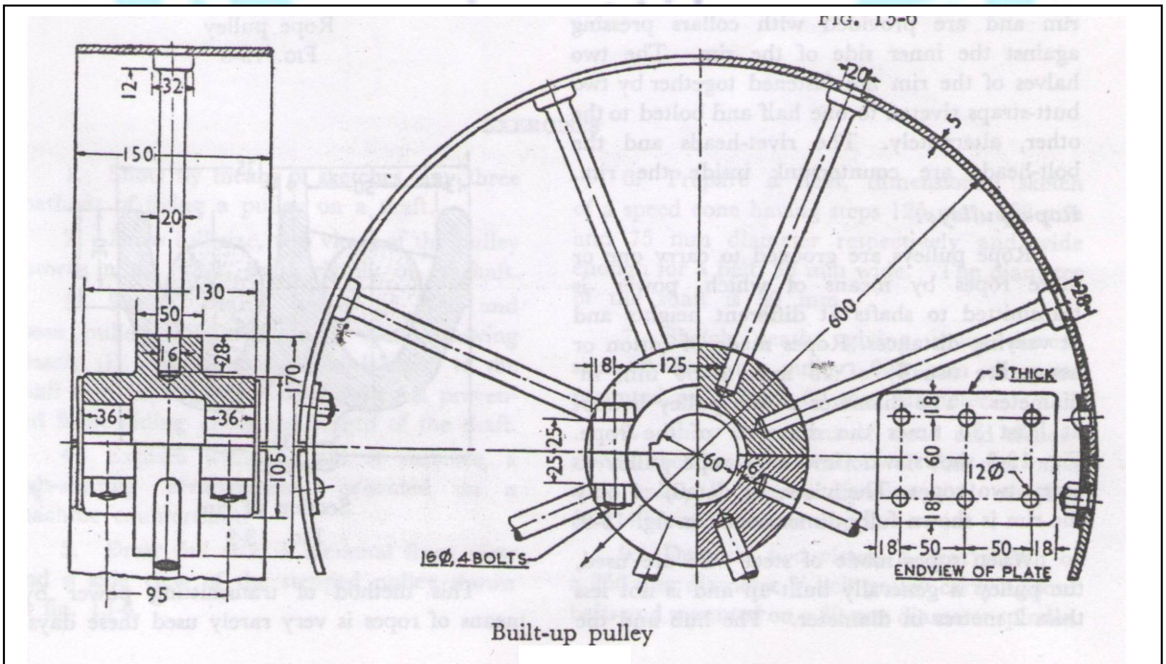


Fig.6

V-belt pulleys(fig.7) (fig.8):

- Pulleys have one or more v-grooves to carry v-belt.
- V-belt used are made of rubber and fiber.
- Widely used in modern times.

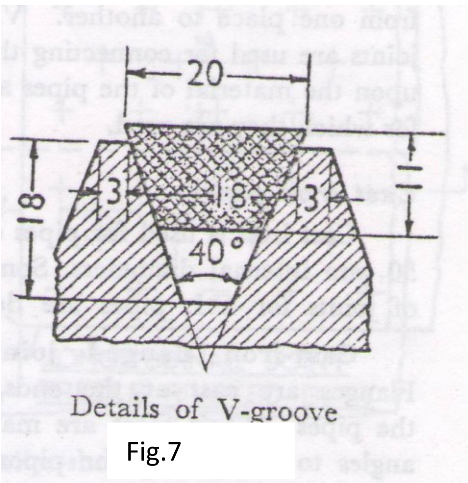


Fig.7

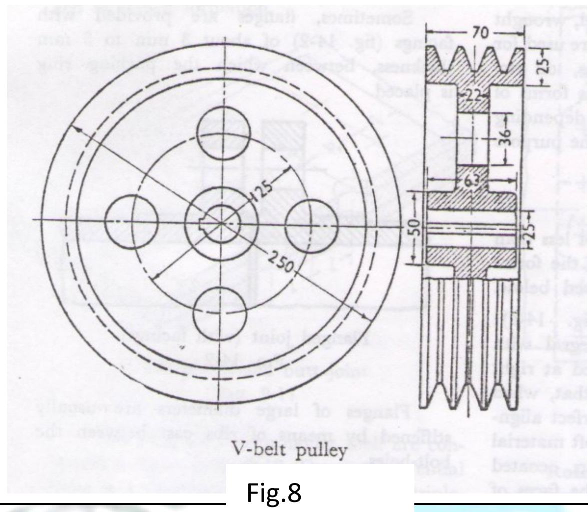


Fig.8

Rope Pulleys:

- Grooved to carry one or more ropes(fig.9) (fig.10):.
- Ropes made of cotton or hemp are 25-50mm in diameter .
- Dp=30DR
- If the ropes is made of steel wire, the pulley is built-up not less than 2m in diameter, the hub and the rim are cast n two halves, while the arms are made of steel.

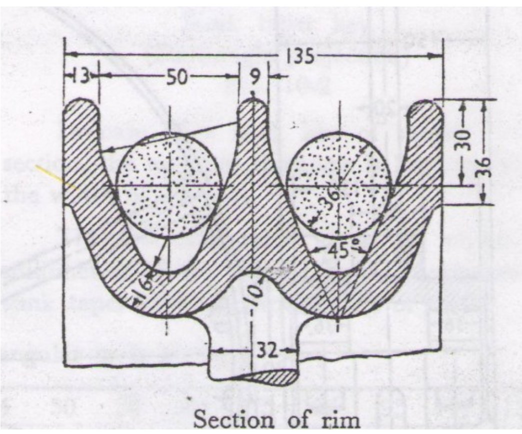


Fig.9

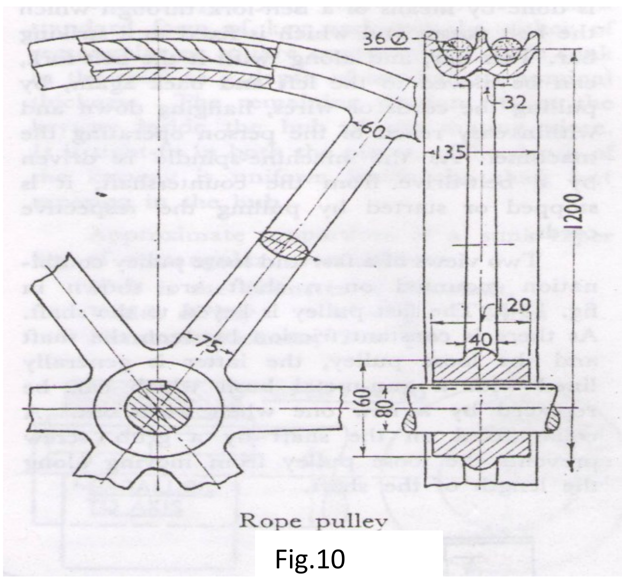
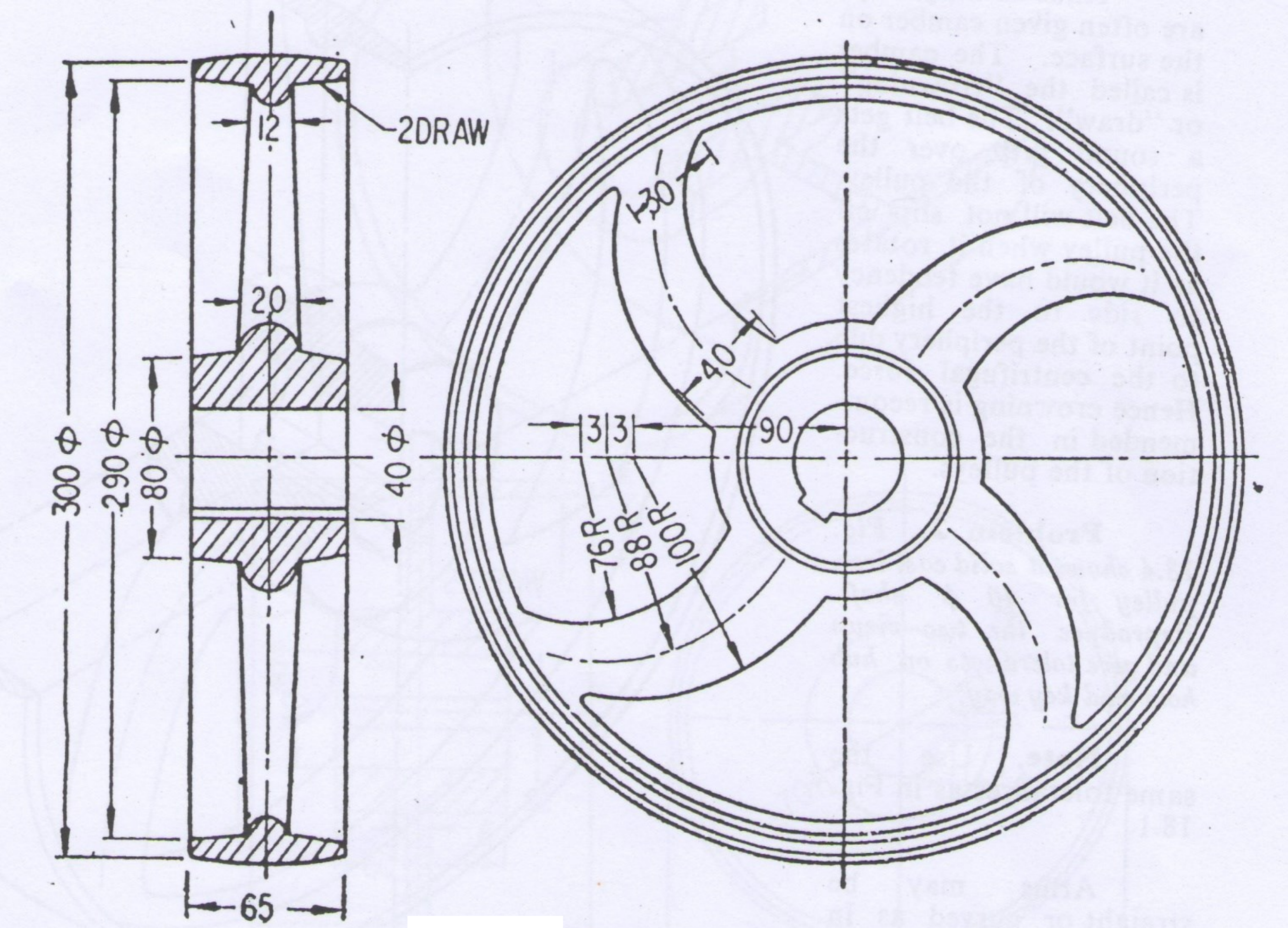


Fig.10



300 mm cast iron pulley.

Fig.11

The 9th to 13th week

a- Gears classification of gears, spur gear, definitions, formulas and calculations.
b- Gear tooth profile, working drawing.
c- Bevel gear, calculations, working drawing.
d- Helical gear, worms and worm gear, rack and pinion.
e- Gear boxes.

1. **Class: second year**

2. **Subject:**

a- Gears classification of gears, spur gear, definitions, formulas and calculations
b- Gear tooth profile, working drawing.
c- Bevel gear, calculations, working drawing.
d- Helical gear, worms and worm gear, rack and pinion.
e- Gear boxes.

Central idea: **To make the students understanding all about the Gears classification of gears, spur gear, definitions, formulas and calculations. Gear tooth profile, working drawing. Bevel gear, calculations, working drawing. Helical gear, worms and worm gear, rack and pinion. Gear boxes, also to teaching the mechanical drawing for all mentioned objects.**

3. **Goals:** **To teach the students the correct drawing in mechanical drawings for the profile of tooth of gears with overview for all definitions, classifications, formulas for these objects with enabling the students to design and draw mechanical drawing for all mentioned objects.**

4. **Pre test:**

   a) **What is your expecting about the gears, and the definitions and classifications for gears?**

   b) **What is your expecting about the drawing for gear tooth profile.**

Gears : Are used to transmitted power and rotating or reciprocating motion from one machine part to another .

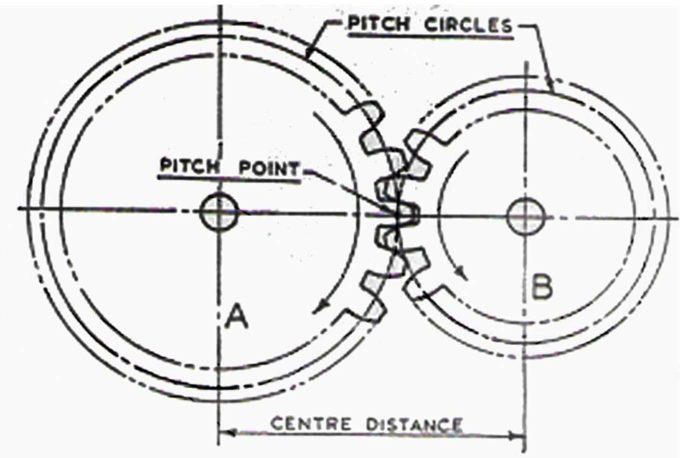
Classification Of Gears:

They may be classified according to the position of the shafts that they connected :

1. Parallel shafts : May be connected by spur gears, helical gears, or herringbone gears.
2. Intersecting shafts: May be connected by bevel gears having either straight, skew, or spiral teeth(Gears which transmit power between shafts in the same plane but whose axes would intersect).
3. Nonparallel, Nonintersecting shafts : May be connected by helical gears, or a worm and worm gear.

1. SPUR GEARS

Gears which transmit motion between two parallel shafts are called spur gears, show the fig.1, the angle between these shafts is usually a right angle.



Toothed wheels
FIG. 16-2
1

1.1 Spur Gear Definitions: Refer to fig.1 for the following:

- Pitch circle: In every pair of gears in mesh, the two circles representing the two plain wheels in contact are always assumed to exist. Each of these circles is called a pitch circle. Its diameter is the pitch circle diameter.
- Pitch surface: The cylindrical surface which the pitch circle represents is the pitch surface.
- Pitch point: It is the point of contact between the pitch circles of two gears in mesh. It lies on the line joining their centers.
- Centre distance: It is the distance between the centers of a pair of mating gears and is equal to the sum of the radii of the pitch circles of the two gears.

Refer to fig.2 for the following:

- Tooth face: It is the side-surface of the tooth above the pitch circle, perpendicular to the plane of the gear.
- Tooth flank: It is the side-surface of the tooth below the pitch circle, perpendicular to the plane of the gear.
- Crest of tooth: It is the outside surface of the tooth, perpendicular to the plane of the gear .
- Root of teeth: It is the junction of the tooth with the material at the bottom of the tooth space.

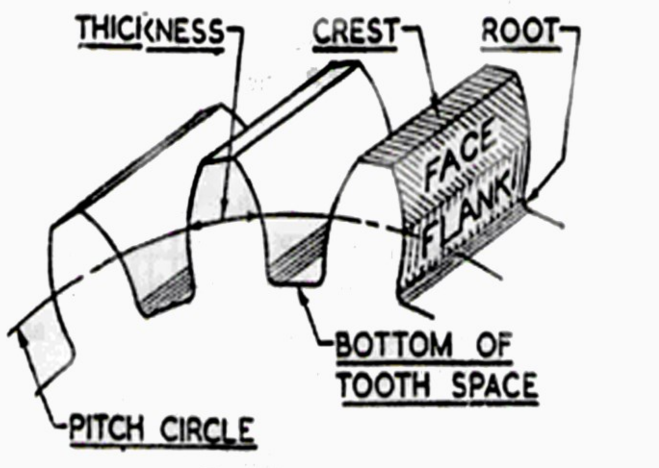


FIG. 16-3
2

- Tooth thickness: It is the thickness of the tooth, measured along the pitch circle.

Refer to fig.3 for the following:

- Addendum: It is the radial height of a tooth above the pitch circle.
- Dedendum: It is the radial depth of a tooth below the pitch circle.
- Clearance: It is the difference between the addendum and the dedendum.
- whole depth: It is the sum of the addendum and dedendum of a tooth.
- working depth: It is the distance by which a tooth extends into the space of a mating gear. It is equal to the whole depth minus the clearance, or twice the addendum.
- Addendum circle: It is the circle which contains the crests of the teeth. Its diameter is called the outside or blank diameter.
- Dedendum circle: It is the circle which contains the bottoms of the tooth spaces. It is also called a root circle. Its diameter is the root diameter.
- Fillet radius: It is the radius of the curve at the root of the tooth.
- Pinion.: It is the smaller of the two unequal gears in engagement.
- Rack: it is a gear having a pitch circle of infinitely large radius i.e. the pitch circle is a straight line.
- Pitch: The pitch of the teeth is expressed in the following four ways:
  1. Circular pitch, C.P. (fig. 3): It is the distance, measured along the pitch circle, from a point on one tooth to a corresponding point on the adjacent tooth.
  2. Diametral pitch, D.P.: It is the number of teeth per unit length of the pitch circle diameter. it is a ratio and not a dimension as in the case of circular pitch.
  3. Module pitch, M: It is the number of units (cm or mm) of pitch circle diameter per tooth. It is thus, the reciprocal of the diametral pitch and is obtained by dividing the pitch circle diameter by the number of teeth. This expression is generally used in metric system.
  4. Chordal pitch: It is the shortest distance or the length of the chord of the pitch circle between a point on one tooth and a corresponding point on the adjacent tooth, both on the pitch circle.

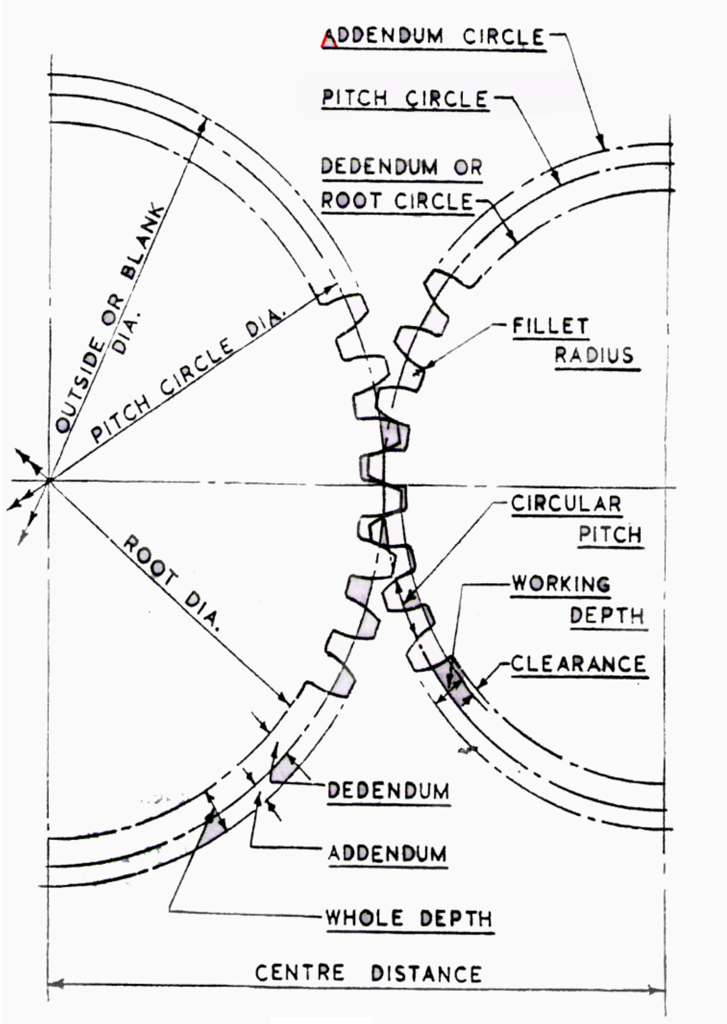


Fig. 3

Refer to fig.4 for the following :

- Base circle : The circle from which the involutes curve for the tooth profile is generated, It is concentric with the pitch circle.

- Line of action($L\bar{L}$) : It is the common tangent to the two base circles of the involutes which form the teeth profiles of the mating gears.
- Pressure angle or angle of obliquity(θ): It is the angle between the line of action and the common tangent to the pitch circles at the pitch point. Its value varies between l4.25^{0}and 22^0 . It is usually taken as 20^o.

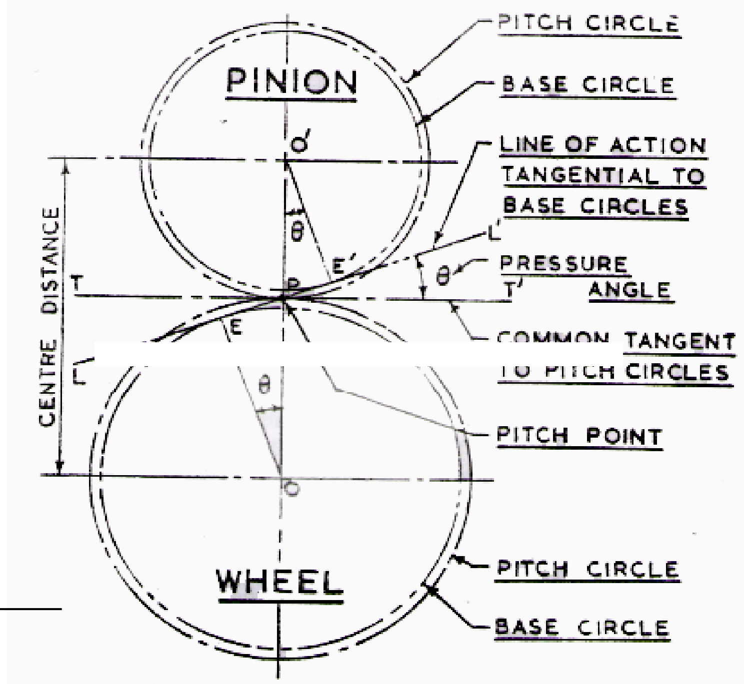


Fig. 4 Construction of base circles

1.2 Formulas And Calculation : The

Relationship between the pitches :

$$\text{Circular pitch} = \frac{\text{Pitch circular diameter} \times \pi}{\text{Number of teeth}}$$

$$\text{C.P.} = \frac{P.C.D \times \pi}{N} \quad \text{...(1)}$$

$$\text{Diameter pitch} = \frac{\text{Number of teeth}}{\text{Pitch circular diameter}}$$

$$\text{D.P} = \frac{N}{P.C.D} \quad \text{..(2) for that C.P.} = \frac{\pi}{D.P.}$$

$$\text{Module pitch} = \frac{\text{Pitch circular diameter}}{\text{Number of teeth}}$$

$$M = \frac{P.C.D}{N} = \frac{1}{D.P.} \quad \text{..............................(3) for that C.P.} = \frac{\pi}{D.P.} = \pi \times M$$

$$\text{Tooth thickness} = \text{Width of space} = \frac{C.P.}{2} \quad \text{..(4)}$$

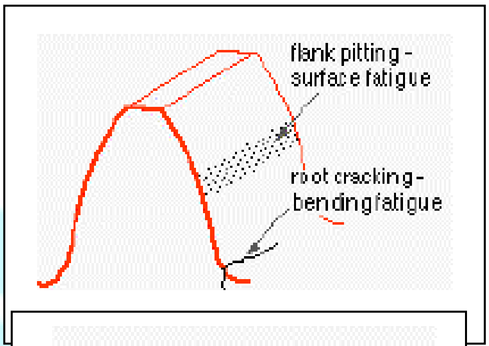
$$\text{Addendum} = M = \frac{1}{D.P.} = \frac{C.P.}{\pi} \quad \text{..(5)}$$

$$\text{Clearance} = \frac{C.P.}{20} = \frac{\pi}{D.P. \times 20.} \quad \text{..(6)}$$

Dedendum = Addendum + Clearance……………………………………………….(7)

Add. Circle diameter = P.C.D. + 2 × addendum…………………………………..(8)

Ded. Circle diameter = P.C.D. – 2 × dedendum…………………………………(9)



1.3 Gear Tooth Profile

: A tooth system is defined by a unique pressure angle and set of tooth proportions which characterize the system's basic rack of . Various systems find application in particular specialized sectors of industry, but by far the most widespread and the only system considered here is the 20° full depth system which incorporates a 20° pressure angle (α) and the other proportions.

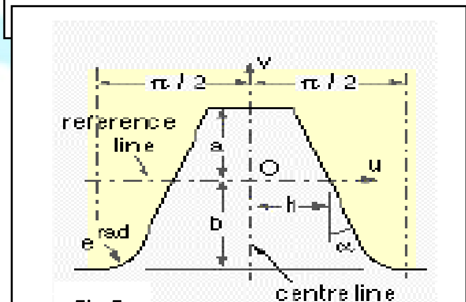
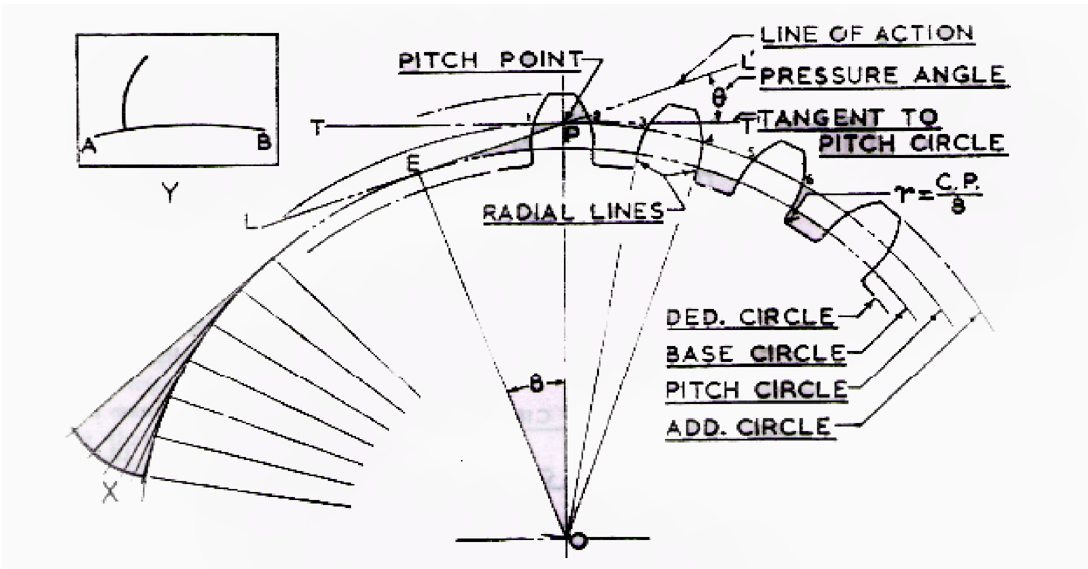


Fig 5

1.4 Working Drawing Of Spur Gears :

A typical working drawing of a spur gears is shown in example below .

Example : Draw the profile of involutes teeth for a gear having 24 teeth and a D.P. equal to 1.2cm, taking centimeter as unit length and assuming a pressure angle of 20°. show the below



Construction of involute teeth profile

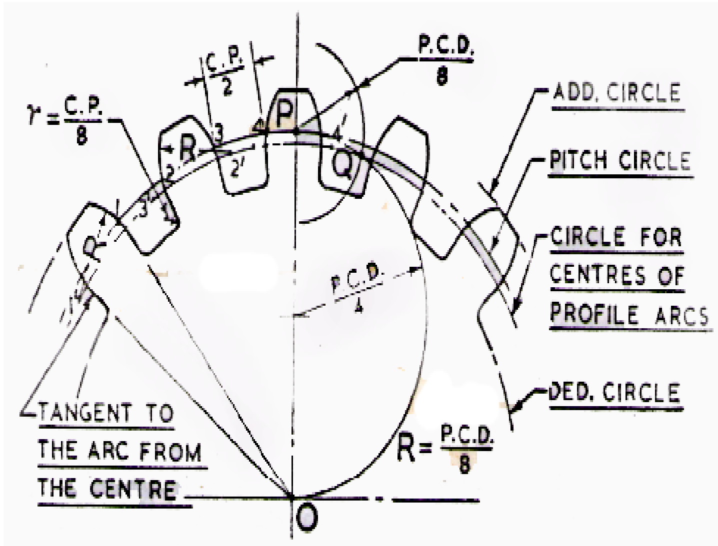
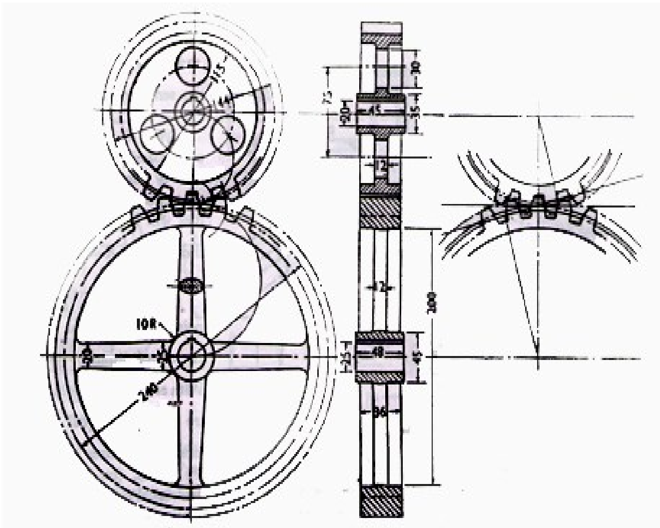


Fig.6 Approximate construction (for gears of less than 30 teeth)

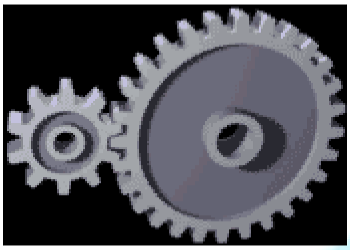


Gears in mesh
FIG. 16-10

Gear

For the gear-like device used to drive a roller chain, see Sprocket.

This article is about mechanical gears. For other uses, see Gear (disambiguation).



Two meshing gears transmitting rotational motion. Note that the smaller gear is rotating faster. Although the larger gear is rotating less quickly, its torque is proportionally greater.

A **gear** is a rotating machine part having cut *teeth*, or *cogs*, which *mesh* with another toothed part in order to transmit torque. Two or more gears working in tandem are called a *transmission* and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, magnitude, and direction of a power source. The most common situation is for a gear to mesh with another gear, however a gear can also mesh a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.

The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear prevent slipping.

When two gears of unequal number of teeth are combined a mechanical advantage is produced, with both the rotational speeds and the torques of the two gears differing in a simple relationship.

In transmissions which offer multiple gear ratios, such as bicycles and cars, the term **gear**, as in *first gear*, refers to a gear ratio rather than an actual physical gear. The term is used to describe similar devices even when gear ratio is continuous rather than discrete, or when the device does not actually contain any gears, as in a continuously variable transmission.

The earliest known reference to gears was circa A.D. 50 by Hero of Alexandria, but they can be traced back to the Greek mechanics of the Alexandrian school in the 3rd century B.C. and were greatly developed by the Greek polymath Archimedes (287–212 B.C.).

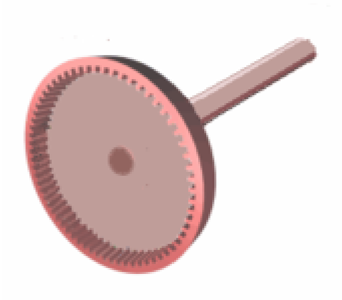
Comparison with other drive mechanisms

The definite velocity ratio which results from having teeth gives gears an advantage over other drives (such as traction drives and V-belts) in precision machines such as watches that depend upon an exact velocity ratio. In cases where driver and follower are in close proximity gears also have an advantage over other drives in the reduced number of parts required; the downside is that gears are more expensive to manufacture and their lubrication requirements may impose a higher operating cost.

The automobile transmission allows selection between gears to give various mechanical advantages.

Types

External vs. internal gears



Internal gear

An *external gear* is one with the teeth formed on the outer surface of a cylinder or cone. Conversely, an *internal gear* is one with the teeth formed on the inner surface of a cylinder or cone. For bevel gears, an internal gear is one with the pitch angle exceeding 90 degrees. Internal gears do not cause direction reversal.[4]

Spur gear

Spur gears or *straight-cut gears* are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and although they are not straight-sided in form, the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears can be meshed together correctly only if they are fitted to parallel axles.

Helical

Helical gears
Top: parallel configuration
Bottom: crossed configuration

Helical gears offer a refinement over spur gears. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix. Helical gears can be meshed in a *parallel* or *crossed* orientations. The former refers to when the shafts are parallel to each other; this is the most common orientation. In the latter, the shafts are non-parallel.

The angled teeth engage more gradually than do spur gear teeth causing them to run more smoothly and quietly. With parallel helical gears, each pair of teeth first make contact at a single point at one side of the gear wheel; a moving curve of contact then grows gradually across the tooth face to a maximum then recedes until the teeth break contact at a single point on the opposite side. In spur gears teeth suddenly meet at a line contact across their entire width causing stress and noise. Spur gears make a characteristic whine at high speeds and can not take as much torque as helical gears. Whereas spur gears are used for low speed applications and those situations where noise control is not a problem, the use of helical gears is indicated when the application involves high speeds, large power transmission, or where noise abatement is important. The speed is considered to be high when the pitch line velocity exceeds 25 m/s.

A disadvantage of helical gears is a resultant thrust along the axis of the gear, which needs to be accommodated by appropriate thrust bearings, and a greater degree of sliding friction between the meshing teeth, often addressed with additives in the lubricant.

For a crossed configuration the gears must have the same pressure angle and normal pitch, however the helix angle and handedness can be different. The relationship between the two shafts is actually defined by the helix angle(s) of the two shafts and the handedness, as defined:

$E = \beta_1 + \beta_2$ for gears of the same handedness
$E = \beta_1 - \beta_2$ for gears of opposite handedness

Where β is the helix angle for the gear. The crossed configuration is less mechanically sound because there is only a point contact between the gears, whereas in the parallel configuration there is a line contact.

Quite commonly helical gears are used with the helix angle of one having the negative of the helix angle of the other; such a pair might also be referred to as having a right-handed helix and a left-handed helix of equal angles. The two equal but opposite angles add to zero: the angle between shafts is zero – that is, the shafts are *parallel*. Where the sum or the difference (as described in the equations above) is not zero the shafts are *crossed*. For shafts *crossed* at right angles the helix angles are of the same hand because they must add to 90 degrees.

- 3D Animation of helical gears (parallel axis)
- 3D Animation of helical gears (crossed axis)

Double helical

Double helical gears
Main article: Double helical gear

Double helical gears, or *herringbone gear*, overcome the problem of axial thrust presented by "single" helical gears by having two sets of teeth that are set in a V shape. Each gear in a double helical gear can be thought of as two standard mirror image helical gears stacked. This cancels out the thrust since each half of the gear thrusts in the opposite direction. Double helical gears are more difficult to manufacture due to their more complicated shape.

For each possible direction of rotation, there are two possible arrangements of two oppositely-oriented helical gears or gear faces. In one possible orientation, the helical gear faces are oriented so that the axial force generated by each is in the axial direction away from the center of the gear; this arrangement is unstable. In the second possible orientation, which is stable, the helical gear faces are oriented so that each axial force is toward the mid-line of the gear. In both arrangements, when the gears are aligned correctly, the total (or *net*) axial force on each gear is zero. If the gears become misaligned in the axial direction, the unstable arrangement generates a net force for disassembly of the gear train, while the stable arrangement generates a net corrective force. If the direction of rotation is reversed, the direction of the axial thrusts is reversed, a stable configuration becomes unstable, and *vice versa*.

Stable double helical gears can be directly interchanged with spur gears without any need for different bearings.

Bevel

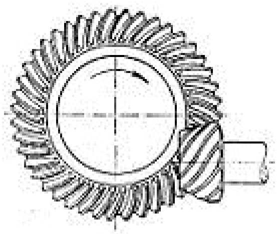
Bevel gear
Main article: Bevel gear

A bevel gear is shaped like a right circular cone with most of its tip cut off. When two bevel gears mesh their imaginary vertices must occupy the same point. Their shaft axes also intersect at this point, forming an arbitrary non-straight angle between the shafts. The angle between the shafts can be anything except zero or 180 degrees. Bevel gears with equal numbers of teeth and shaft axes at 90 degrees are called *miter gears*.

The teeth of a bevel gear may be straight-cut as with spur gears, or they may be cut in a variety of other shapes. *Spiral bevel gear* teeth are curved along the tooth's length and set at an angle, analogously to the way helical gear teeth are set at an angle compared to spur gear teeth. *Zerol bevel gears* have teeth which are curved along their length, but not angled. Spiral bevel gears have the same advantages and disadvantages relative to their straight-cut cousins as helical gears do to spur gears. Straight bevel gears are generally used only at speeds below 5 m/s (1000 ft/min), or, for small gears, 1000 r.p.m.

- 3D Animation of two bevel gears

Hypoid

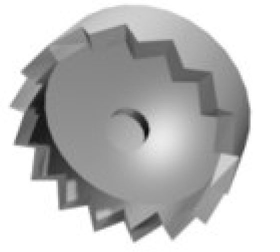


Hypoid gear
Main article: Spiral bevel gear

Hypoid gears resemble spiral bevel gears except the shaft axes do not intersect. The pitch surfaces appear conical but, to compensate for the offset shaft, are in fact hyperboloids of revolution.

Hypoid gears are almost always designed to operate with shafts at 90 degrees. Depending on which side the shaft is offset to, relative to the angling of the teeth, contact between hypoid gear teeth may be even smoother and more gradual than with spiral bevel gear teeth. Also, the pinion can be designed with fewer teeth than a spiral bevel pinion, with the result that gear ratios of 60:1 and higher are feasible using a single set of hypoid gears. This style of gear is most commonly found in mechanical differentials.

Crown



Crown gear

Crown gears or *contrate gears* are a particular form of bevel gear whose teeth project at right angles to the plane of the wheel; in their orientation the teeth resemble the points on a crown. A crown gear can only mesh accurately with another bevel gear, although crown gears are sometimes seen meshing with spur gears. A crown gear is also sometimes meshed with an escapement such as found in mechanical clocks.

Worm

Worm gear

Main article: Worm drive

Worm gears resemble screws. A worm gear is usually meshed with an ordinary looking, disk-shaped gear, which is called the *gear*, *wheel*, or *worm wheel*.

Worm-and-gear sets are a simple and compact way to achieve a high torque, low speed gear ratio. For example, helical gears are normally limited to gear ratios of less than 10:1 while worm-and-gear sets vary from 10:1 to 500:1. A disadvantage is the potential for considerable sliding action, leading to low efficiency.

Worm gears can be considered a species of helical gear, but its helix angle is usually somewhat large (close to 90 degrees) and its body is usually fairly long in the axial direction; and it is these attributes which give it its screw like qualities. The distinction between a worm and a helical gear is made when at least one tooth persists for a full rotation around the helix. If this occurs, it is a 'worm'; if not, it is a 'helical gear'. A worm may have as few as one tooth. If that tooth persists for several turns around the helix, the worm will appear, superficially, to have more than one tooth, but what one in fact sees is the same tooth reappearing at intervals along the length of the worm. The usual screw nomenclature applies: a one-toothed worm is called *single thread* or *single start*; a worm with more than one tooth is called *multiple thread* or *multiple start*. The helix angle of a worm is not usually specified. Instead, the lead angle, which is equal to 90 degrees minus the helix angle, is given.

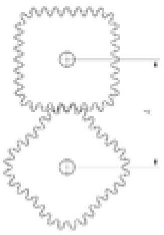
In a worm-and-gear set, the worm can always drive the gear. However, if the gear attempts to drive the worm, it may or may not succeed. Particularly if the lead angle is small, the gear's teeth may simply lock against the worm's teeth, because the force component circumferential to the worm is not sufficient to overcome friction. Worm-and-gear sets that do lock are called **self locking**, which can be used to advantage, as for instance when it is desired to set the position of a mechanism by turning the worm and then have the mechanism hold that position. An example is the machine head found on some types of stringed instruments.

If the gear in a worm-and-gear set is an ordinary helical gear only a single point of contact will be achieved. If medium to high power transmission is desired, the tooth shape of the gear is modified to achieve more intimate contact by making both gears partially envelop each other. This is done by making both concave and joining them at a saddle point; this is called a **cone-drive**.

Worm gears can be right or left-handed following the long established practice for screw threads.

- 3D Animation of a worm-gear set

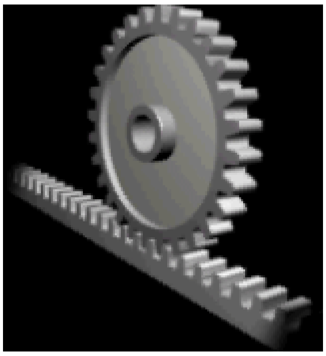
Non-circular



Non-circular gears
Main article: Non-circular gear

Non-circular gears are designed for special purposes. While a regular gear is optimized to transmit torque to another engaged member with minimum noise and wear and maximum efficiency, a non-circular gear's main objective might be ratio variations, axle displacement oscillations and more. Common applications include textile machines, potentiometers and continuously variable transmissions.

Rack and pinion

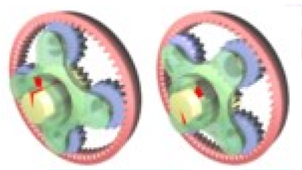


Rack and pinion gearing

Main article: Rack and pinion

A rack is a toothed bar or rod that can be thought of as a sector gear with an infinitely large radius of curvature. Torque can be converted to linear force by meshing a rack with a pinion: the pinion turns; the rack moves in a straight line. Such a mechanism is used in automobiles to convert the rotation of the steering wheel into the left-to-right motion of the tie rod(s). Racks also feature in the theory of gear geometry, where, for instance, the tooth shape of an interchangeable set of gears may be specified for the rack (infinite radius), and the tooth shapes for gears of particular actual radii then derived from that. The rack and pinion gear type is employed in a rack railway.

Epicyclic

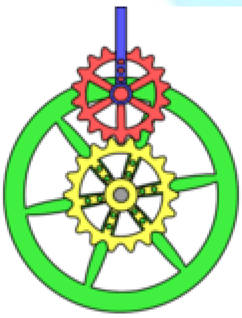


Epicyclic gearing

Main article: Epicyclic gearing

In epicyclic gearing one or more of the gear axes moves. Examples are sun and planet gearing (see below) and mechanical differentials.

Sun and planet

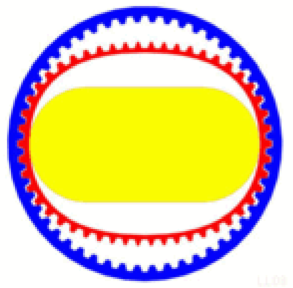


Sun (yellow) and planet (red) gearing

Main article: Sun and planet gear

Sun and planet gearing was a method of converting reciprocal motion into rotary motion in steam engines. It played an important role in the Industrial Revolution. The Sun is yellow, the planet red, the reciprocating crank is blue, the flywheel is green and the driveshaft is grey.

Harmonic drive



Harmonic drive gearing
Main article: Harmonic drive

A *harmonic drive* is a specialized proprietary gearing mechanism.

Cage gear

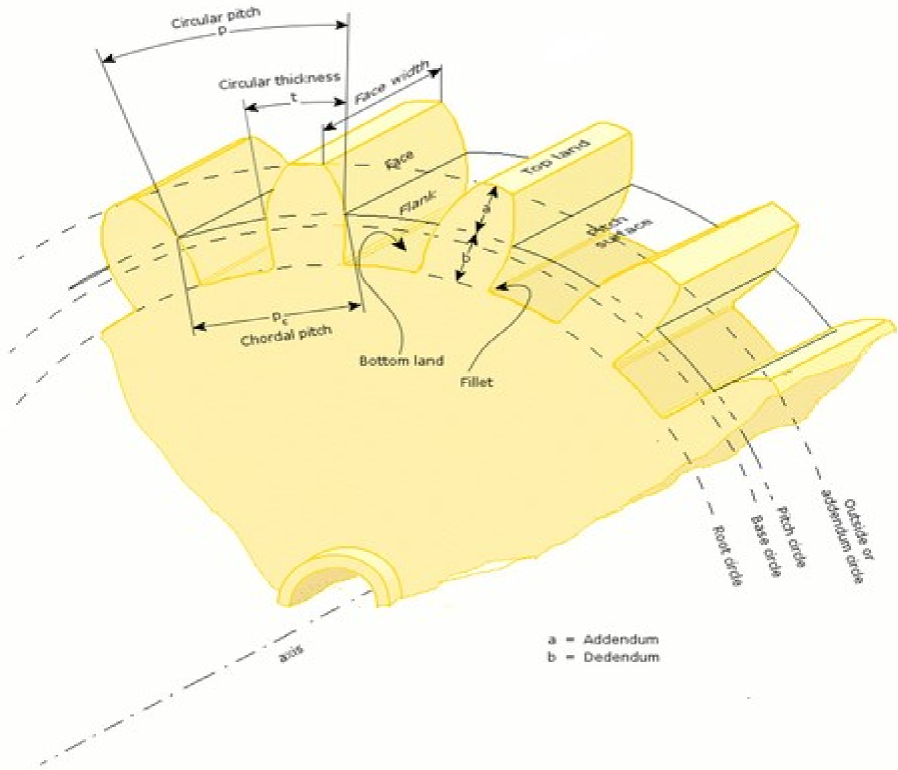
Cage gear in Pantigo Windmill, Long Island

A *cage gear*, also called a *lantern gear* or *lantern pinion* has cylindrical rods for teeth, parallel to the axle and arranged in a circle around it, much as the bars on a round bird cage or lantern. The assembly is held together by disks at either end into which the tooth rods and axle are set.

Nomenclature

Main article: Gear nomenclature

Main Definitions & General nomenclature



Rotational frequency, n
Measured in rotation over time, such as RPM.

Angular frequency, ω
Measured in radians per second. 1*RPM* = π / 30 rad/second

Number of teeth, N
How many teeth a gear has, an integer. In the case of worms, it is the number of thread starts that the worm has.

Gear, wheel
The larger of two interacting gears.

Pinion
The smaller of two interacting gears.

Path of contact
Path followed by the point of contact between two meshing gear teeth.

Line of action, pressure line
Line along which the force between two meshing gear teeth is directed. It has the same direction as the force vector. In general, the line of action changes from moment to moment during the period of engagement of a pair of teeth. For involute gears, however, the tooth-to-tooth force is always directed along the same line—that is, the line of action is constant. This implies that for involute gears the path of contact is also a straight line, coincident with the line of action—as is indeed the case.

Axis

Axis of revolution of the gear; center line of the shaft.

Pitch point, p

Point where the line of action crosses a line joining the two gear axes.

Pitch circle, pitch line

Circle centered on and perpendicular to the axis, and passing through the pitch point. A predefined diametral position on the gear where the circular tooth thickness, pressure angle and helix angles are defined.

Pitch diameter, d

A predefined diametral position on the gear where the circular tooth thickness, pressure angle and helix angles are defined. The standard pitch diameter is a basic dimension and cannot be measured, but is a location where other measurements are made. Its value is based on the number of teeth, the normal module (or normal diametral pitch), and the helix angle. It is calculated as:

$d = \frac{Nm_n}{cos\psi}$ in metric units or $d = \frac{N}{P_d cos\psi}$ in imperial units.

Module, m

A scaling factor used in metric gears with units in millimeters who's effect is to enlarge the gear tooth size as the module increases and reduce the size as the module decreases. Module can be defined in the normal (m_n), the transverse (m_t), or the axial planes (m_a) depending on the design approach employed and the type of gear being designed. Module is typically an input value into the gear design and is seldom calculated.

Operating pitch diameters

Diameters determined from the number of teeth and the center distance at which gears operate. Example for pinion:

$$d_w = \frac{2a}{u+1} = \frac{2a}{\frac{z_2}{z_1}+1}.$$

Pitch surface

In cylindrical gears, cylinder formed by projecting a pitch circle in the axial direction. More generally, the surface formed by the sum of all the pitch circles as one moves along the axis. For bevel gears it is a cone.

Angle of action

Angle with vertex at the gear center, one leg on the point where mating teeth first make contact, the other leg on the point where they disengage.

Arc of action

Segment of a pitch circle subtended by the angle of action.

Pressure angle, θ

The complement of the angle between the direction that the teeth exert force on each other, and the line joining the centers of the two gears. For involute gears, the teeth always exert force along the line of action, which, for involute gears, is a straight line; and thus, for involute gears, the pressure angle is constant.

Outside diameter, D_o

Diameter of the gear, measured from the tops of the teeth.

Root diameter

Diameter of the gear, measured at the base of the tooth.

Addendum, a

Radial distance from the pitch surface to the outermost point of the tooth. $a = (D_o - D) / 2$

Dedendum, b

Radial distance from the depth of the tooth trough to the pitch surface. $b = (D - rootdiameter) / 2$

Whole depth, h_t

The distance from the top of the tooth to the root; it is equal to addendum plus dedendum or to working depth plus clearance.

Clearance

Distance between the root circle of a gear and the addendum circle of its mate.

Working depth

Depth of engagement of two gears, that is, the sum of their operating addendums.

Circular pitch, p

Distance from one face of a tooth to the corresponding face of an adjacent tooth on the same gear, measured along the pitch circle.

Diametral pitch, p_d

Ratio of the number of teeth to the pitch diameter. Could be measured in teeth per inch or teeth per centimeter.

Base circle

In involute gears, where the tooth profile is the involute of the base circle. The radius of the base circle is somewhat smaller than that of the pitch circle.

Base pitch, normal pitch, p_b

In involute gears, distance from one face of a tooth to the corresponding face of an adjacent tooth on the same gear, measured along the base circle.

Interference

Contact between teeth other than at the intended parts of their surfaces.

Interchangeable set

A set of gears, any of which will mate properly with any other.

Helical gear nomenclature

Helix angle, ψ

Angle between a tangent to the helix and the gear axis. Is zero in the limiting case of a spur gear.

Normal circular pitch, p_n

Circular pitch in the plane normal to the teeth.

Transverse circular pitch, p

Circular pitch in the plane of rotation of the gear. Sometimes just called "circular pitch". $p_n = p\cos(\psi)$

Several other helix parameters can be viewed either in the normal or transverse planes. The subscript n usually indicates the normal.

Worm gear nomenclature

Lead

Distance from any point on a thread to the corresponding point on the next turn of the same thread, measured parallel to the axis.

Linear pitch, p

Distance from any point on a thread to the corresponding point on the adjacent thread, measured parallel to the axis. For a single-thread worm, lead and linear pitch are the same.

Lead angle, λ

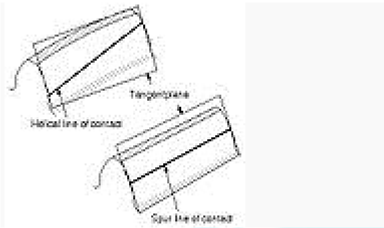
Angle between a tangent to the helix and a plane perpendicular to the axis. Note that it is the complement of the helix angle which is usually given for helical gears.

Pitch diameter, d_w

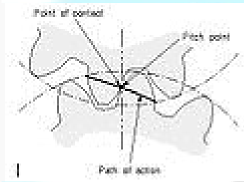
Same as described earlier in this list. Note that for a worm it is still measured in a plane perpendicular to the gear axis, not a tilted plane.

Subscript w denotes the worm, subscript g denotes the gear.

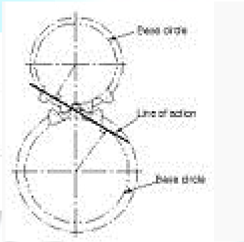
Tooth contact nomenclature



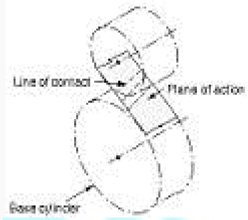
Line of contact



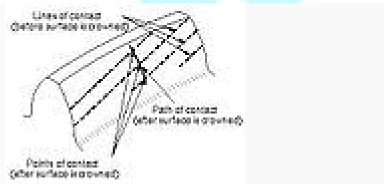
Path of action



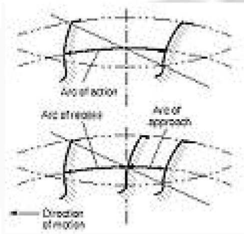
Line of action



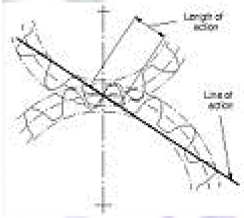
Plane of action



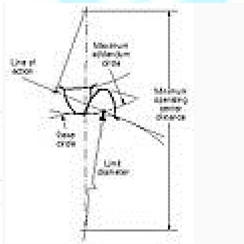
Lines of contact (helical gear)



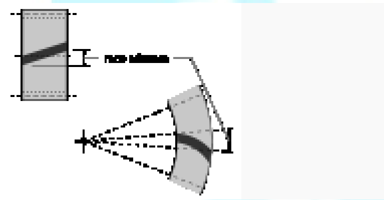
Arc of action



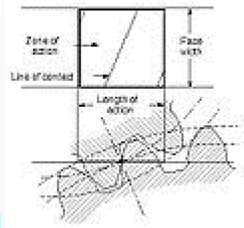
Length of action



Limit diameter



Face advance



Zone of action

Point of contact

Any point at which two tooth profiles touch each other.

Line of contact

A line or curve along which two tooth surfaces are tangent to each other.

Path of action

The locus of successive contact points between a pair of gear teeth, during the phase of engagement. For conjugate gear teeth, the path of action passes through the pitch point. It is the trace of the surface of action in the plane of rotation.

Line of action

The path of action for involute gears. It is the straight line passing through the pitch point and tangent to both base circles.

Surface of action

The imaginary surface in which contact occurs between two engaging tooth surfaces. It is the summation of the paths of action in all sections of the engaging teeth.

Plane of action

The surface of action for involute, parallel axis gears with either spur or helical teeth. It is tangent to the base cylinders.

Zone of action (contact zone)

For involute, parallel-axis gears with either spur or helical teeth, is the rectangular area in the plane of action bounded by the length of action and the effective face width.

Path of contact

The curve on either tooth surface along which theoretical single point contact occurs during the engagement of gears with crowned tooth surfaces or gears that normally engage with only single point contact.

Length of action

The distance on the line of action through which the point of contact moves during the action of the tooth profile.

Arc of action, Q_t

The arc of the pitch circle through which a tooth profile moves from the beginning to the end of contact with a mating profile.

Arc of approach, Q_a

The arc of the pitch circle through which a tooth profile moves from its beginning of contact until the point of contact arrives at the pitch point.

Arc of recess, Q_r

The arc of the pitch circle through which a tooth profile moves from contact at the pitch point until contact ends.

Contact ratio, m_c, ε

The number of angular pitches through which a tooth surface rotates from the beginning to the end of contact.In a simple way, it can be defined as a measure of the average number of teeth in contact during the period in which a tooth comes and goes out of contact with the mating gear.

Transverse contact ratio, m_p, ε_α

The contact ratio in a transverse plane. It is the ratio of the angle of action to the angular pitch. For involute gears it is most directly obtained as the ratio of the length of action to the base pitch.

Face contact ratio, m_F, ε_β

The contact ratio in an axial plane, or the ratio of the face width to the axial pitch. For bevel and hypoid gears it is the ratio of face advance to circular pitch.

Total contact ratio, m_t, ε_γ

The sum of the transverse contact ratio and the face contact ratio.

$\varepsilon_\gamma = \varepsilon_\alpha + \varepsilon_\beta$

$m_t = m_p + m_F$

Modified contact ratio, m_o

For bevel gears, the square root of the sum of the squares of the transverse and face contact ratios.

$$m_o = (m_p^2 + m_F^2)^{0.5}$$

Limit diameter

Diameter on a gear at which the line of action intersects the maximum (or minimum for internal pinion) addendum circle of the mating gear. This is also referred to as the start of active profile, the start of contact, the end of contact, or the end of active profile.

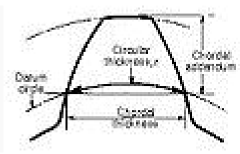
Start of active profile (SAP)

Intersection of the limit diameter and the involute profile.

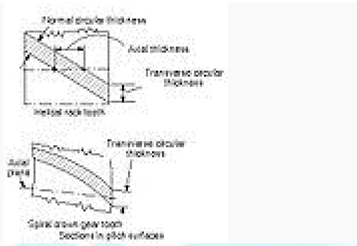
Face advance

Distance on a pitch circle through which a helical or spiral tooth moves from the position at which contact begins at one end of the tooth trace on the pitch surface to the position where contact ceases at the other end.

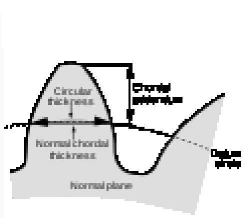
Tooth thickness nomeclature



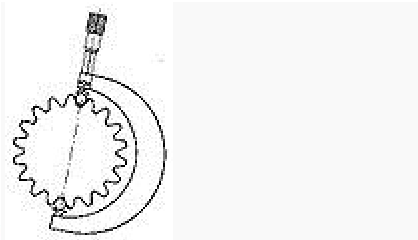
Tooth thickness

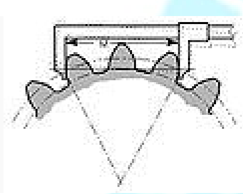


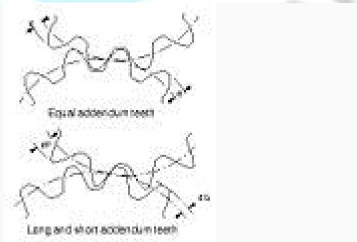
Thickness relationships



Chordal thickness


Tooth thickness measurement over pins


Span measurement



Long and short addendum teeth

Circular thickness

Length of arc between the two sides of a gear tooth, on the specified datum circle.

Transverse circular thickness

Circular thickness in the transverse plane.

Normal circular thickness

Circular thickness in the normal plane. In a helical gear it may be considered as the length of arc along a normal helix.

Axial thickness

In helical gears and worms, tooth thickness in an axial cross section at the standard pitch diameter.

Base circular thickness

In involute teeth, length of arc on the base circle between the two involute curves forming the profile of a tooth.

Normal chordal thickness

Length of the chord that subtends a circular thickness arc in the plane normal to the pitch helix. Any convenient measuring diameter may be selected, not necessarily the standard pitch diameter.

Chordal addendum (chordal height)

Height from the top of the tooth to the chord subtending the circular thickness arc. Any convenient measuring diameter may be selected, not necessarily the standard pitch diameter.

Profile shift

Displacement of the basic rack datum line from the reference cylinder, made non-dimensional by dividing by the normal module. It is used to specify the tooth thickness, often for zero backlash.

Rack shift

Displacement of the tool datum line from the reference cylinder, made non-dimensional by dividing by the normal module. It is used to specify the tooth thickness.

Measurement over pins

Measurement of the distance taken over a pin positioned in a tooth space and a reference surface. The reference surface may be the reference axis of the gear, a datum surface or either one or two pins positioned in the tooth space or spaces opposite the first. This measurement is used to determine tooth thickness.

Span measurement

Measurement of the distance across several teeth in a normal plane. As long as the measuring device has parallel measuring surfaces that contact on an unmodified portion of the involute, the measurement will be along a line tangent to the base cylinder. It is used to determine tooth thickness.

Modified addendum teeth

Teeth of engaging gears, one or both of which have non-standard addendum.

Full-depth teeth

Teeth in which the working depth equals 2.000 divided by the normal diametral pitch.

Stub teeth

Teeth in which the working depth is less than 2.000 divided by the normal diametral pitch.

Equal addendum teeth

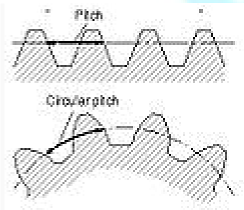
Teeth in which two engaging gears have equal addendums.

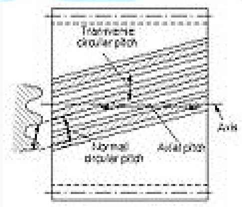
Long and short-addendum teeth

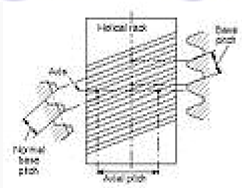
Teeth in which the addendums of two engaging gears are unequal.

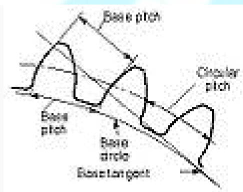
Pitch nomenclature

Pitch is the distance between a point on one tooth and the corresponding point on an adjacent tooth.[4] It is a dimension measured along a line or curve in the transverse, normal, or axial directions. The use of the single word *pitch* without qualification may be ambiguous, and for this reason it is preferable to use specific designations such as transverse circular pitch, normal base pitch, axial pitch.









Pitch Tooth pitch Base pitch relationshipsPrincipal pitches

Circular pitch, *p*

Arc distance along a specified pitch circle or pitch line between corresponding profiles of adjacent teeth.

Transverse circular pitch, p_t

Circular pitch in the transverse plane.

Normal circular pitch, p_n, p_e

Circular pitch in the normal plane, and also the length of the arc along the normal pitch helix between helical teeth or threads.

Axial pitch, p_x

Linear pitch in an axial plane and in a pitch surface. In helical gears and worms, axial pitch has the same value at all diameters. In gearing of other types, axial pitch may be confined to the pitch surface and may be a circular measurement. The term axial pitch is preferred to the term linear pitch. The axial pitch of a helical worm and the circular pitch of its worm gear are the same.

Normal base pitch, p_N, p_{bn}

An involute helical gear is the base pitch in the normal plane. It is the normal distance between parallel helical involute surfaces on the plane of action in the normal plane, or is the length of arc on the normal base helix. It is a constant distance in any helical involute gear.

Transverse base pitch, p_b, p_{bt}

In an involute gear, the pitch on the base circle or along the line of action. Corresponding sides of involute gear teeth are parallel curves, and the base pitch is the constant and fundamental distance between them along a common normal in a transverse plane.

Diametral pitch (transverse), P_d

Ratio of the number of teeth to the standard pitch diameter in inches.

$$P_d = \frac{N}{d} = \frac{25.4}{m} = \frac{\pi}{p}$$

Normal diametral pitch, P_{nd}

Value of diametral pitch in a normal plane of a helical gear or worm.

$$P_{nd} = \frac{P_d}{\cos\psi}$$

Angular pitch, θ_N, τ

Angle subtended by the circular pitch, usually expressed in radians.

$\tau = \frac{360}{z}$ degrees or $\frac{2\pi}{z}$ radians

Backlash

Main article: Backlash (engineering)

Backlash is the error in motion that occurs when gears change direction. It exists because there is always some gap between the trailing face of the driving tooth and the leading face of the tooth behind it on the driven gear, and that gap must be closed before force can be transferred in the new direction. The term "backlash" can also be used to refer to the size of the gap, not just the phenomenon it causes; thus, one could speak of a pair of gears as having, for example, "0.1 mm of backlash." A pair of gears could be designed to have zero backlash, but this would presuppose perfection in manufacturing, uniform thermal expansion characteristics throughout the system, and no lubricant. Therefore, gear pairs are designed to have some backlash. It is usually provided by reducing the tooth thickness of each gear by half the desired gap distance. In the case of a large gear and a small pinion, however, the backlash is usually taken entirely off the gear and the pinion is given full sized teeth. Backlash can also be provided by moving the gears farther apart.

For situations, such as instrumentation and control, where precision is important, backlash can be minimised through one of several techniques. For instance, the gear can be split along a plane perpendicular to the axis, one half fixed to the shaft in the usual manner, the other half placed alongside it, free to rotate about the shaft, but with springs between the two halves providing relative torque between them, so that one achieves, in effect, a single gear with expanding teeth. Another method involves tapering the teeth in the axial direction and providing for the gear to be slid in the axial direction to take up slack.

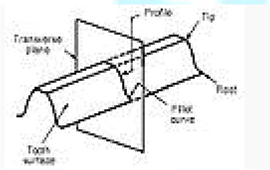
Shifting of gears

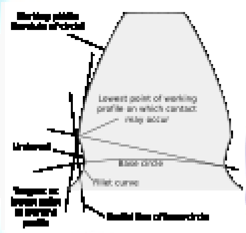
In some machines (e.g., automobiles) it is necessary to alter the gear ratio to suit the task. There are several methods of accomplishing this. For example:

- Manual transmission
- Automatic transmission
- Derailleur gears which are actually sprockets in combination with a roller chain
- Hub gears (also called epicyclic gearing or sun-and-planet gears)

There are several outcomes of gear shifting in motor vehicles. In the case of vehicle noise emissions, there are higher sound levels emitted when the vehicle is engaged in lower gears. The design life of the lower ratio gears is shorter so cheaper gears may be used (i.e. spur for 1st and reverse) which tends to generate more noise due to smaller overlap ratio and a lower mesh stiffness etc than the helical gears used for the high ratios. This fact has been utilized in analyzing vehicle generated sound since the late 1960s, and has been incorporated into the simulation of urban roadway noise and corresponding design of urban noise barriers along roadways.

Tooth profile





Profile of a spur gear

Undercut

A profile is one side of a tooth in a cross section between the outside circle and the root circle. Usually a profile is the curve of intersection of a tooth surface and a plane or surface normal to the pitch surface, such as the transverse, normal, or axial plane.

The fillet curve (root fillet) is the concave portion of the tooth profile where it joins the bottom of the tooth space.[2]

As mentioned near the beginning of the article, the attainment of a non fluctuating velocity ratio is dependent on the profile of the teeth. Friction and wear between two gears is also dependent on the tooth profile. There are a great many tooth profiles that will give a constant velocity ratio, and in many cases, given an arbitrary tooth shape, it is possible to develop a tooth profile for the mating gear that will give a constant velocity ratio. However, two constant velocity tooth profiles have been by far the most commonly used in modern times. They are the cycloid and the involute. The cycloid was more common until the late 1800s; since then the involute has largely superseded it, particularly in drive train applications. The cycloid is in some ways the more interesting and flexible shape; however the involute has two advantages: it is easier to manufacture, and it permits the center to center spacing of the gears to vary over some range without ruining the constancy of the velocity ratio. Cycloidal gears only work properly if the center spacing is exactly right. Cycloidal gears are still used in mechanical clocks.

An undercut is a condition in generated gear teeth when any part of the fillet curve lies inside of a line drawn tangent to the working profile at its point of juncture with the fillet. Undercut may be deliberately introduced to facilitate finishing operations. With undercut the fillet curve intersects the working profile. Without undercut the fillet curve and the working profile have a common tangent.

Gear materials

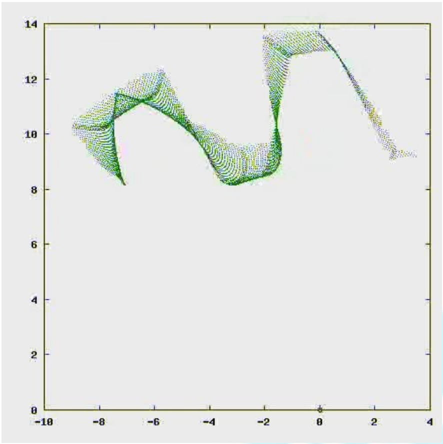
Wooden gears of a historic windmill

Numerous nonferrous alloys, cast irons, powder-metallurgy and even plastics are used in the manufacture of gears. However steels are most commonly used because of their high strength to weight ratio and low cost. Plastic is commonly used where cost or weight is a concern. A properly designed plastic gear can replace steel in many cases because it has many desirable properties, including dirt tolerance, low speed meshing, and the ability to "skip" quite well. Manufacturers have employed plastic gears to make consumer items affordable in items like copy machines, optical storage devices, VCRs, cheap dynamos, consumer audio equipment, servo motors, and printers.

The module system

Countries which have adopted the metric system generally use the module system. As a result, the term module is usually understood to mean the pitch diameter in millimeters divided by the number of teeth. When the module is based upon inch measurements, it is known as the *English module* to avoid confusion with the metric module. Module is a direct dimension, whereas diametral pitch is an inverse dimension (like "threads per inch"). Thus, if the pitch diameter of a gear is 40 mm and the number of teeth 20, the module is 2, which means that there are 2 mm of pitch diameter for each tooth.

Manufacture



Gear Cutting simulation (length 1m35s) faster, high bitrate version.

This section requires expansion.

Gear are most commonly produced via hobbing, but they are also shaped, broached, cast, and in the case of plastic gears, injection molded. For metal gears the teeth are usually heat treated to make them hard and more wear resistant while leaving the core soft and tough. For large gears that are prone to warp a quench press is used.

Gear model in modern physics

Modern physics adopted the gear model in different ways. In nineteenth century James Clerk Maxwell developed a model of electromagnetism in which magnetic field lines were rotating tubes of incompressible fluid. Maxwell used gear wheel and called it “idle wheel” to explain the electrical current as a rotation of particles in opposite direction to that of the rotating field lines.

5. Post test:

a) What is the definition of "gears ", "tooth profile"?

b) What are the common types of gears? Draw all types?

c) Also define all common characters for gear And draw pinion and rack with mish between them for 24 teeth for the rack and pinion?

6. References:

1. R.B. Gupta, "Engineering Drawing and Graphics", effective 1993&other engg.exams.
2. N.D. Bhatt, "Machine Drawing", Twenty-Second Edition, (1991).
3. (1988) in Henry H. Ryffel (ed.): Machinery's Handbook 23rd Edition. New York: Industrial Press Inc. ISBN 0-8311-1200-X.
4. Wikipedia, the free encyclopedia

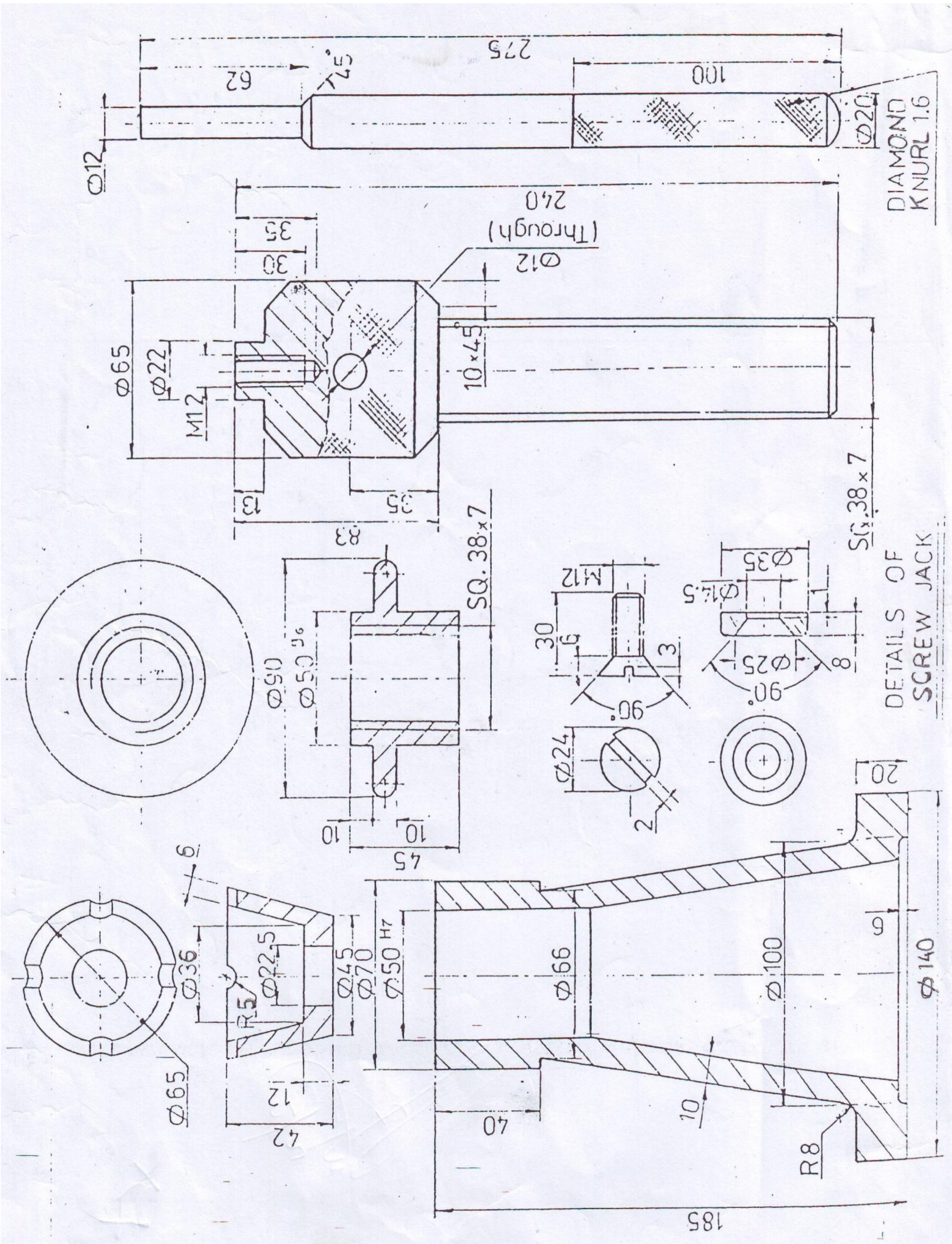
The 14th – 17th week

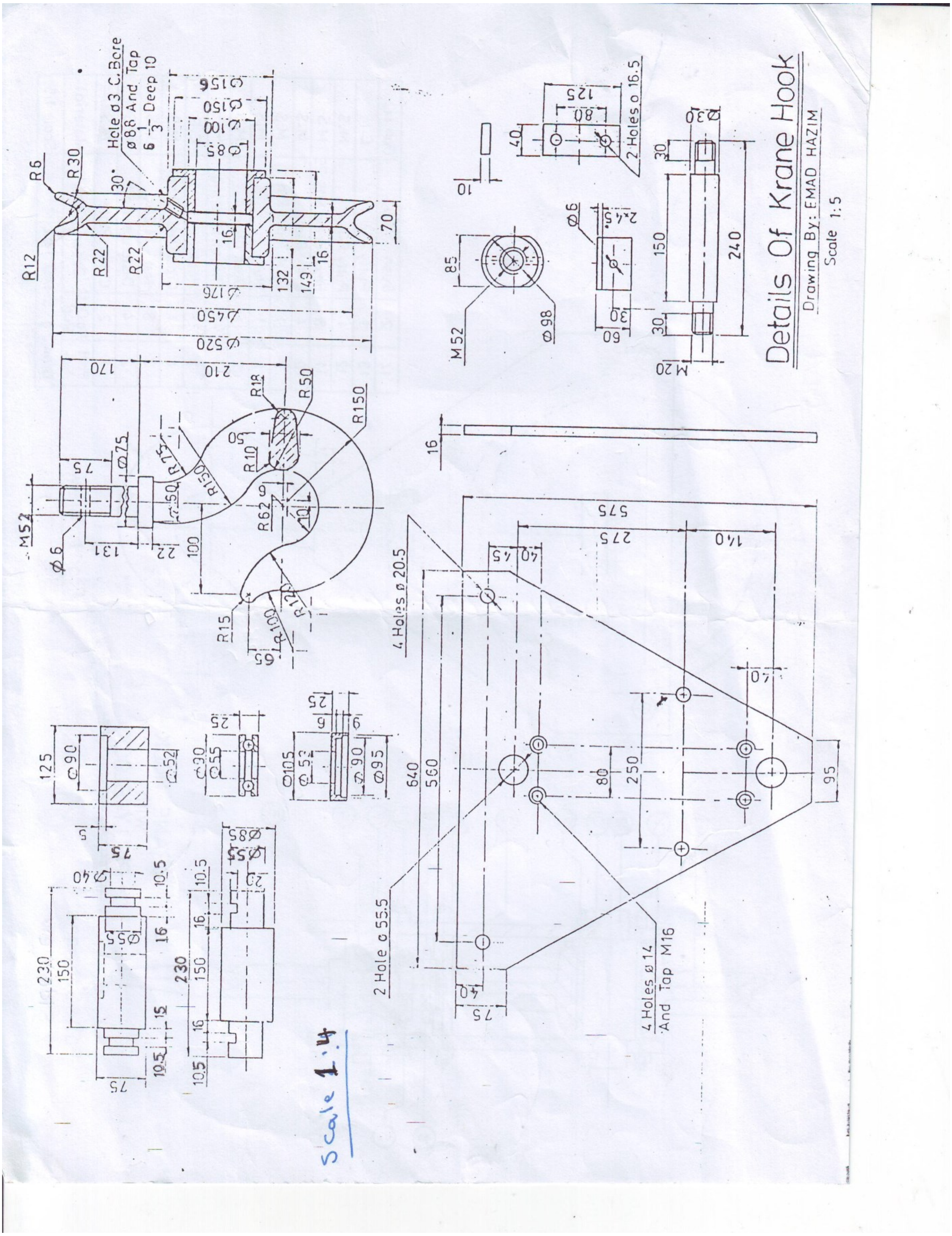
Assembly and details of common mechanical unit, (Vice).

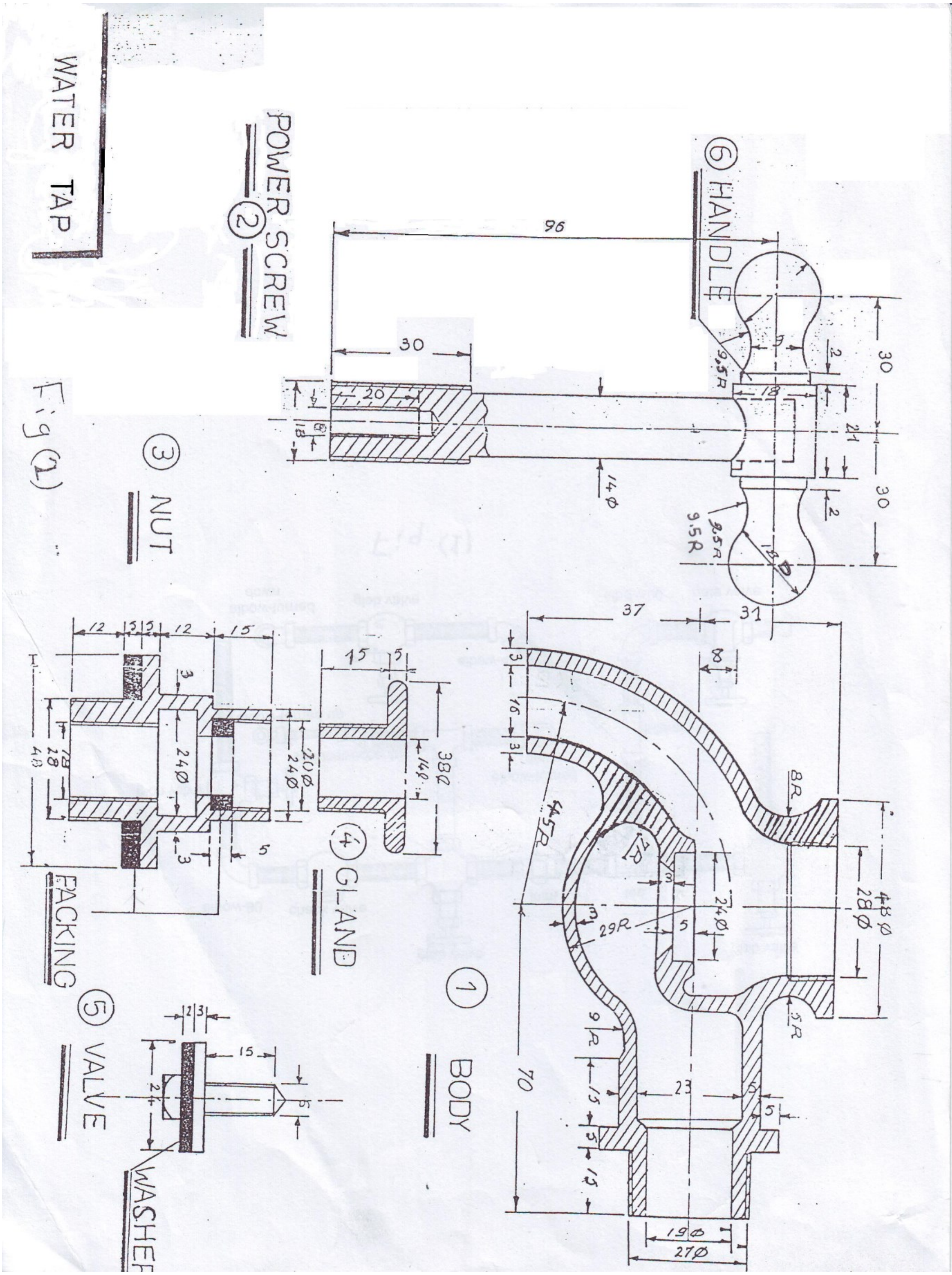
1. Assembly and details of common mechanical unit, (Vice).
2. **Class:** second year
3. **Subject:** general introduction for the assembly and details for common mechanical unit.
4. **Central idea:** To make the students understanding all about the assembly and details of common mechanical unit with common applications in different machines units.
5. **Goals:** **To teach the students the correct drawing in mechanical drawings for different scientific subjects also to show the students all used symbols in refrigeration and air conditioning drawings through the standard conventions and all the drawing fundamentals.**
6. **Pre test:**

   a) **What is your expecting about assembly and details of common mechanical unit, (Vice).?**

   b) **Give an example for assembly drawing.**


DETAILS OF SCREW JACK
DIAMOND KNURL 1.6
Ø12 (Through)
SQ. 38 x 7


Details Of Krane Hook
Drawing By: EMAD HAZIM
Scale 1:5
Scale 1:4


WATER TAP
POWER SCREW
2
HANDLE
6
NUT
3
GLAND
4
BODY
1
PACKING
VALVE
5
WASHER
Fig (1)

7. Post test:

a) **Draw an assembly for the screw jack.**

b) **Draw an assembly for a crane hook.**

c) **Draw an assembly for water tap?**

8. References:

5. R.B. Gupta, "Engineering Drawing and Graphics", effective 1993&other engg.exams.
6. N.D. Bhatt, "Machine Drawing", Twenty-Second Edition, (1991).
7. (1988) in Henry H. Ryffel (ed.): Machinery's Handbook 23rd Edition. New York: Industrial Press Inc. ISBN 0-8311-1200-X.
8. Wikipedia, the free encyclopedia

The 18th to 19th week
Coupling, Types of coupling, rigid and flexible coupling. Muff, old ham's and universal coupling

1. Coupling, Types of coupling, rigid and flexible coupling, Muff, old ham's and universal coupling
2. **Class:** second year
3. **Subject:** general introduction for the assembly and details for common mechanical unit in coupling.
4. **Central idea:** To make the students understanding all about the Coupling, Types of coupling, rigid and flexible coupling with common applications in different machines units. Also to over viewing for especial types of shaft couplings (Muff, old ham's and universal coupling)
5. **Goals:** **To teach the students the correct drawing in mechanical drawings for different scientific subjects use coupling, Types of coupling, rigid and flexible coupling also to show the students all used symbols in refrigeration and air conditioning drawings used the couple through the standard conventions and all the drawing fundamentals.**
6. **Pre test:**

   a) **What is your expecting about Coupling.**

   b) **List your expected types of coupling**

   c) **What is your expecting about rigid and flexible coupling.**

Shaft coupling

Shaft couplings: Are used for transmitting rotary motion directly from one shaft to another.

They may be classified as:

A) **faster or rigid**
B) **Loose or disengaging**
C) **Flexible couplings**

A) **Faster or rigid couplings**: These couplings do not permit any relative rotation between the two shafts. The various types of rigid couplings are described below:

1) **Box or muff coupling**(Fig.1):

- Consists of cast iron, cylindrical
- Ends of the two shafts butt against each other
- Along, sunk taper key is driven through both the shafts and the muff.
- D_{muff} is equal to $2D_{shaft}$,and L_{muff} is equal to $3D_{shaft}$

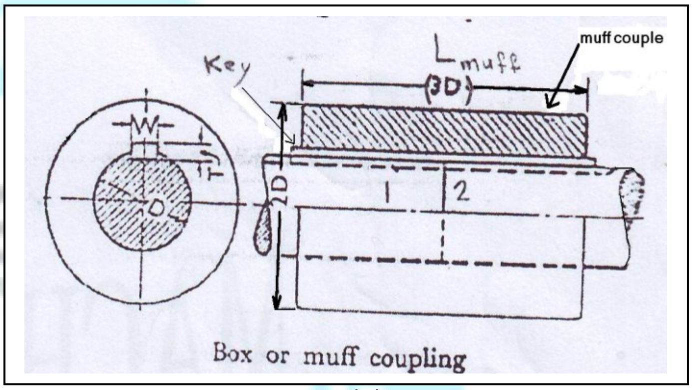


Fig.(1)

2) **Half-lap coupling** (Fig.2)

- Ends of the shafts are made to overlap each other for the short length.
- The taper in the over-lap prevents the shafts from separating, if pulled in opposite directions due to the tension.
- A hollow saddle key is used to connect the muff and the shafts.
- The diameter and the length of the muff are both equal to about twice the diameter of the shafts.

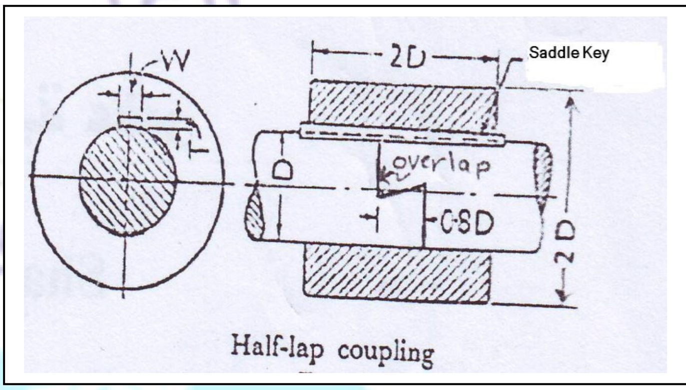


Fig.(2)

3) **Split-muff coupling** (Fig.3)

Muff is made in two semi-cylindrical halves which are joined together by means of bolts and nuts.

The coupling is done with the help of a feather key.

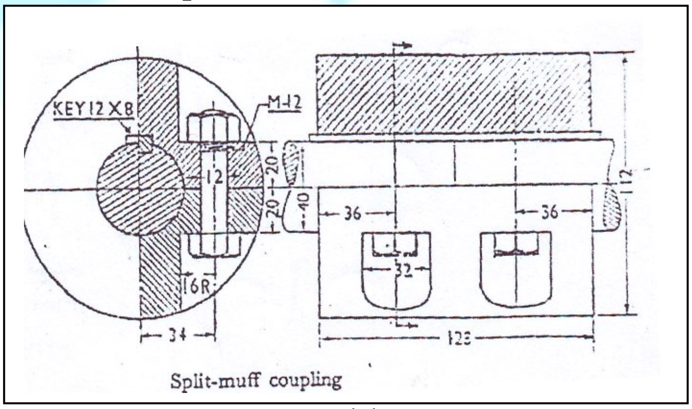


Fig.(3)

4) Flanged coupling (Fig.4)

- This is a standard form of coupling and is extensively used.
- It consists of two cast-iron flanges keyed to the ends of the two shafts and fastened together by means of a number of lights fitting bolts.
- Sunk taper keys of rectangular or square cross-section are used for the purpose.
- The shafts may be kept in alignment by the spigot and socket arrangement (Fig.5)

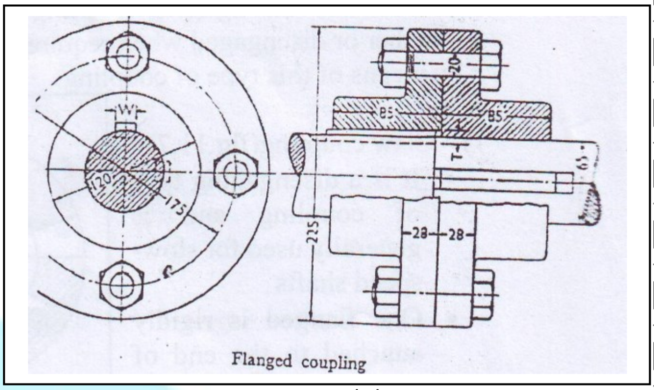


Fig.(4)

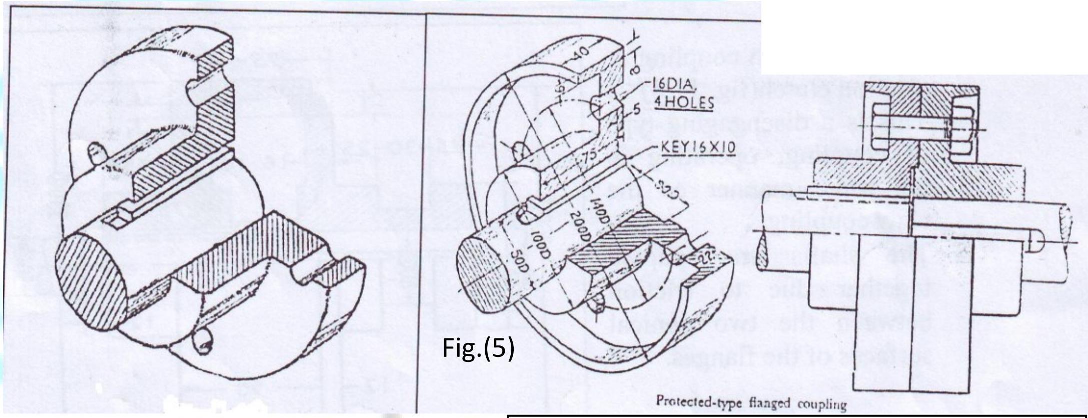


Fig.(5)

5) Solid flanged coupling (Fig.6)

- This type of coupling is used mainly for shafts of marine engines.
- The flanges are forged solid with the shafts and are connected together by means of a number of headless taper bolts.

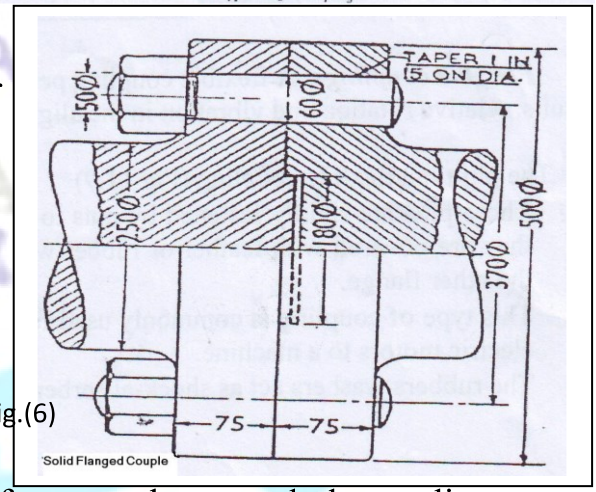


Fig.(6)

B) Loose or disengaging coupling: The shafts may be coupled coupling or disengaged when required, even while they may be rotating, by means of this type of coupling.

1) Claw coupling(Fig.7)

- It is a disengaging type of coupling and is generally used for slow-speed shafts
- One flanged is rigidly attached to the end of one shaft.

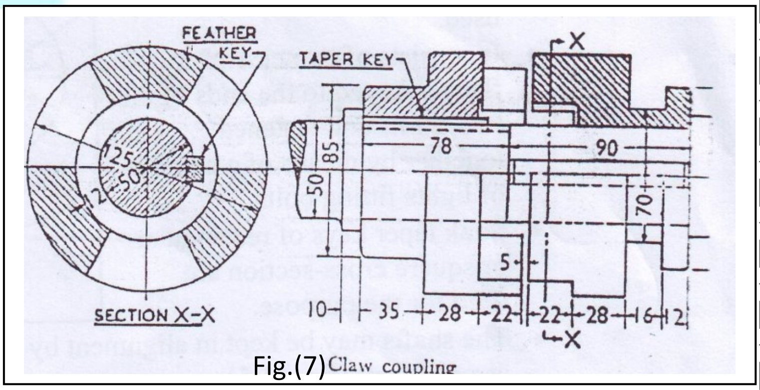


Fig.(7)Claw coupling

2) Conical friction coupling or con friction clutch (Fig.8)

- This is a disengaging type of coupling, operating in the same manner as the claw coupling.
- The shafts are coupled together due to friction between the two conical surfaces of the flanges.

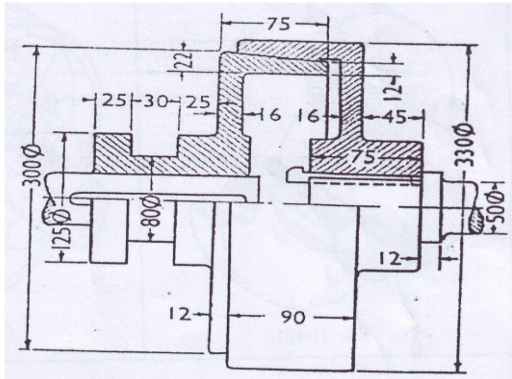


Fig.(8) Cone friction clutch

C) Flexible couplings: A flexible coupling permits within certain limits, relative rotation and vibration in the alignment of shafts.

1) The pin-type flexible coupling (Fig.9)

- These pins are rigidly fastened by nuts to one of the flan^{g}es while they are covered with leather or rubber washers and kept loose in the other flange.
- This type of coupling is commonly used for directly connecting an electric motors to a machine.
- The rubbers washers act as shock-absorbers and insulators.

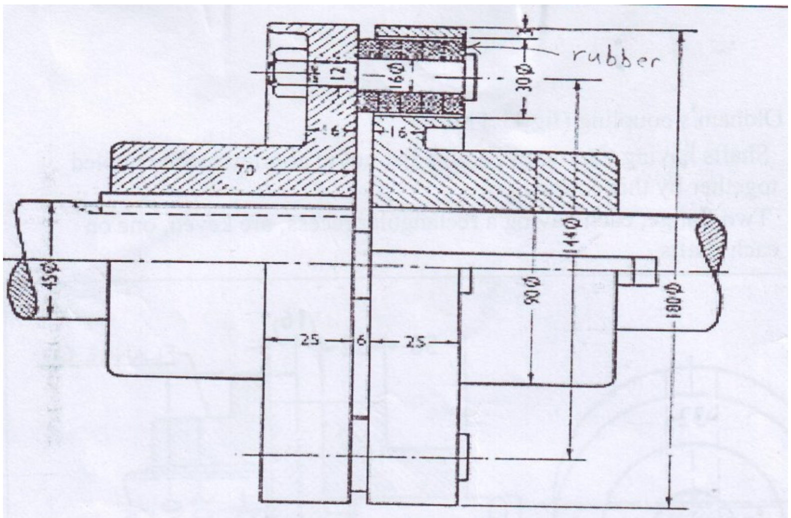


Fig.9 Pin-type flexible coupling

Other forms of coupling

1) Universal coupling or hookes-joint (Fig.10) :

- This form of COLIpling' is used to couple together two shafts whose axes together
- intersect.
- Two similar forks are keyed on to the ends of the two shafts .
- In this type of coupling, the angle between the shafts may be varied even when they are in motion.

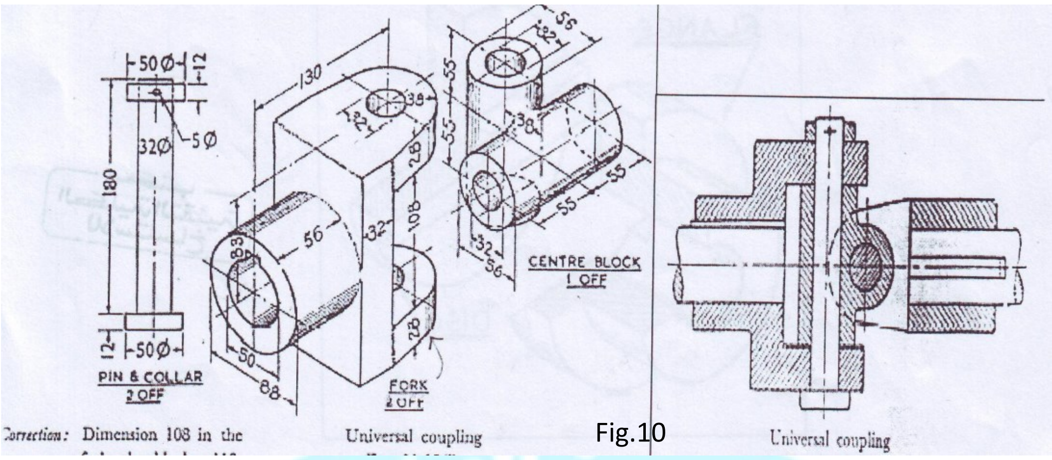


Fig.10

2) Oldham's coupling (Fig.11) :

- Shafts having their axes parallel but not in alignment are coupled together by this coupling.
- Two flange, each having a rectangular recess, are keyed, one on each shafts .

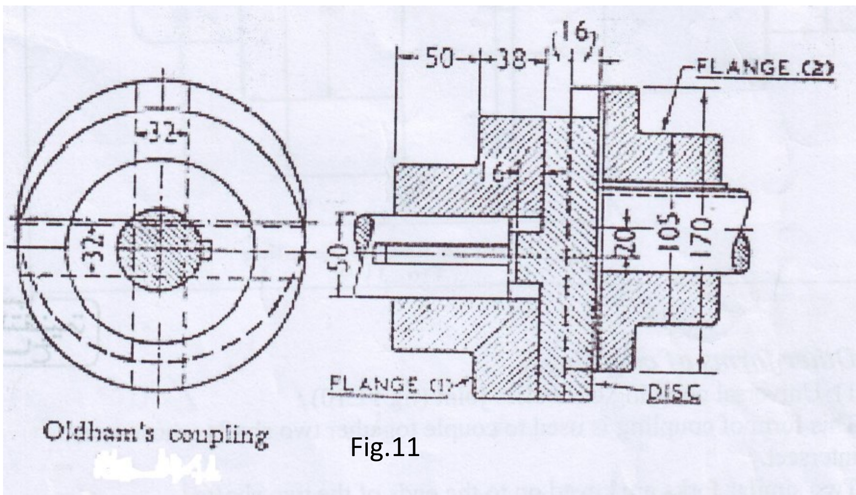
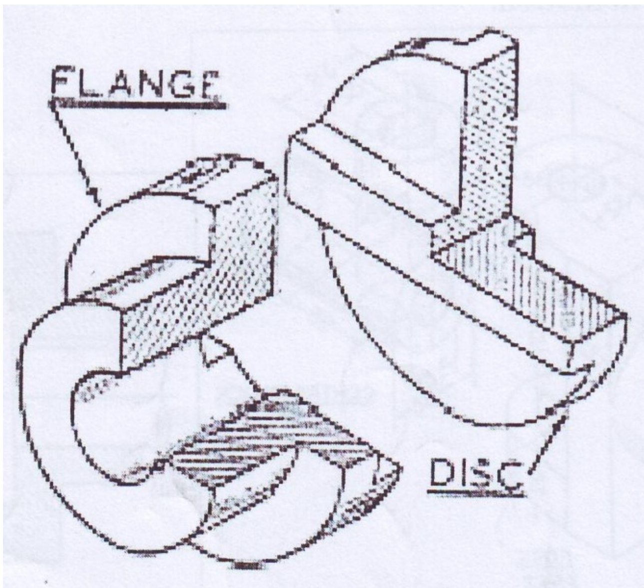


Fig.11



7. Post test:

a) List all shaft couplings classifications.

b) Compare between muff coupling & Half-lap coupling.

c) Draw Split-muff coupling?

8. References:

1. Wikipedia, the free encyclopedia
2. R.B. Gupta, "Engineering Drawing and Graphics", effective 1993&other engg.exams.
3. N.D. Bhatt, "Machine Drawing", Twenty-Second Edition, (1991).
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The 20th – 21th week

Bearings, types of bearings, sliding contact bearings.

1. **Class:** second year
2. **Subject:** general introduction for the Bearings, types of bearings, sliding contact bearings.
3. **Central idea:** To make the students understanding all about the Bearings, types of bearings, sliding contact bearings with common applications in different machines units.
4. **Goals:** To teach the students the correct drawing in mechanical drawings for different scientific subjects use Bearings, types of bearings, sliding contact bearings. Also to show the students all used symbols in refrigeration and air conditioning drawings used the Bearings through the standard conventions and all the drawing fundamentals.
5. **Pre test:**

a) What is your expecting about Bearings.

b) List your expected types of Bearings

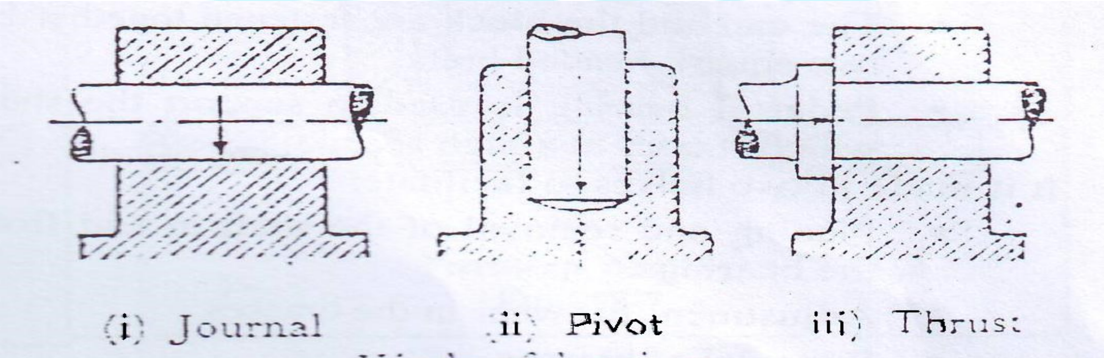
c) What is your expecting about sliding contact bearings?

d)

A bearing is a machine element which supports another moving machine element. It permits a relative motion between the contact surfaces of the members while carrying the load. Due to the relative motion between the contact surfaces, a certain amount of power is wasted in overcoming frictional resistance.

There are three main kinds of bearings:

1. A journal bearing
2. A pivot bearing
3. A collar or thrust bearing

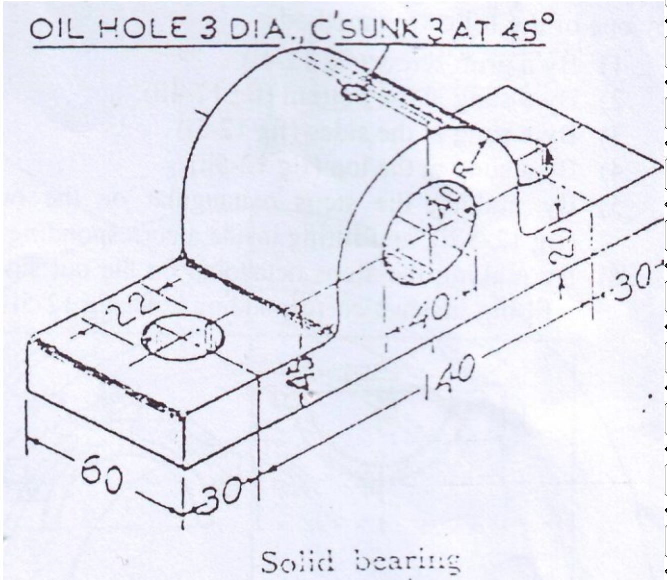


Kinds of bearings

1. Journal bearing. [Fig.1(i)]: in which the bearing pressure is perpendicular to the axis of the shaft.

i) Solid bearing [Fig.2]

- This is the simplest form of a journal bearing.
- It is made of cast-iron.
- An oil-hole is drilled at the top to lubricate the bearing, and to reduce the friction between the shaft and the bearing.
- Its rectangular base-plate or sole has two holes drilled in it for bolting down the bearing in its position.
- Used for shafts which Carry light loads and which rotate at comparatively slow speeds



Solid bearing

Fig.1

- It has Very limited field of application.

ii)Bushed bearing [Fig.3]

- It is a slight modified form of the solid type of bearings.
- It is has a hollow bush of brass or gun metal, the bush is pressed inside the bore in the bearing and is prevented from rotating or sliding by means of a grub-screw or a dowel-pin inserted half inside the bush and half in the block.

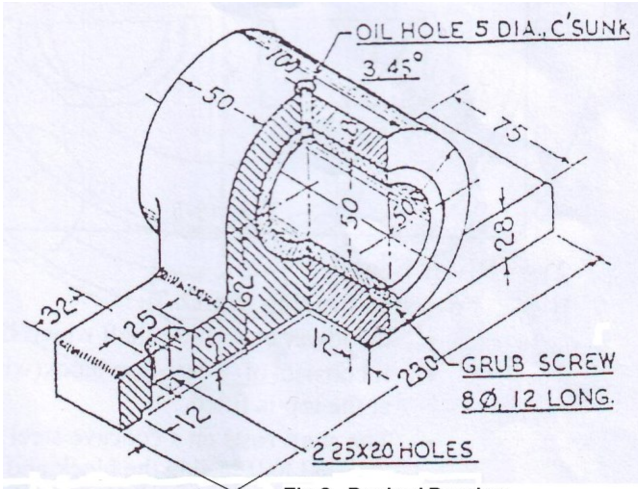


Fig.3 Bushed Bearing

- Easily removed and replaced the bush by a new one when the bush gets worm out.
- The bolt-holes are made longer and with semi-circular ends for adjusting the position of the bearing.
- iii) **Pedestal bearing or** Plummer block **[Fig.4] :** A pedestal bearing is consist of
  - A cast-iron pedestal or block with a sole.
  - Gun-metal brasses or steps made in two halves.
  - A cast-iron cap and two mild-steel bolts.
  - The cap and the block are fastened together by two square-headed bolts.
  - Pedestal bearing is used to support the shaft which rotates at a high speed.

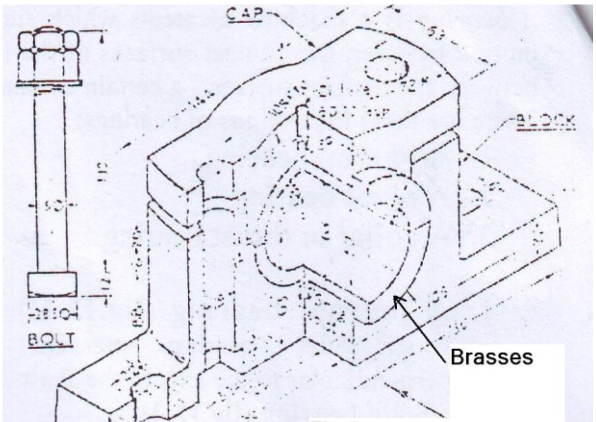


Fig.4

It is made in two halves to facilitate:

- Placing and removal of the shaft in and from the bearings.
- Adjustment for wear in the brasses.
- Renewal of brasses.

Brasses are prevented from rotating along with the shaft by one of the following methods:

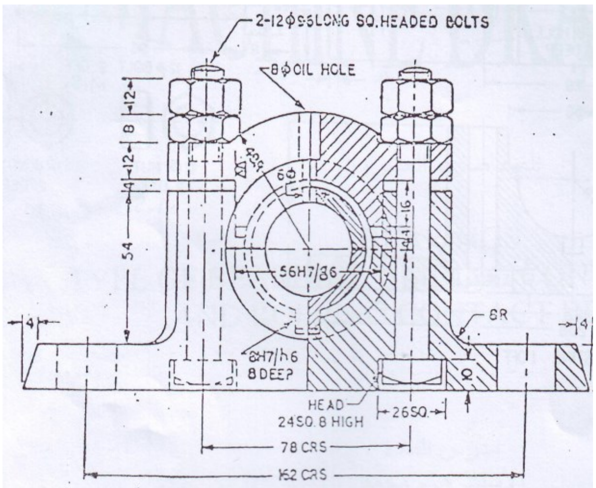


Fig.5

1) lay a grub screw (Fig.4)
2) By a sung at the bottom (Fig.5)
3) By a sung at the sides (Fig.6i)
4) By a sung at the top (Fig.6ii)
5) By making the steps rectangular on the outside (Fig.6iii), and fitting inside a corresponding hole.

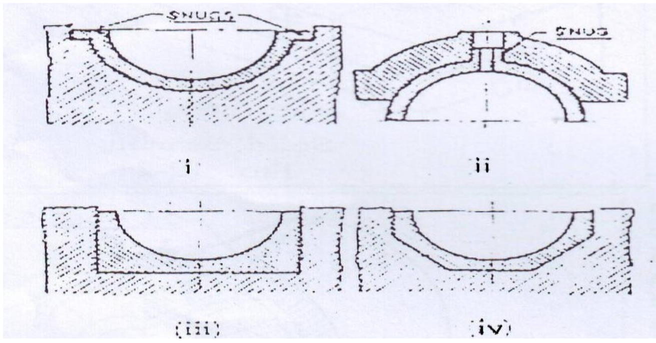


Fig.6

6) By making the steps octagonal on the outside and fifing inside a corresponding hole [Fig.6iv)

Pivot Bearing

i) Foot-step bearing [Fig.7]:

- The lower end of the shaft which is vertical is supported.
- It consists of a cast-iron block (with a sole), into which gun metal bush having a collar at the top is fitted.
- The shaft rests on a concave steel disc; this disc is prevented from rotating by a pin. Inserted half inside the block and half inside the disc and away from the centre.

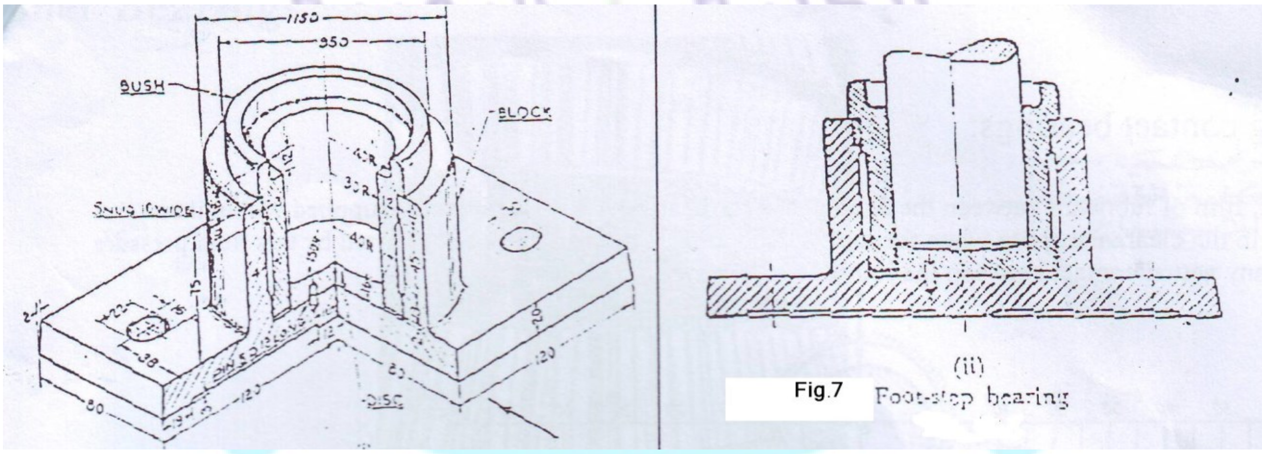


Fig.7 Foot-step bearing

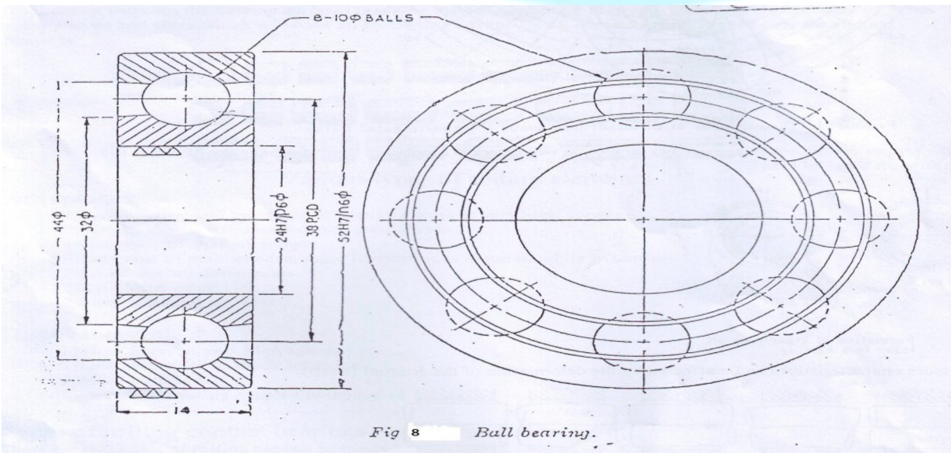


Fig 8 Ball bearing.

Sliding contact bearings:

The thick film of lubricant between the Journal and the bearing if it is sufficiently supplied will build a pressure in the clearance space when the journal is rotating. The load can be supported by this fluid pressure without any actual contact between the journal and bearing.

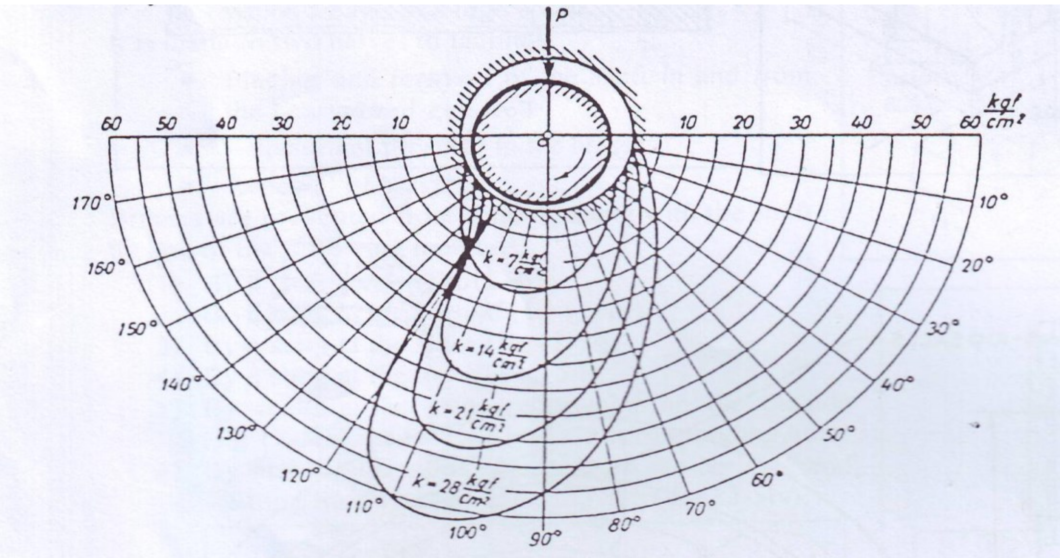


Fig.9 Pressure in the oil layer at different unit loads k (experimental data)

Under the proper conditions this resistance to motion will develop a pressure distribution in the lubricant film that can support a useful load

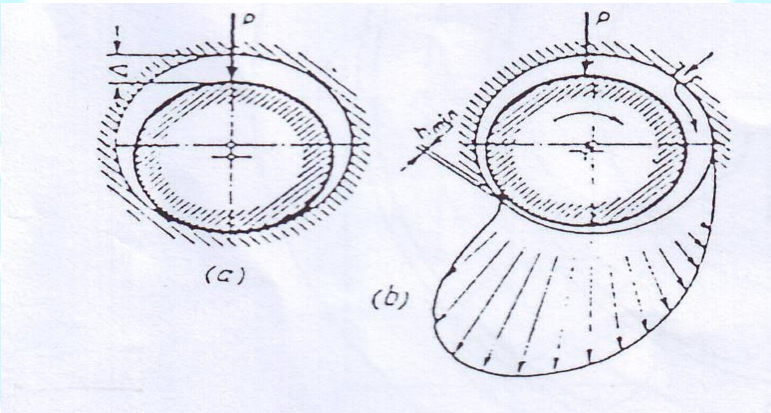


Fig.10 Formation of a carrying oil layer in a bearing

The pressure characteristics can be affected by the deformation of the Journal (shaft)

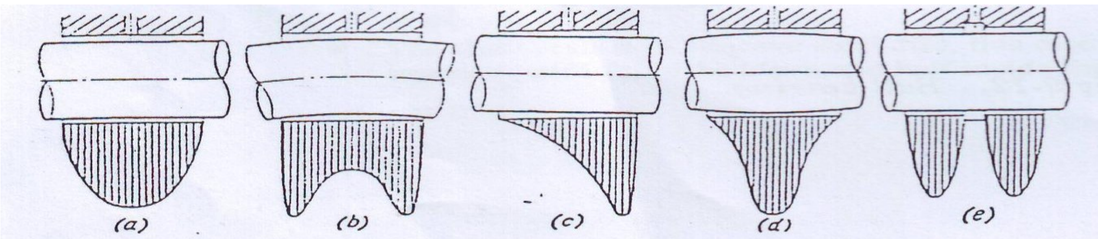


Fig.11 Pressure in the oil layer along the bearing axis

Roller Bearings

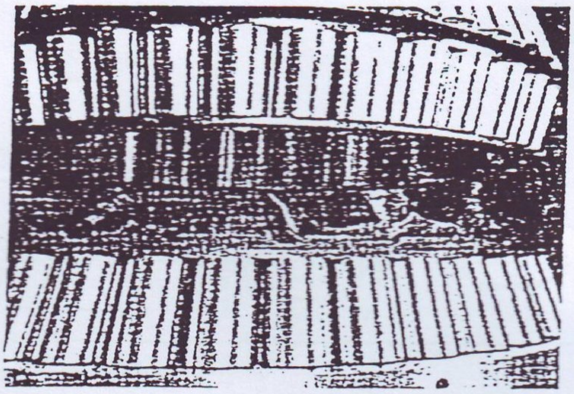


Fig.12

A 5.61 ton, 1.2 m outer diameter four-row tapered roller bearing made by FAG, Schweinfurt, Germany.

The contact between the bearing surfaces is rolling instead of sliding; the types of rolling elements are of many shapes and sizes which will have an outstanding advantage of a low starting friction over the sliding bearings

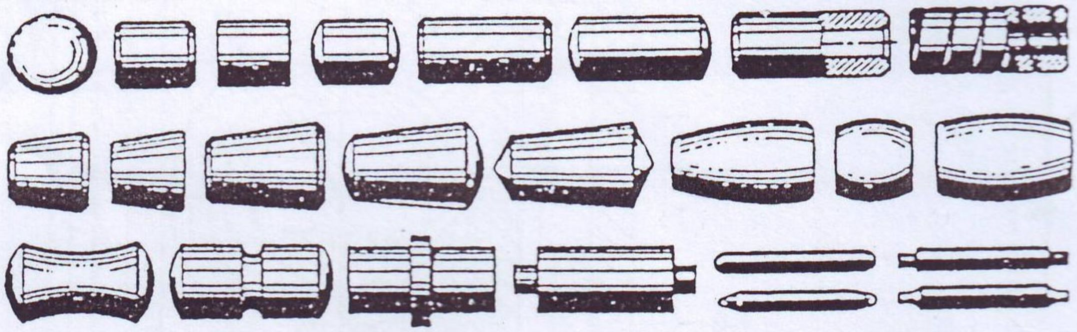


Fig.13 Various types of rolling elements

Advantages:

1) Low starting and low running friction except at very high speeds

2) Ability to withstand momentary shock- loads

3) Accuracy of shaft alignment.

4) Low cost of maintenance, as no lubrication is required while in service

5) Small overall dimensions.

6) Reliability of service

7) Easy to mount and erect

8) Cleanness

Disadvantages:

1) More noisy at very high speeds
2) Low resistance to shock loading
3) More initial cost
4) Design of bearing housing complicated

Types of rolling contact bearings

There are two types of rolling contact bearings:

1) Ball bearing

2) Roller bearing

The bearings consists of inner race which is mounted on the shaft or journal and an outer race which is carried by a housing or casing, in between the inner and outer race there are balls or rollers which is held in place by means of a cage

Footstep Bearing or Pivot Bearing

Footstep bearing is used to support a vertical shaft. The bearing consists of three parts (i) cast iron block with sole (ii) gunmetal liner or bush having a collar at the top and (iii) gunmetal pad or disc. The pad is prevented from rotating by a Snug provided at its bottom away from the center (out of the center) which fits into the corresponding.

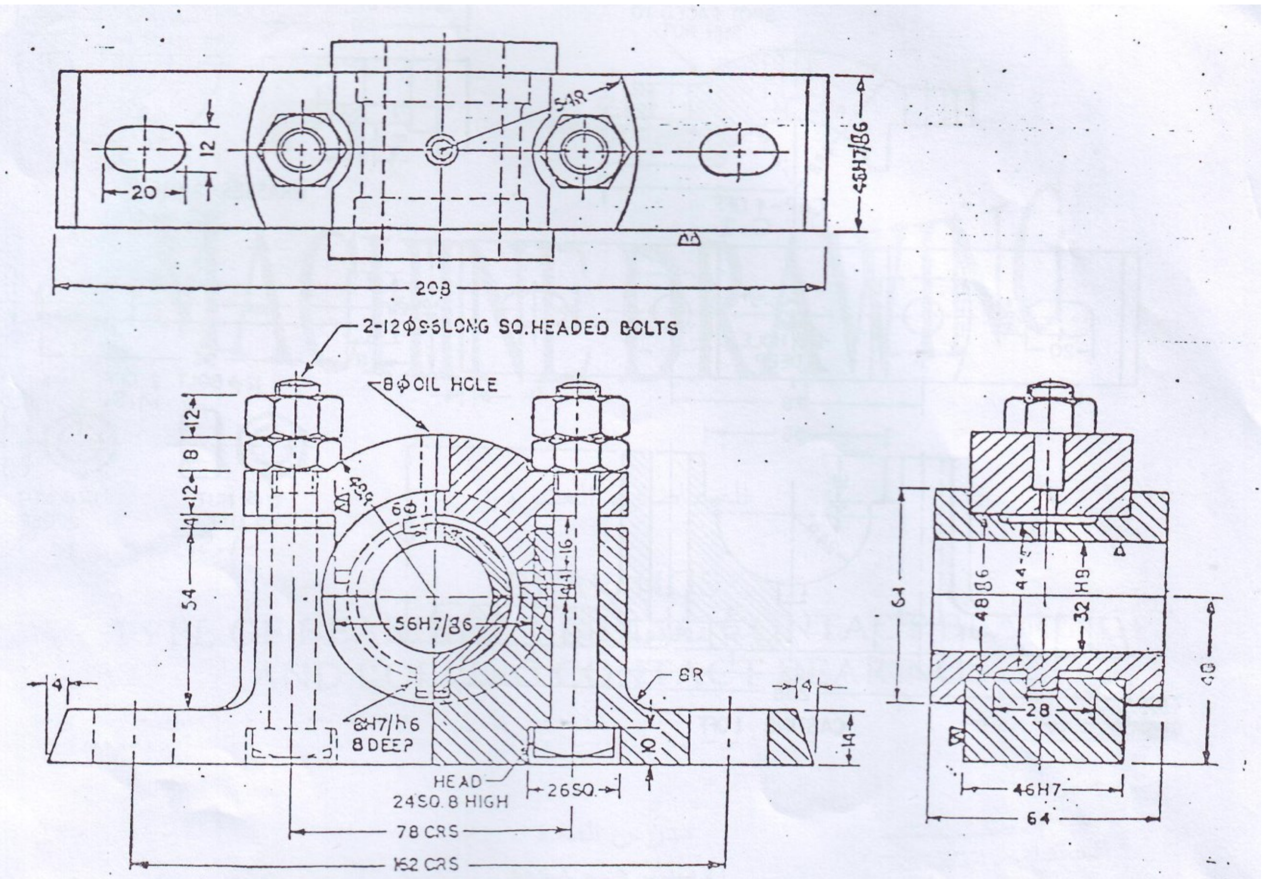
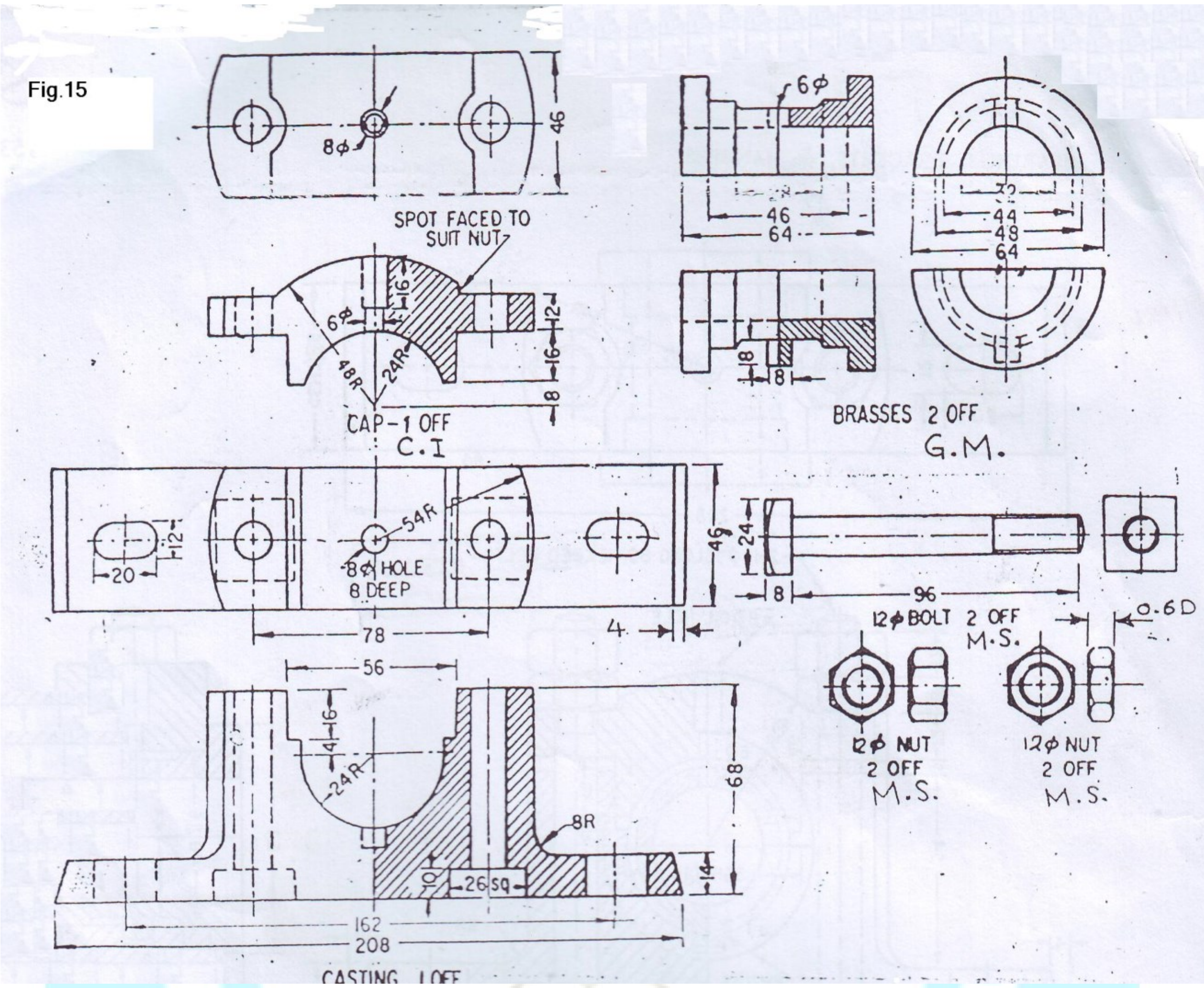


Fig 9-8. Pedestal Bearing.

Material list

S. No.	*Parts name*	*Material*	*No. off.*
1	Supporting casting	C.I.	1
2	Bush	G.M.	1
3	Pad.	G.M.	1
4	Shaft	M.S.	1

Fig.14



7. Post test:

a) List all bearing classifications.

b) Pedestal bearing or Plummer block show in Fig.(15)

8. References:

1. Wikipedia, the free encyclopedia
2. R.B. Gupta, "Engineering Drawing and Graphics", effective 1993&other engg.exams.
3. N.D. Bhatt, "Machine Drawing", Twenty-Second Edition, (1991).
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The 22th-23 week

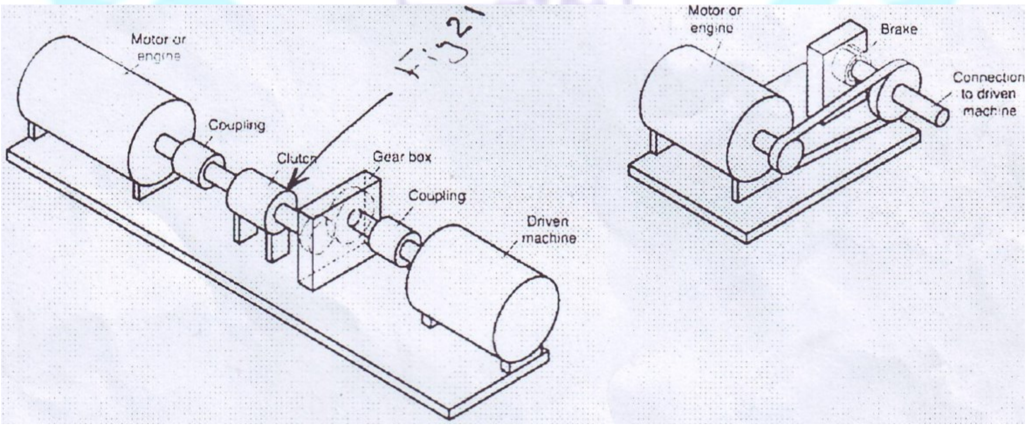
Clutches and brakes

A clutch is a device which permits the smooth gradual connection of two shafts rotating at different speeds. A brake enables the controlled dissipation of energy to slow down, stop or control the speed of a system

When a machine is started from rest it must be accelerated to the desired speed. A clutch is used to connect or disconnect a driven component from a prime mover such as an engine or motor, A familiar application is the use of clutch between the engine's crankshaft and the gearbox in automotive applications.

The need for the clutch arises from the relatively high torque requirement to get a vehicle moving and a low torque output from an internal combustion engine at low level of rotational speed. The disconnection of the engine from the drive enables the engine to speed up unloaded to about 1000 **rpm** where it is generating sufficient torque to drive the transmission. The clutch can then be engaged, allowing power to be transmitted to the gear box, transmission shafts and wheels.

A brake is a device used to reduce or control the speed of a system or bring it to rest. Typical applications of a clutch and a brake is illustrated bellow:



Whenever the speed or direction of motion of a body is changed there is force exerted on the body, if the speed changes so does the energy, either by addition or absorption, the acceleration α of a rotating machine is given by $\alpha = T/I$, where T is the torque and I is the mass moment of inertia.

If the acceleration is set and the mass moment of inertia is determined, the approximate value of torque required to accelerate or brake can be estimated. this can be used as the principal starting point for the design or selection of the clutch or brake

Torque is equal to the ratio of power and angular velocity, In other words, torque is inversely proportional to angular velocity. This implies that it is usually advisable to locate the clutch or brake on the highest speed shaft in the system so that the required torque is a minimum. size, cost and response

Time are all lower when the torque is lower. The disadvantage is that the speed differential between components can result in increased slipping and associated frictional heating, potentially causing overheating problems.

Friction type clutches and brakes are the most common. Two or more surfaces are pushed together with a normal force to generate a friction torque. Normally , at least one surface is metal and the other a high friction material referred to as the lining.

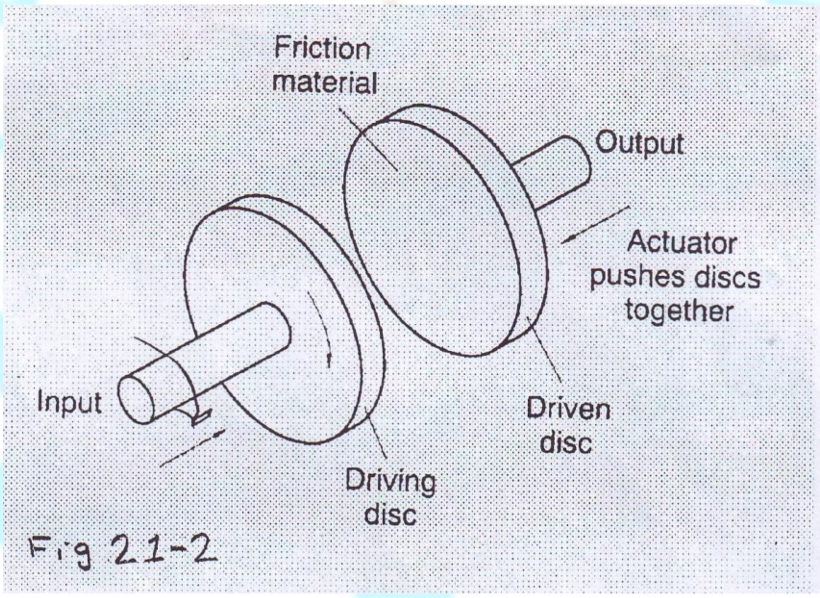


Fig 21-2

Clutches

The function of a clutch is to permit the connection and disconnection of two shafts. The clutch classifications is presented bellow

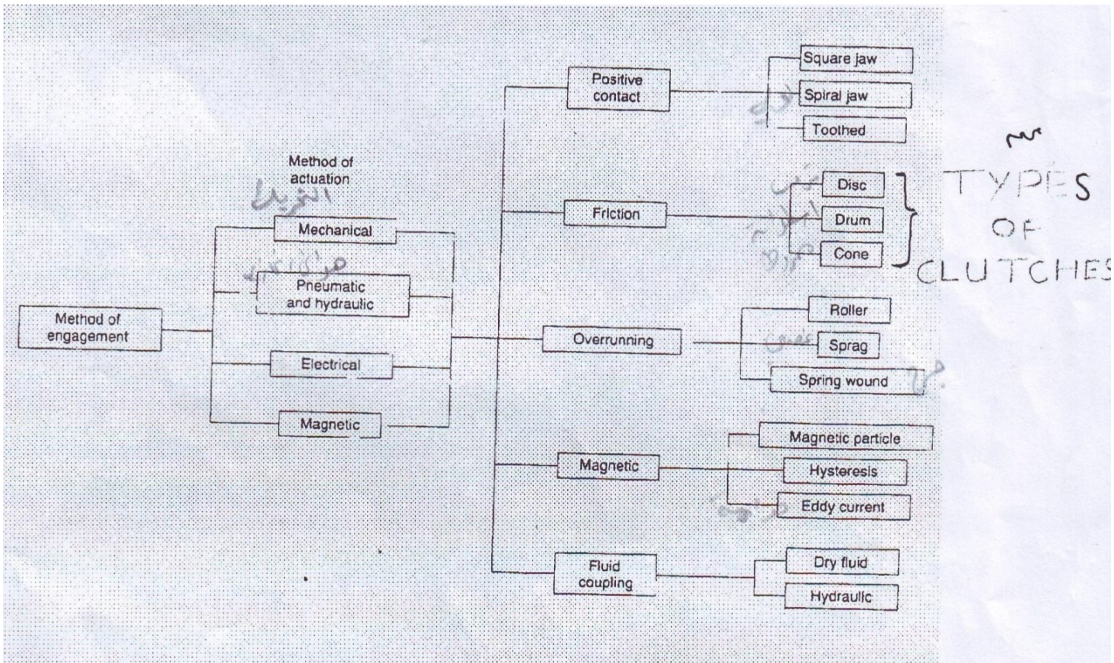


Fig 21-3

Clutches must be designed principally to satisfy four requirements:

1. The necessary actuation force should not be excessive.
2. The coefficient of friction should be constant.
3. The energy converted to heat must be dissipated
4. Wear must be limited to provide reasonable clutch life.

Design of Disc Clutches

Disc clutches can consist of single or multiple discs. Generally multiple disc Clutches enable greater torque capacity but are harder to cool. Frictional clutches can be run dry or wet using oil. Typical coefficient of friction are 0.07 for a wet clutch and 0.45 for a dry clutch

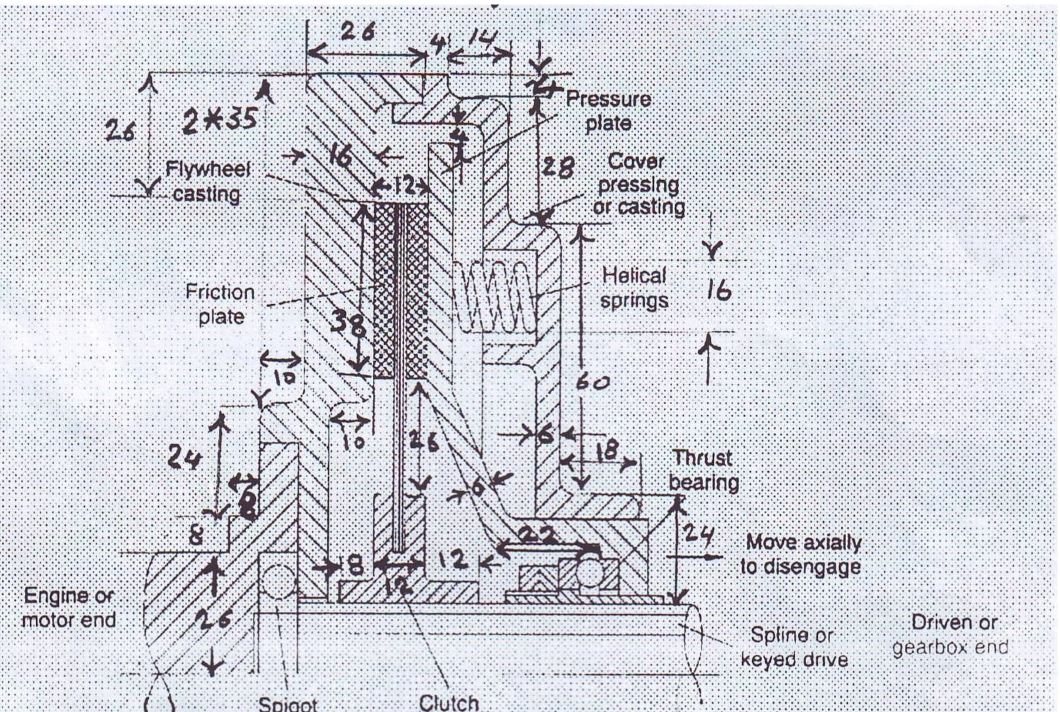


Fig 21-4

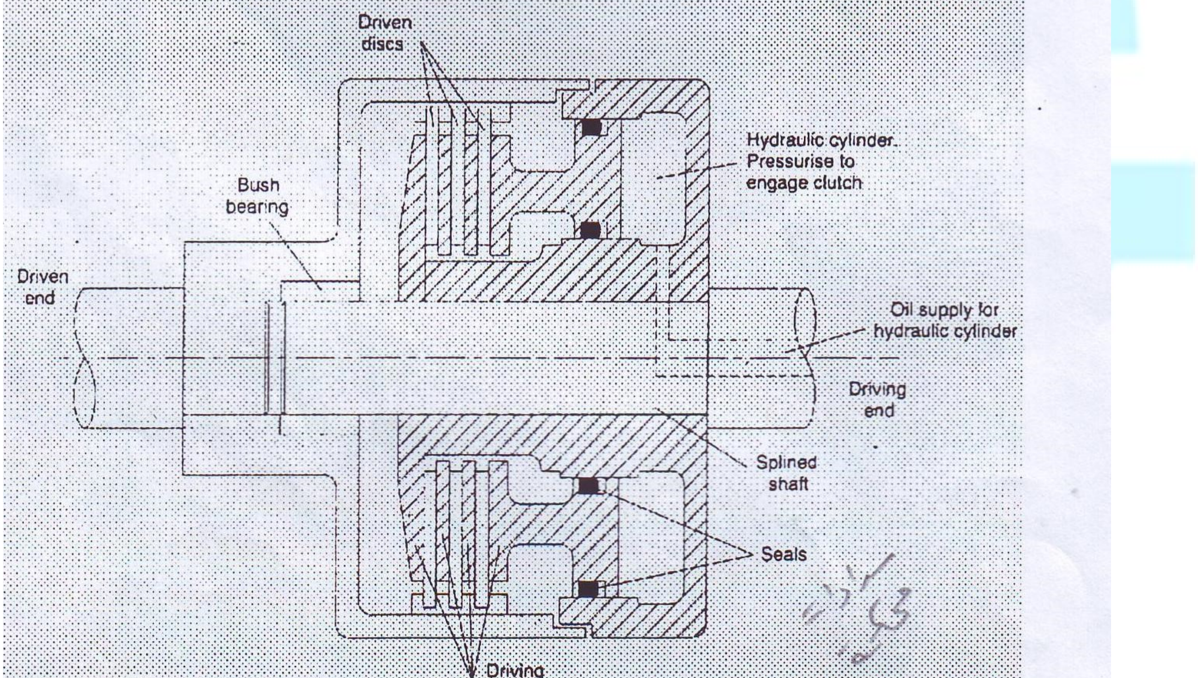


Fig 21-5

Two basic assumptions are used in the development of procedures for disc clutch design, based upon a uniform rate of wear at the mating surfaces or a uniform pressure distribution between the mating surfaces.

The 24th – 28th week

Pipes And Pipe Joints

pipes are used for transporting liquids and glasses and for structural elements. pipes are circular hollow cylinders made of cast iron, wrought iron, steel, brass, copper or lead. earthen, cement concrete and wooden pipes are also made.

pipes are extensively used for carrying fluids – water , oil, steam, gas etc., from one part to another due to the force of gravity or pressure excreted upon it.

different pipes and there uses:

1. Cast iron pipes

are widely used for carrying water, gas, and steam

available in various size from 50mm tol200mm diameter

are connected to gather by flanged joints, socket and spigot joints, and hydraulic joints.

2. Wrought iron or malleable iron pipes

used for carrying water for domestic purpose and also gas at low pressure.

galvanized all over

generally made by welding process

available in various size from 6mm tol50mm diameter

3. Steel pipes

more popular for carrying water, steam, gas, sewage and air at a high pressures

have much greater strength than the above

longer length and less liable to breakage.

may have welded seams or may be seamless

available in size usually varying frorn50mmto 1800mm diameter

4. Lead pipes

used for domestic purposes

made by expanding molten lead through a die over mandrel.

two lead pipes are joined by soldering process called piped joint

5. Copper and brass pipes

used for carrying hot water and fabricating radiator

easily bent or coiled to the desired shapes

used ,vhere there is no connected by separate brass-flanges which are attached to the pipe ends by brazing

6. Hydraulic pipes (fig 19. 1)

have stronger joint

7. Special pipes

Pipes and tubing of other materials ,such as aluminum , stainless steel, plastic pipe

* is light weight, corrosion proof, and resistance to many chemicals

* it has a smooth inner surface which offers low flow resistance

7.1 Polyvinyl Chloride (PVC): Used where high working pursuers

7.2 Chlorinated Polyvinyl Chloride (CPVC): has a maximum temperature 132 ^{O}C .

7.3 Black Polyethylene Flexible Pipes: Approved by the national sanitation foundation for use with drinking water, has a rated working pressure of 100psi .

Pipe Joints

the joints between pipes, fittings, and valves may

1) screwed
2) flanged
   - 2.1 Cast Iron Flanged
   - 2.2 Spigot And Socket Joint
   - 2.3 Hydraulic Joint Of Flanged Type
3) welded
4) tubing

Pipe Fittings

are used to join adjacent length pipe and frequently also to provide changes of direction, to provide branch connections at different angles, or to effect a changing size (Fig. 25-5, 25-6, 25-7)

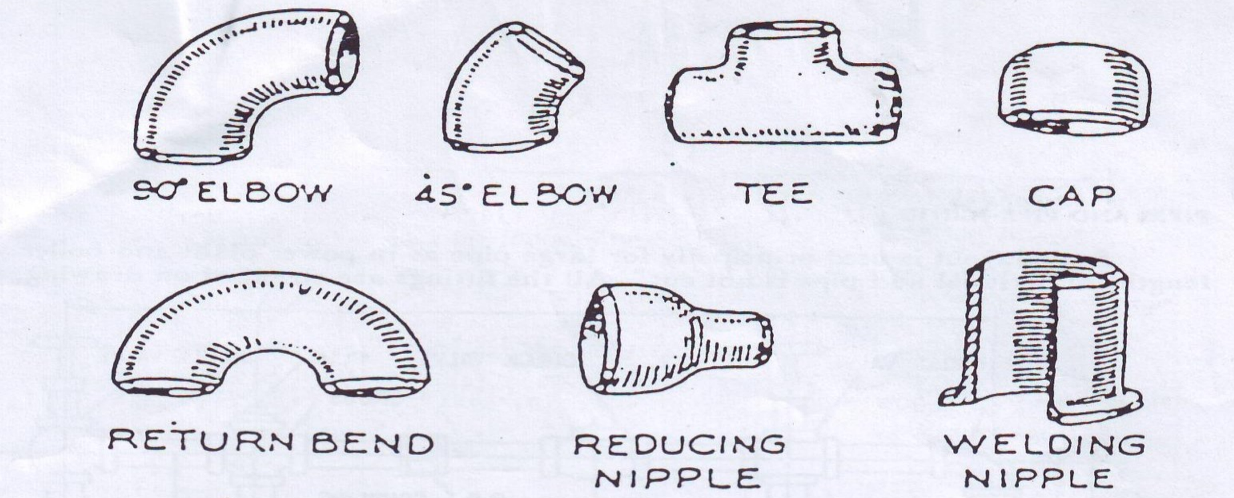


FIGURE 25.6 Butt-Welded Fittings.

FIGURE 25.5 Screwed Fittings.

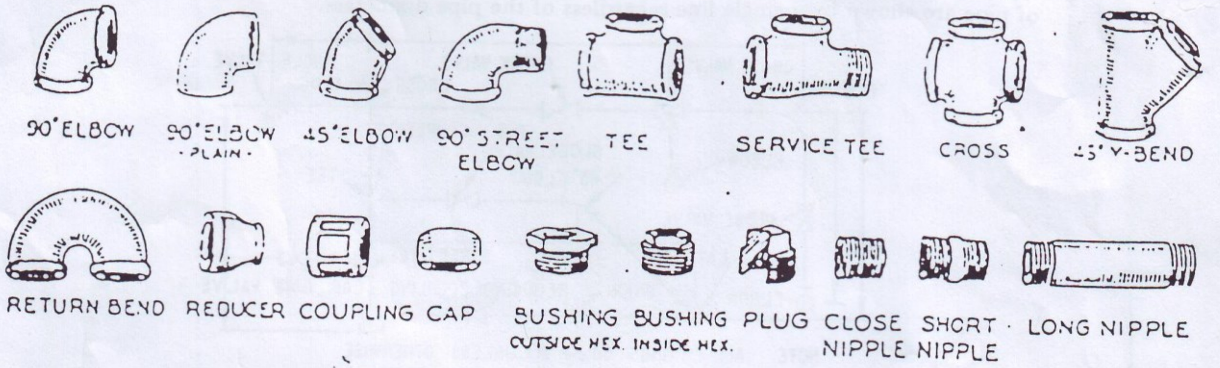
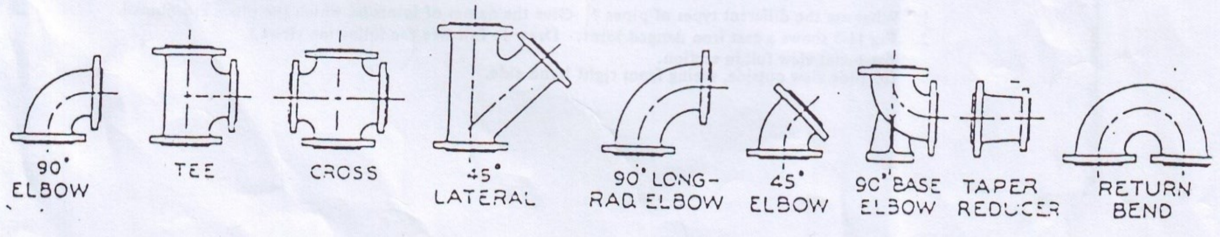


FIGURE 25.7 Flanged Fittings.



The 29th – 30th week

Introduction to (CAD), components of computer aided drawing(CAD), relationship between CAD & CAM in modern design and manufacturing facilities

And

Main advantages of (CAD) difference between plotting and drawing

{It has been given by first two weeks}

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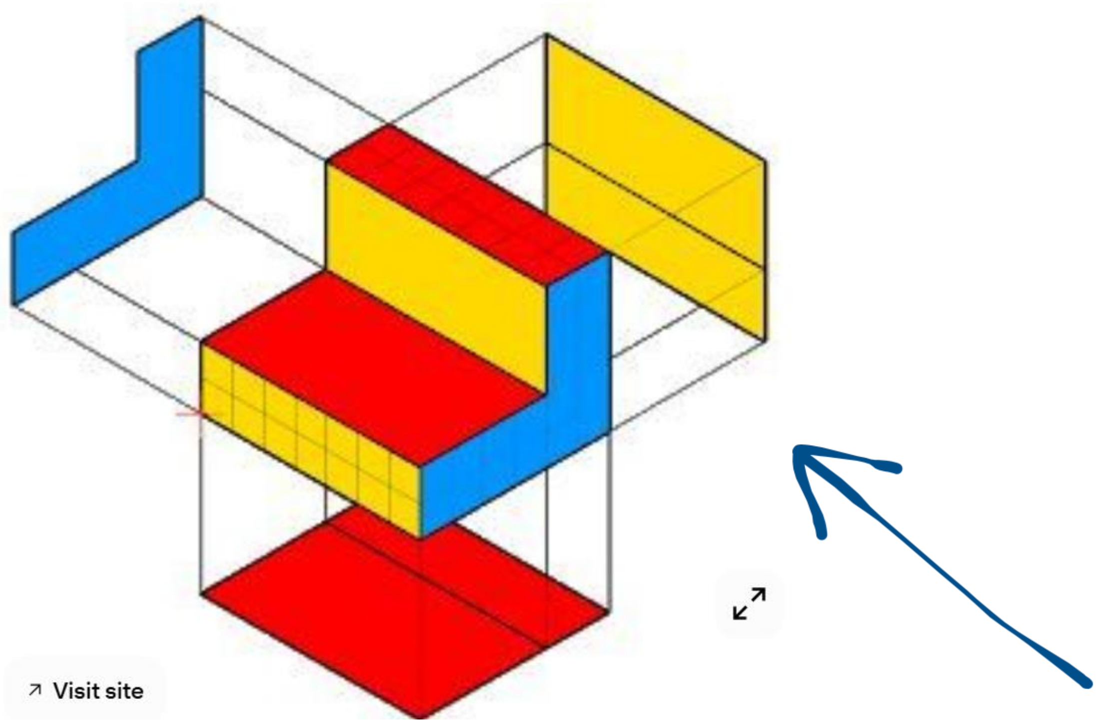
وفقكم الله يا املنا يا شباب اليوم و رجال الغد و سدد خطاكم و هداكم لافضل الاعمال

الدكتور المهندس

ثامر عون الدين محمد شيت المولى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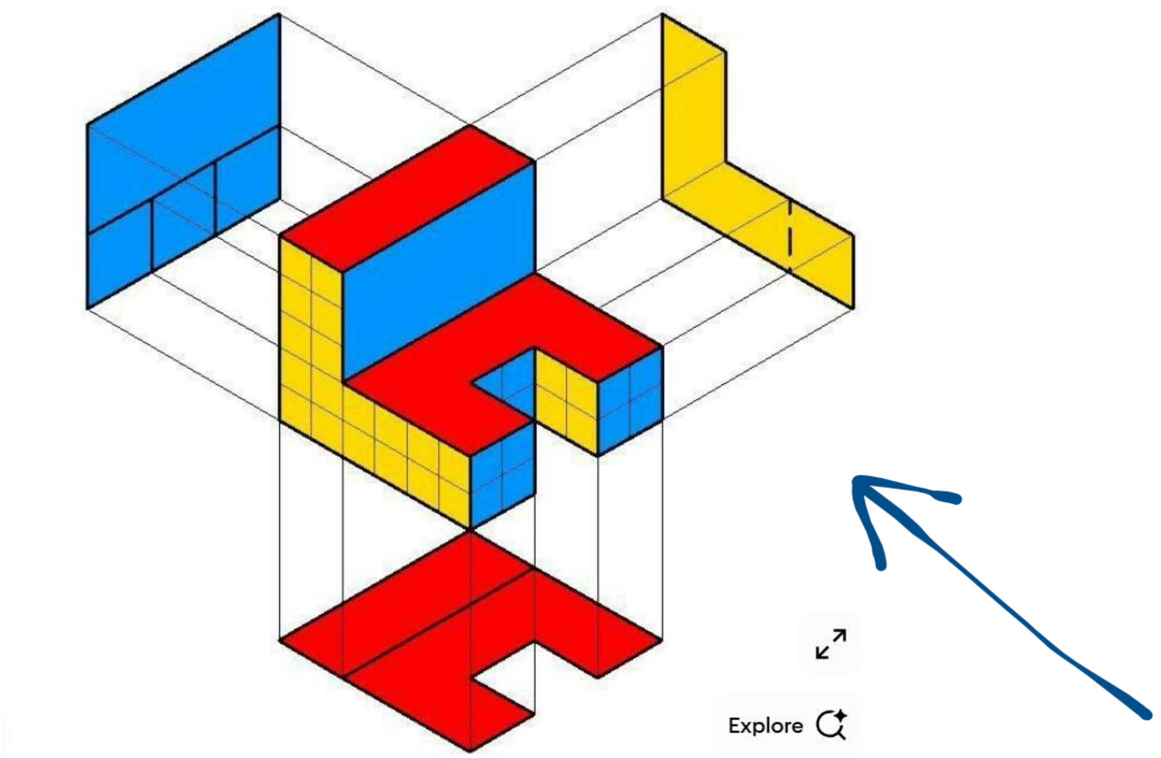
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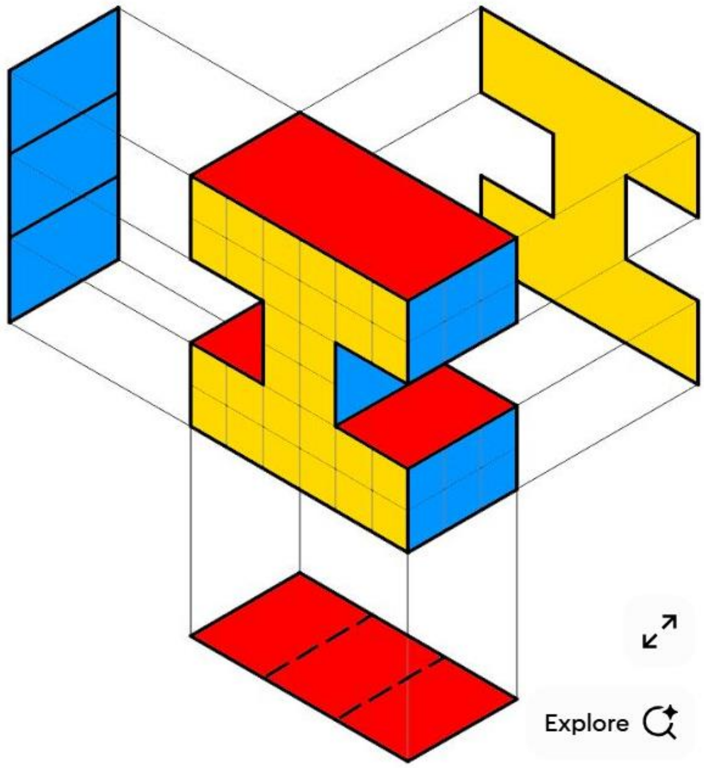
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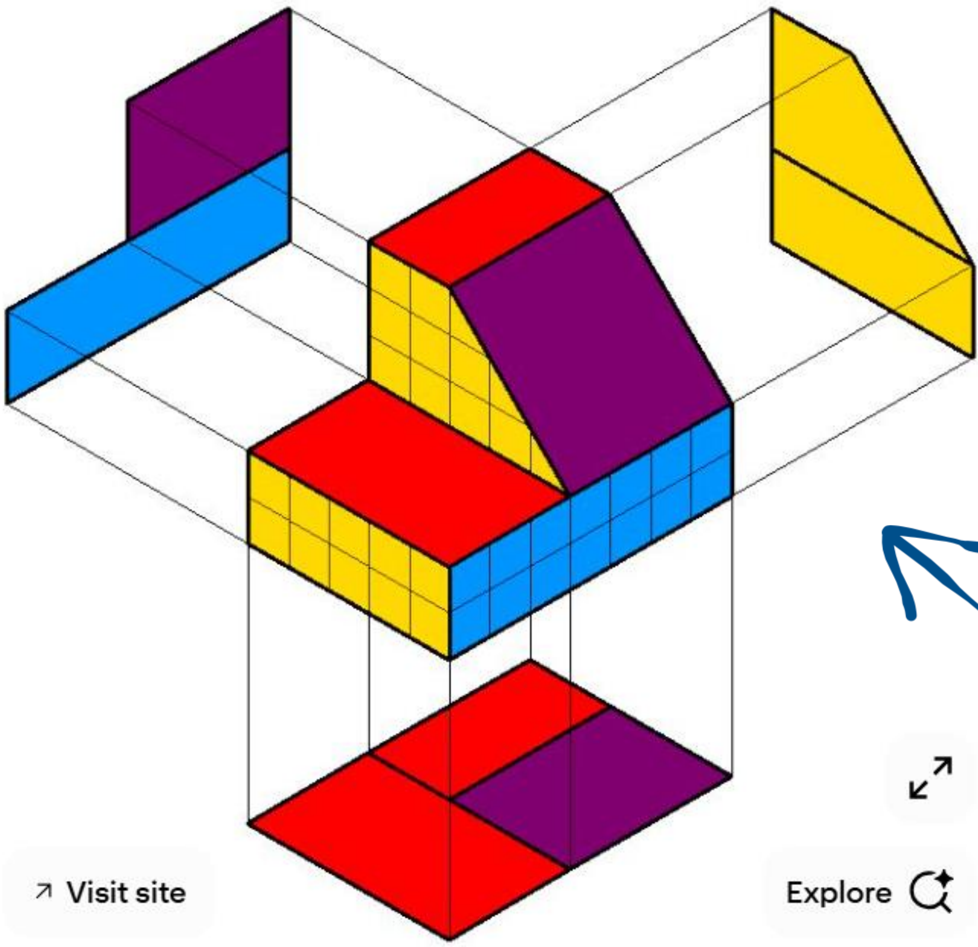
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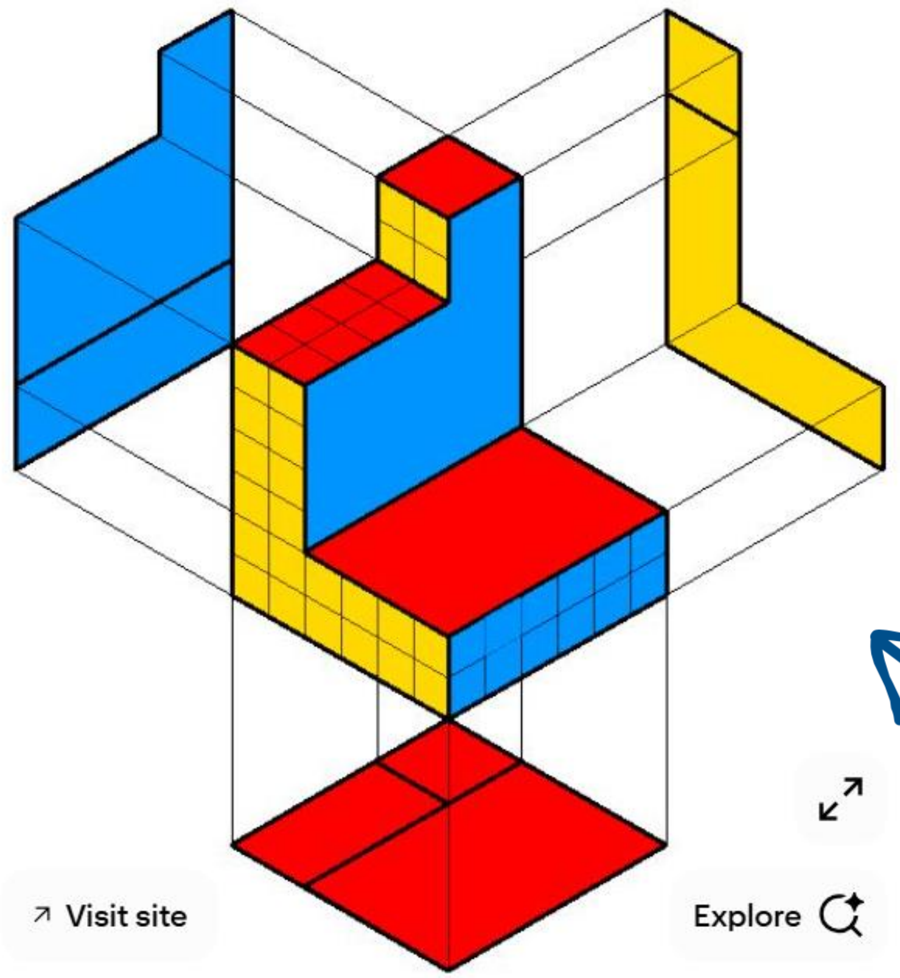

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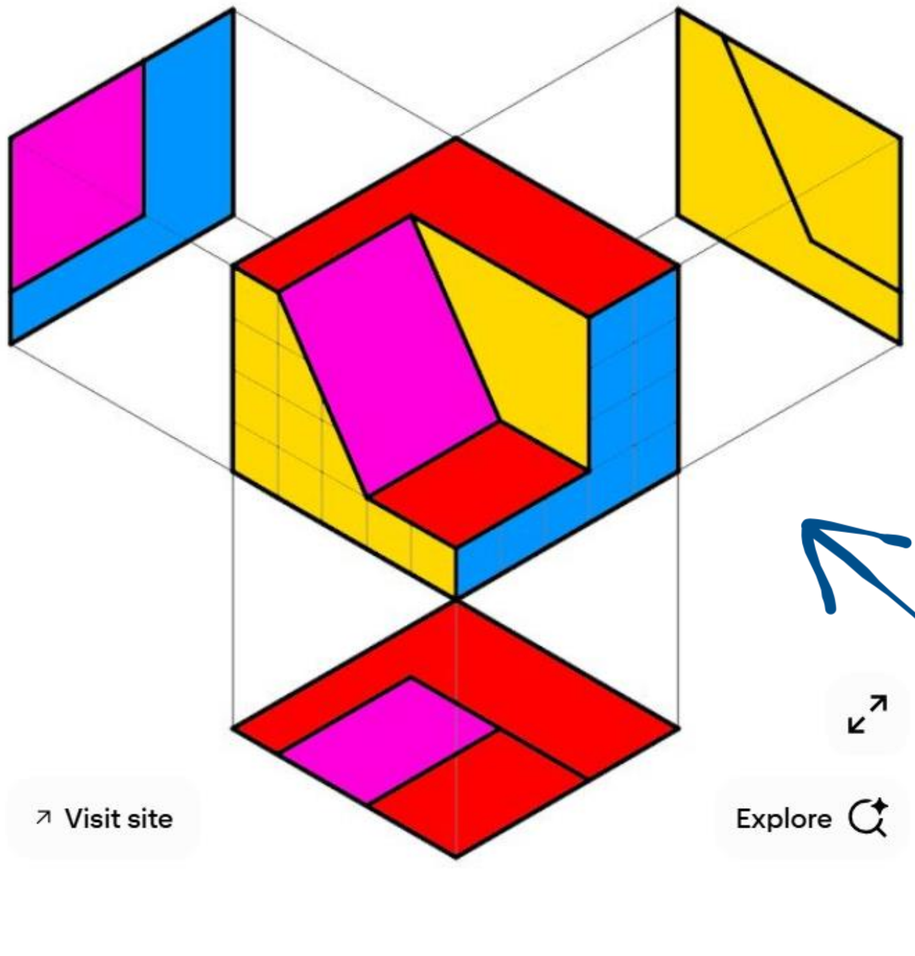

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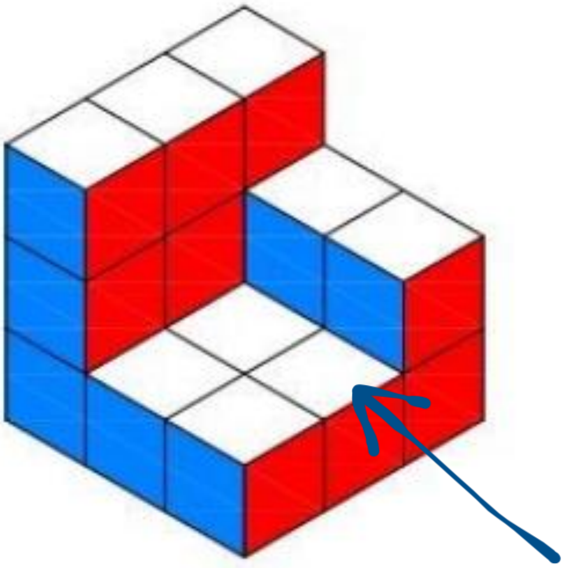
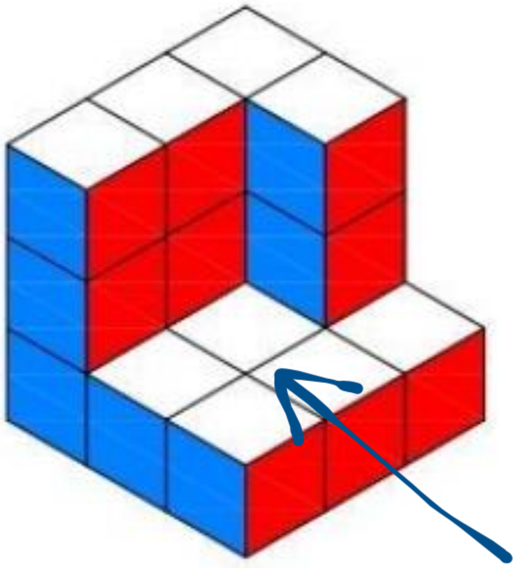
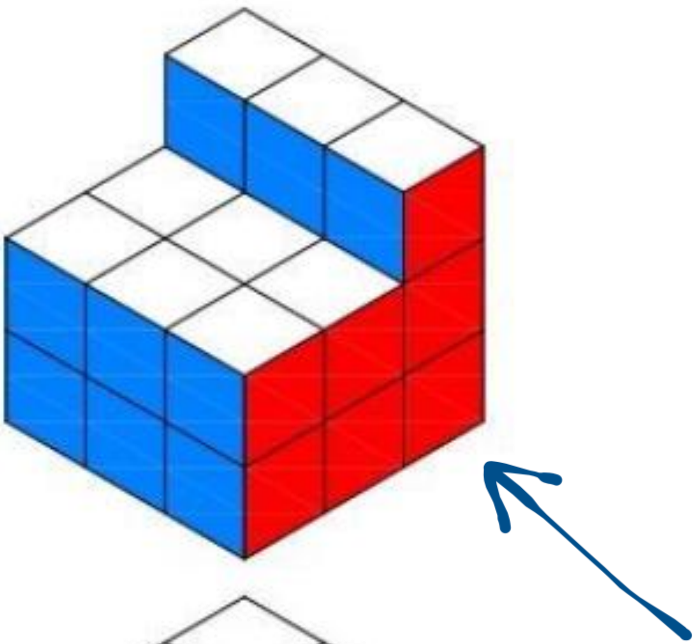
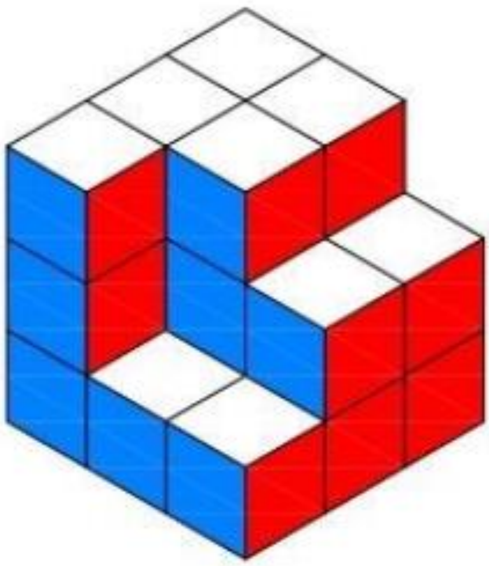
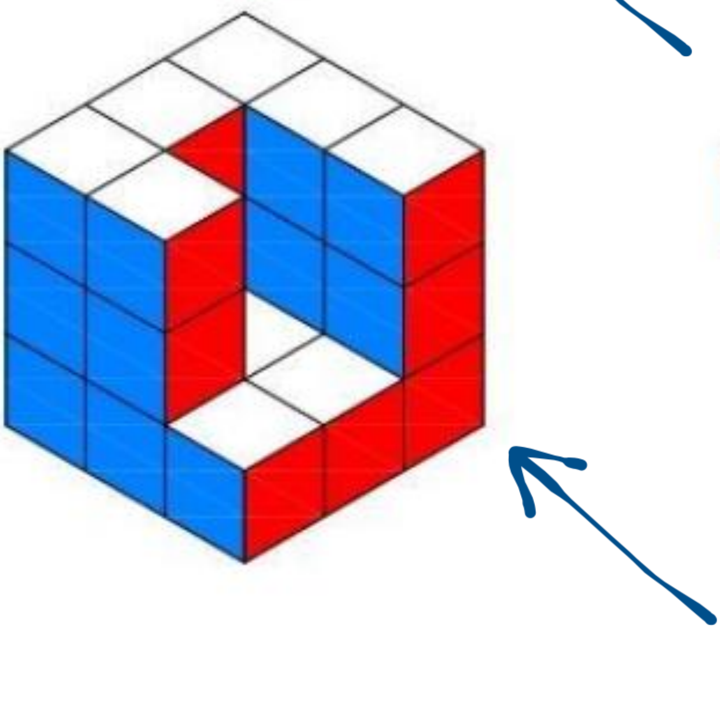
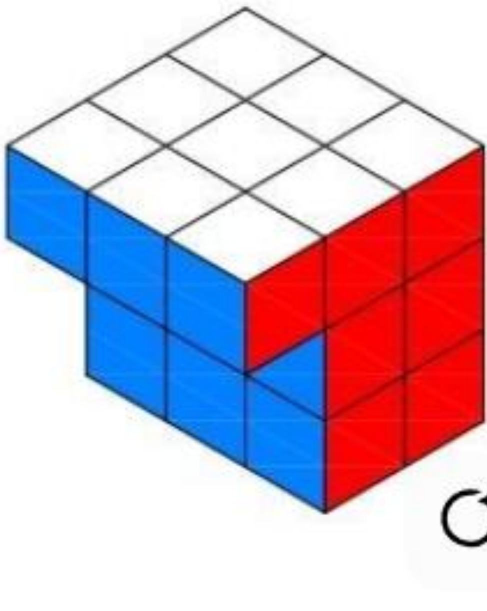

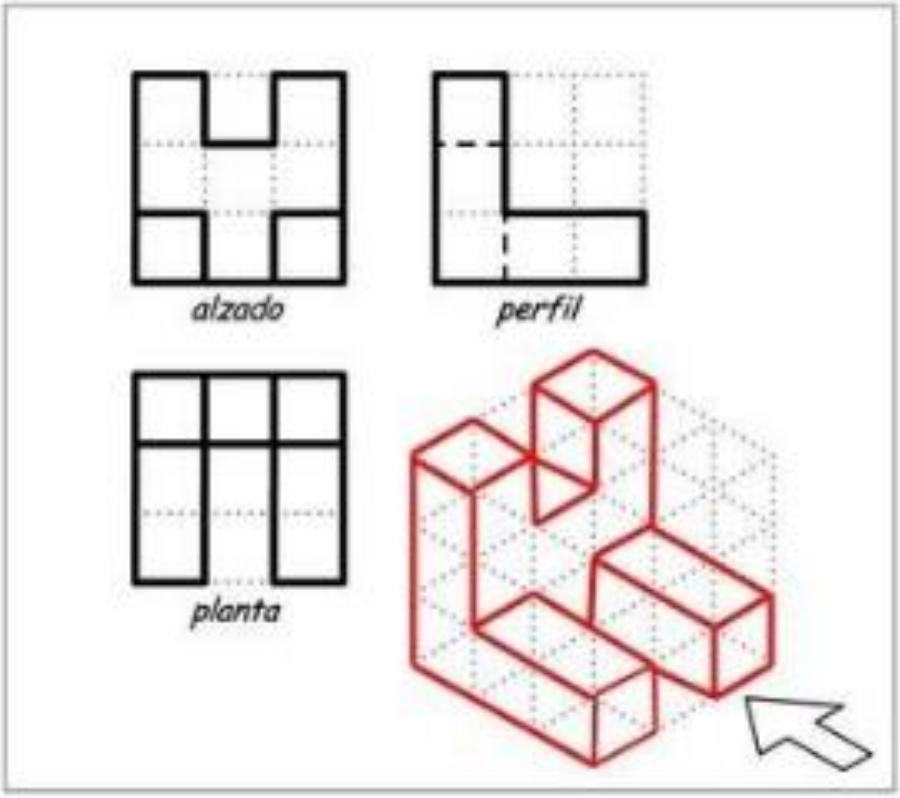
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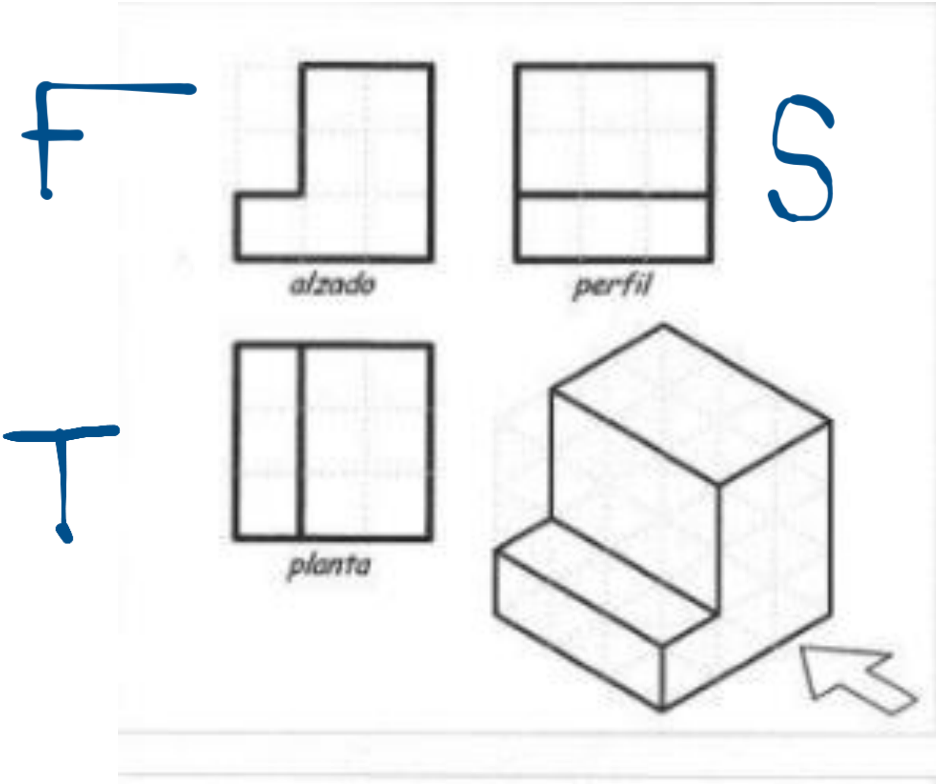
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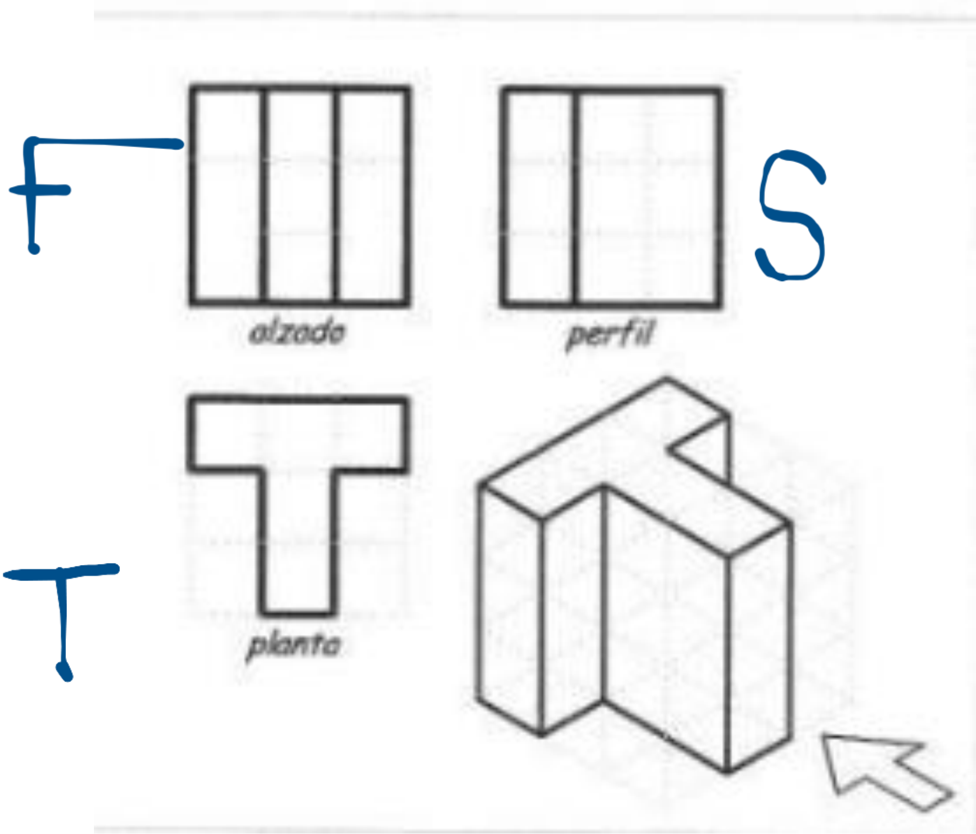

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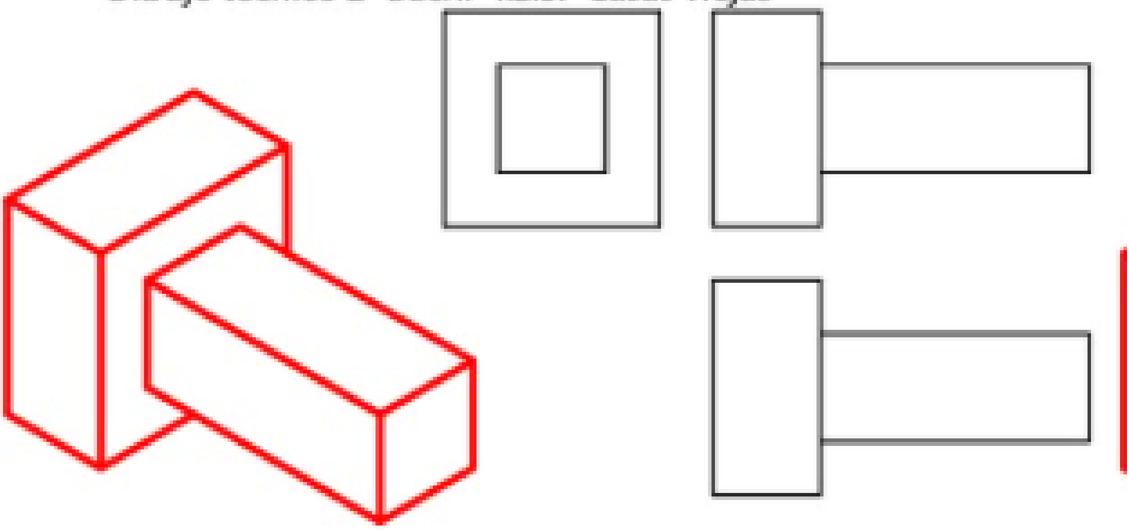

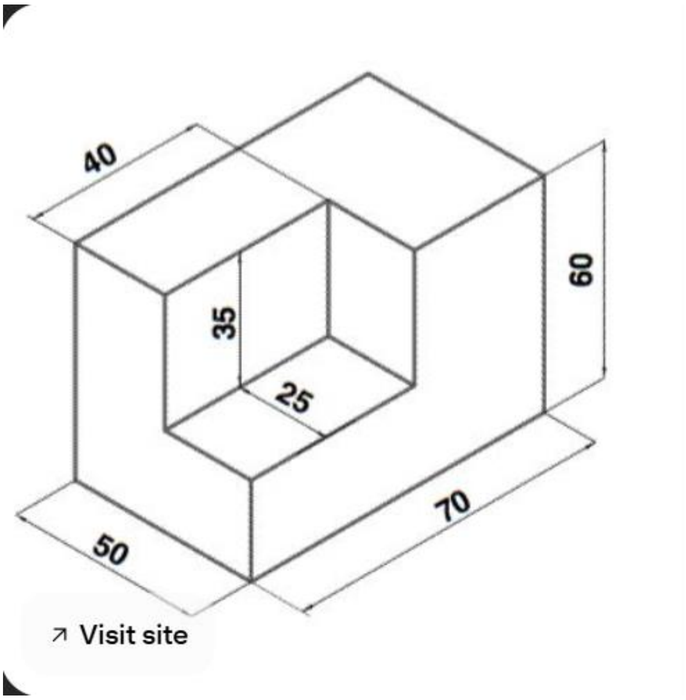
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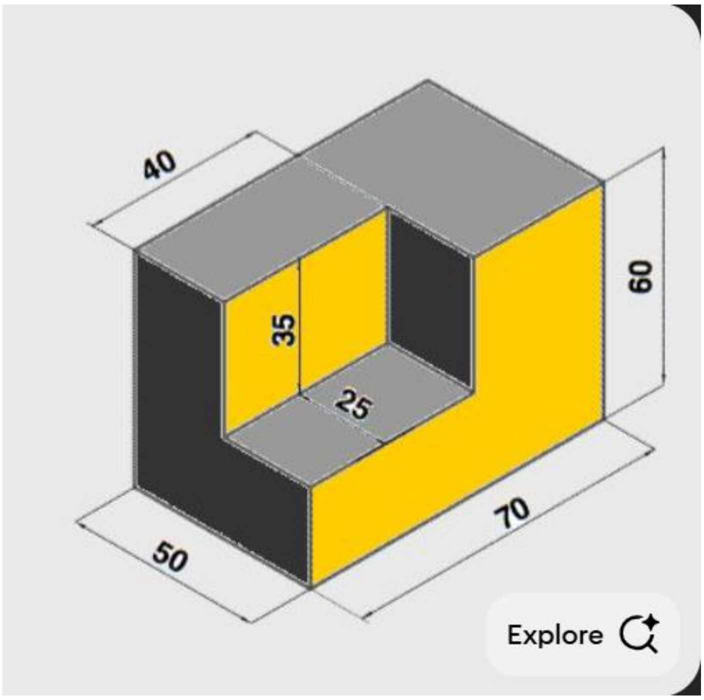
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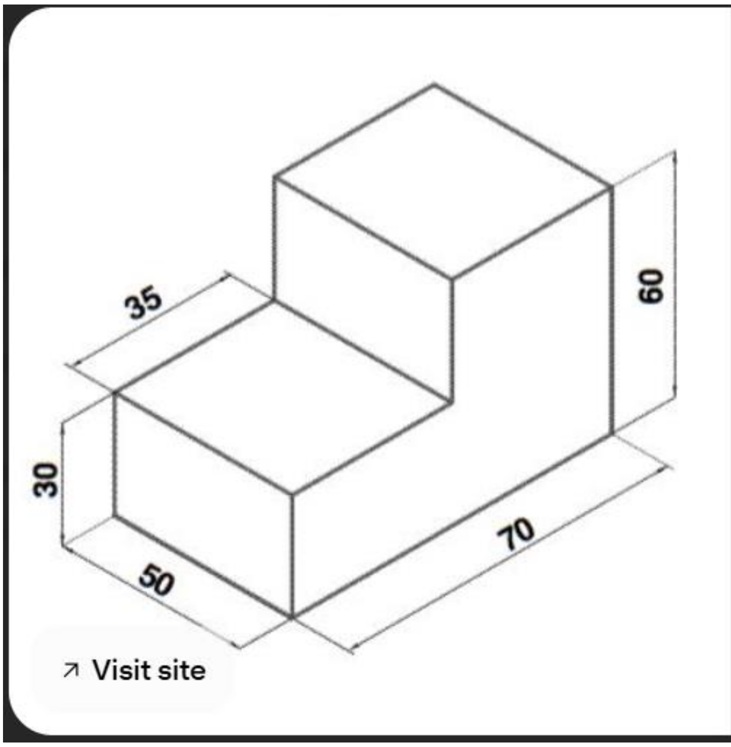
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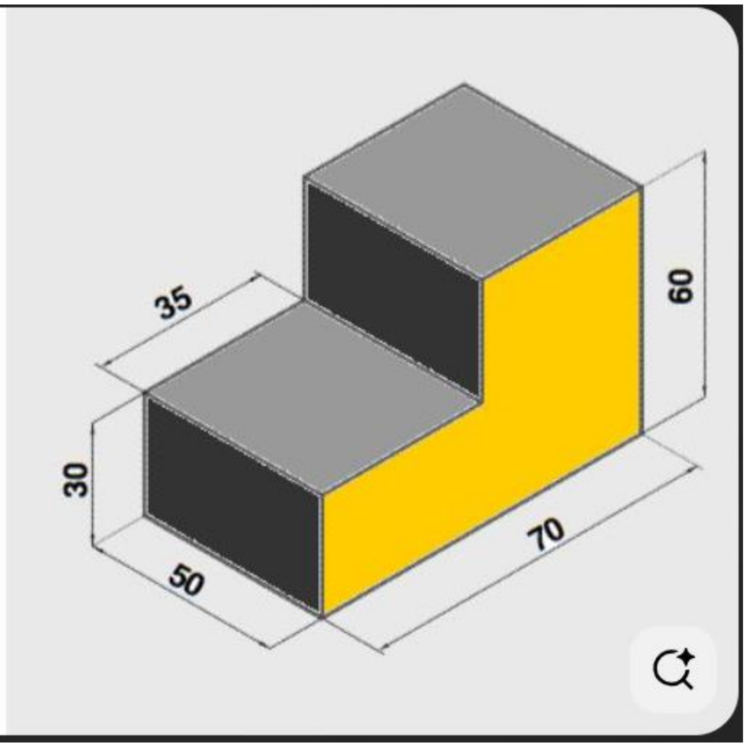
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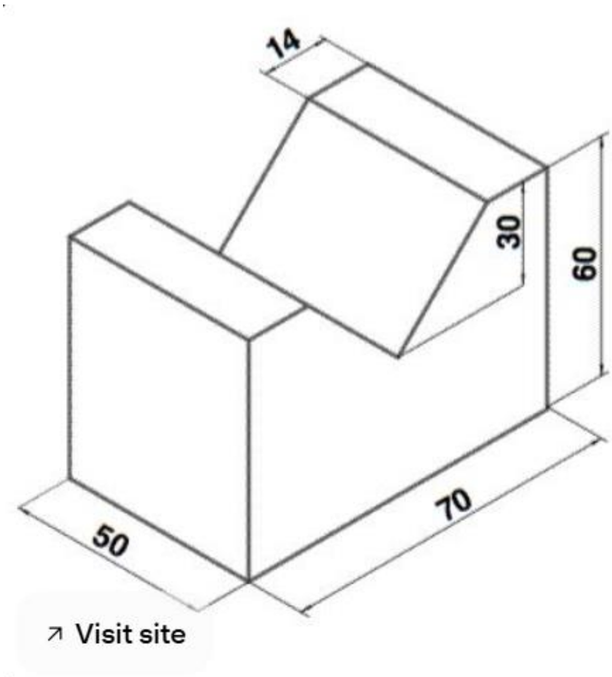
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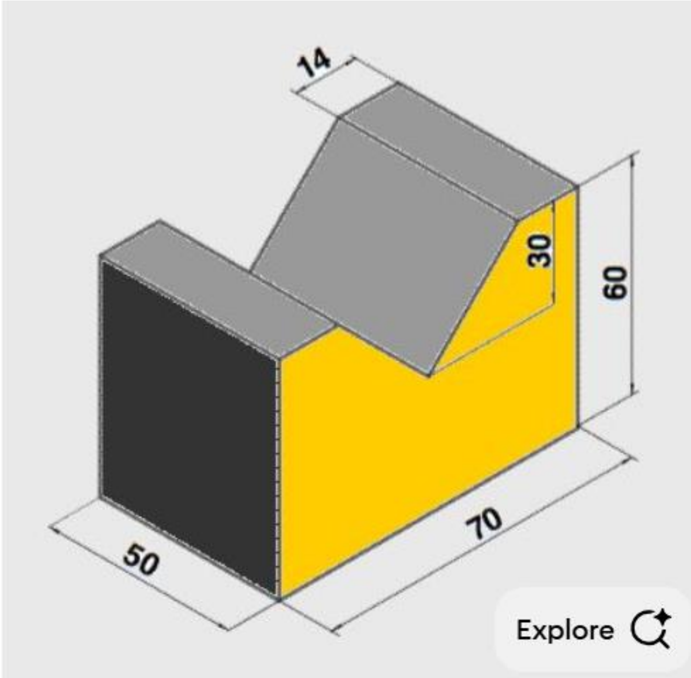
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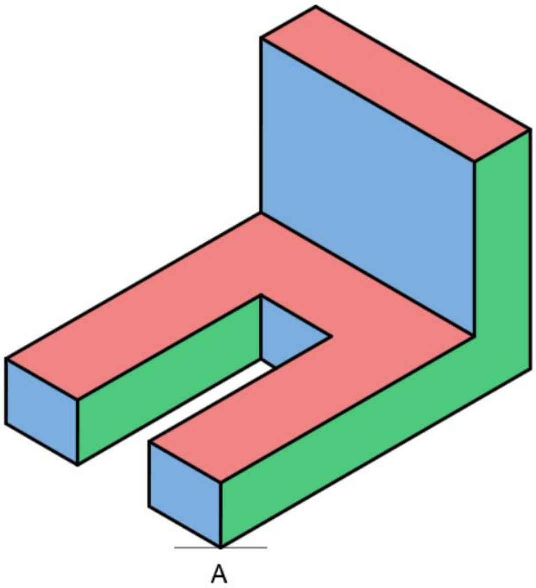
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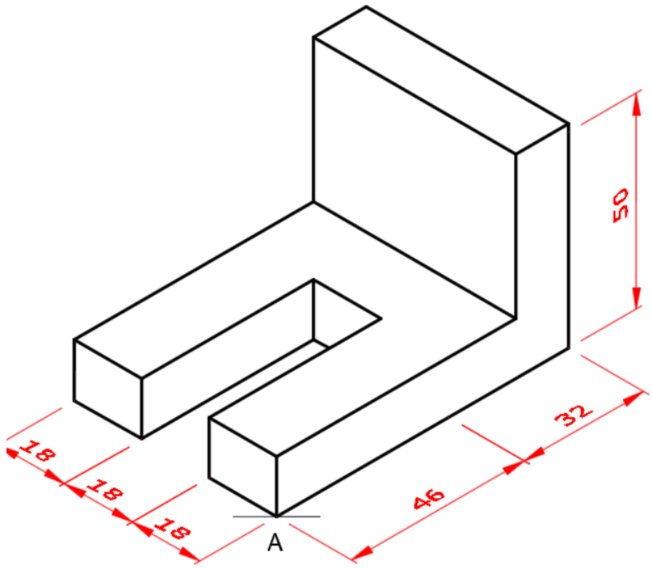
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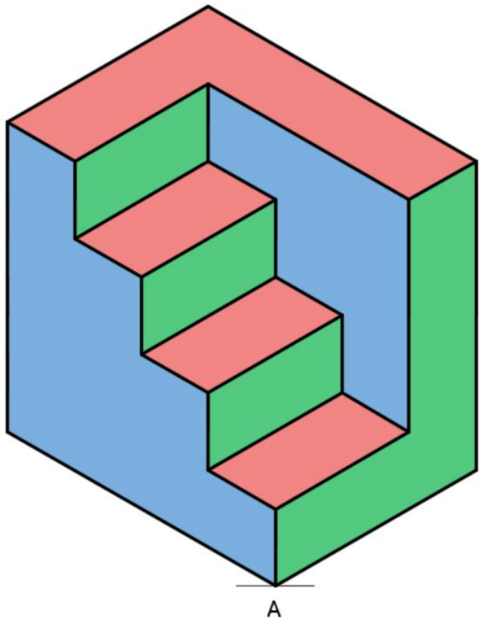
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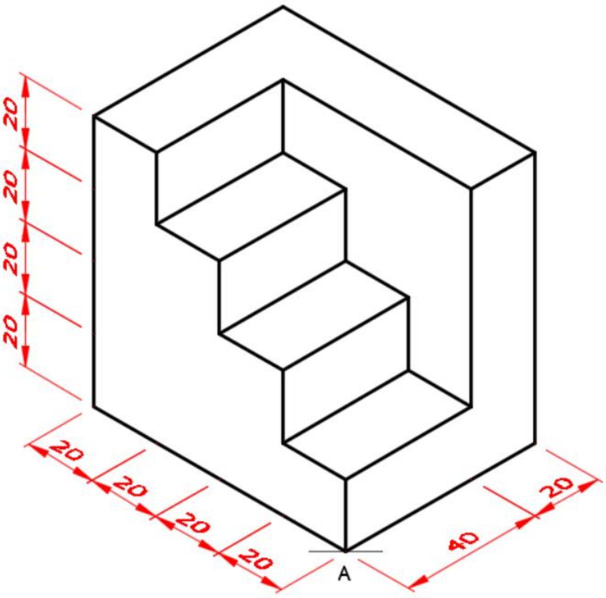
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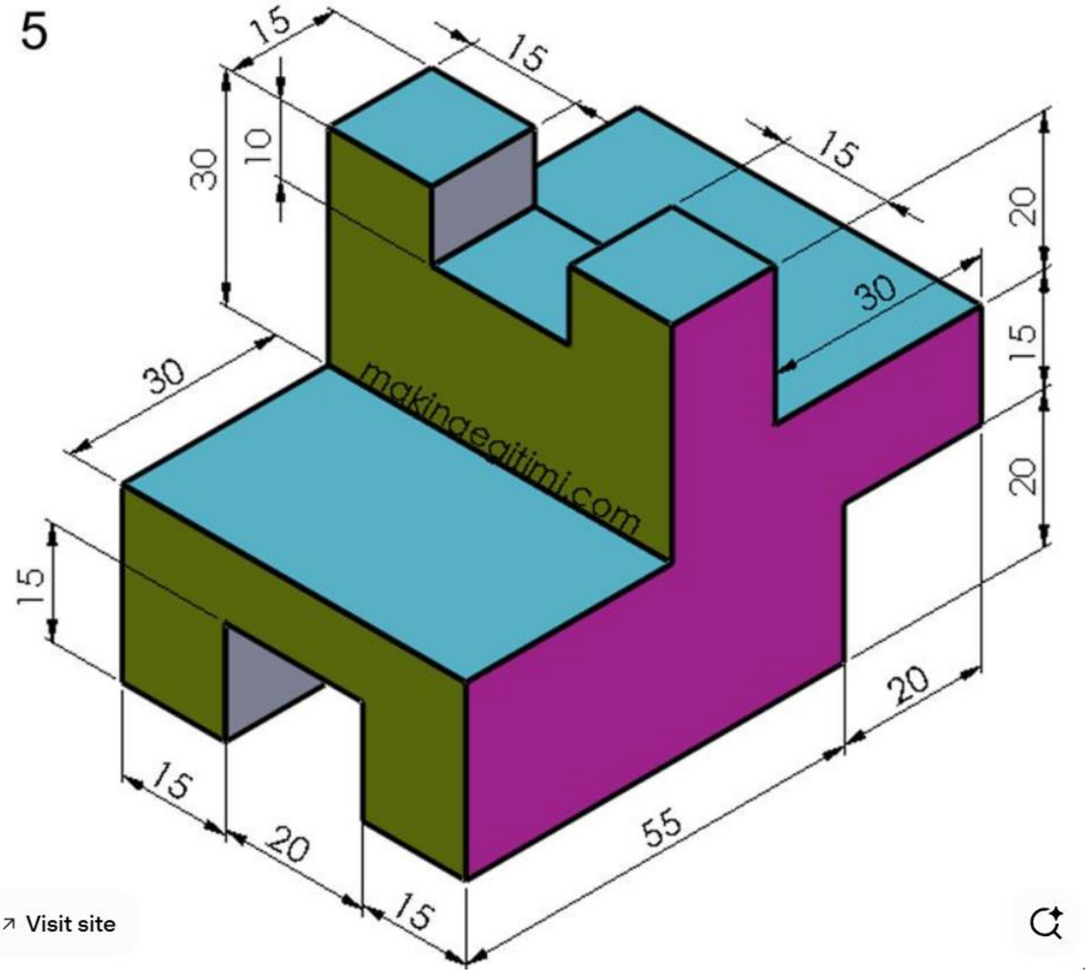
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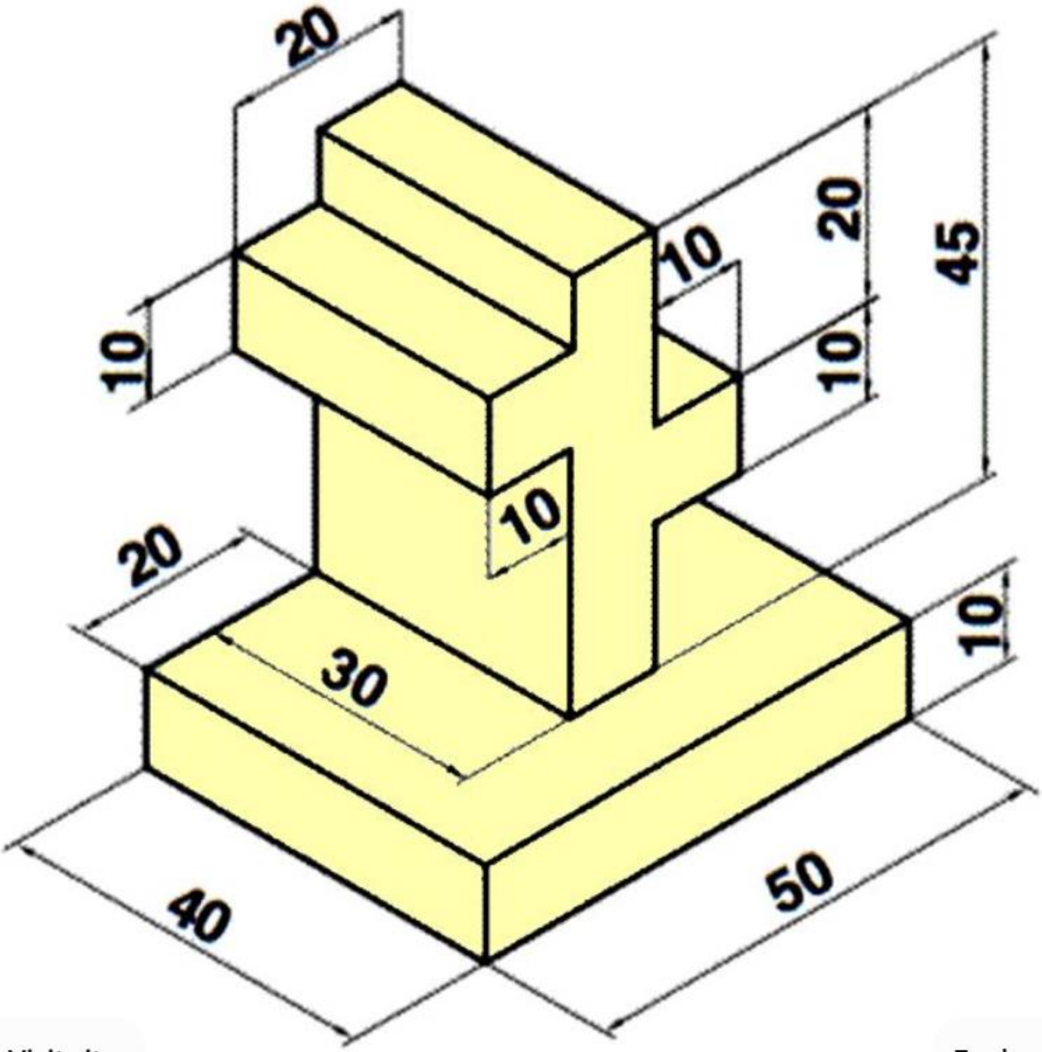

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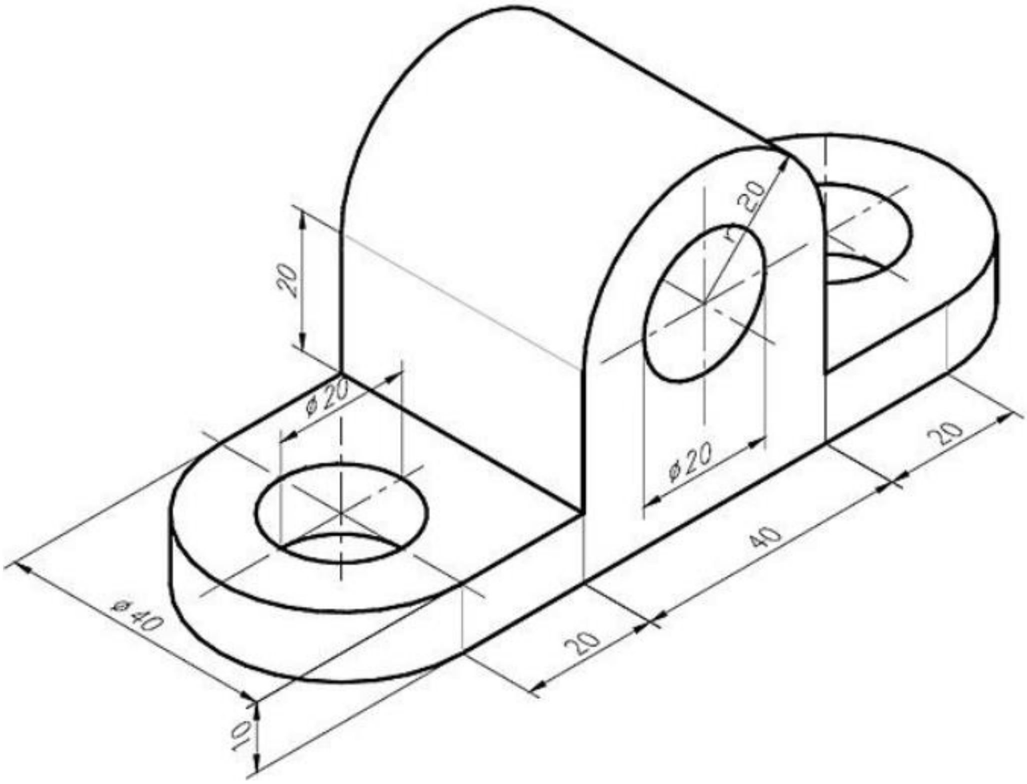
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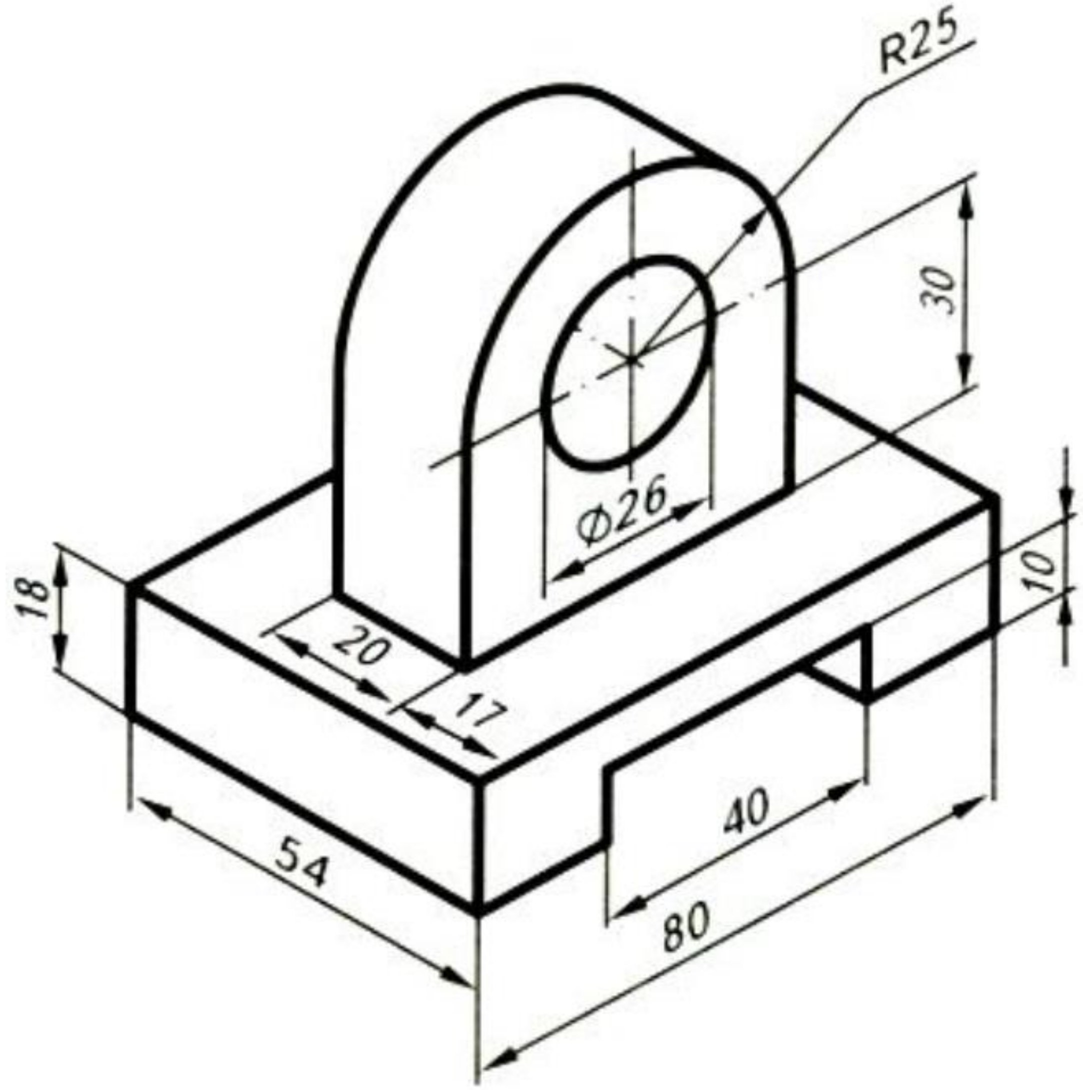
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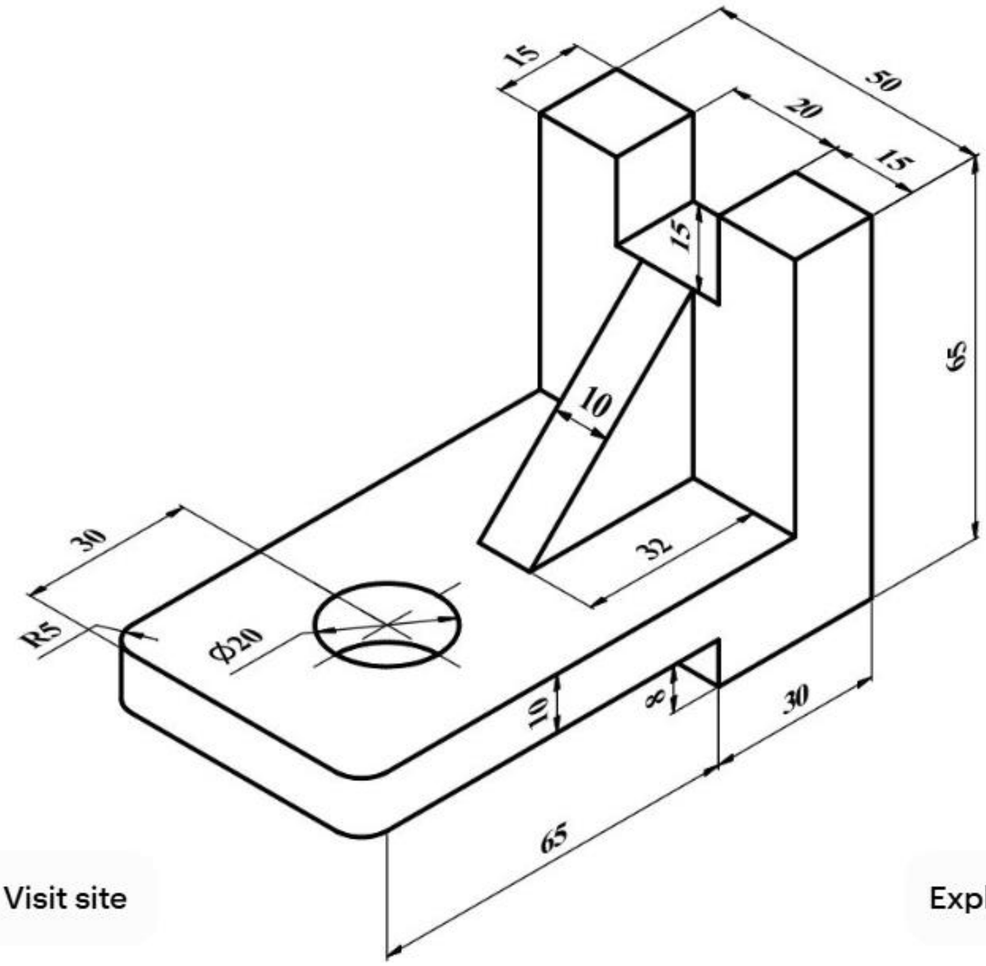

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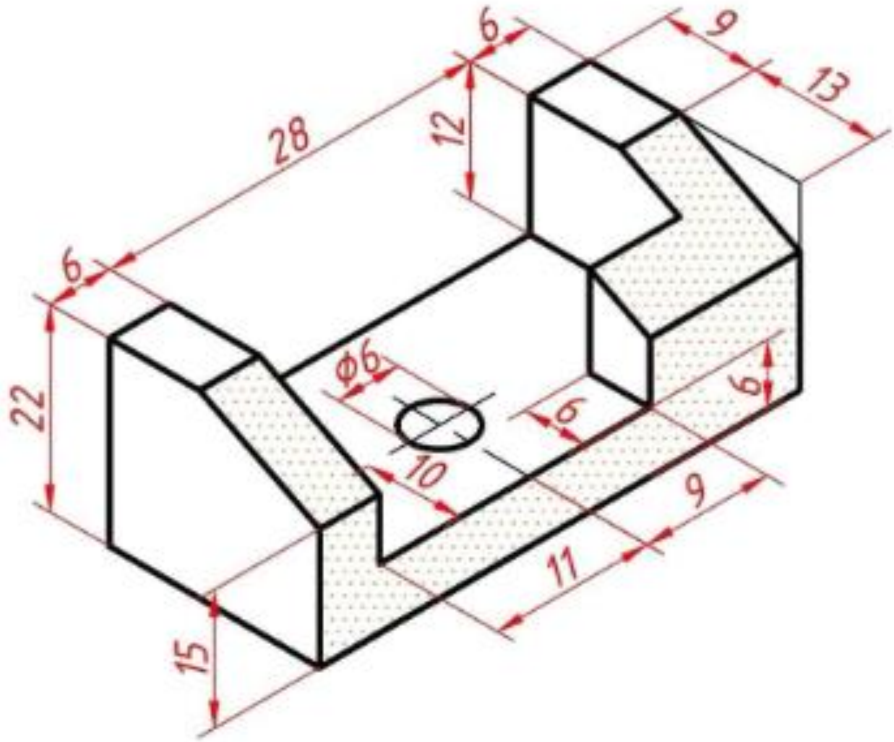
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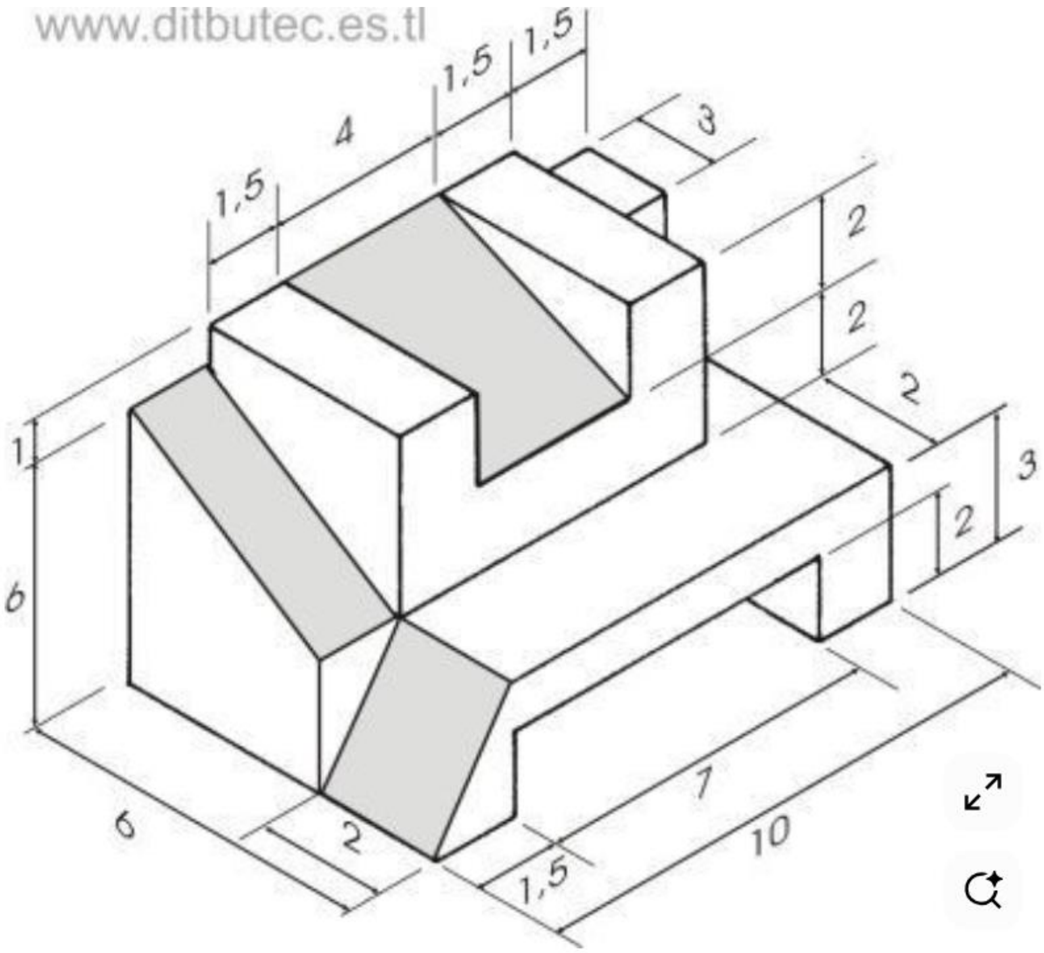
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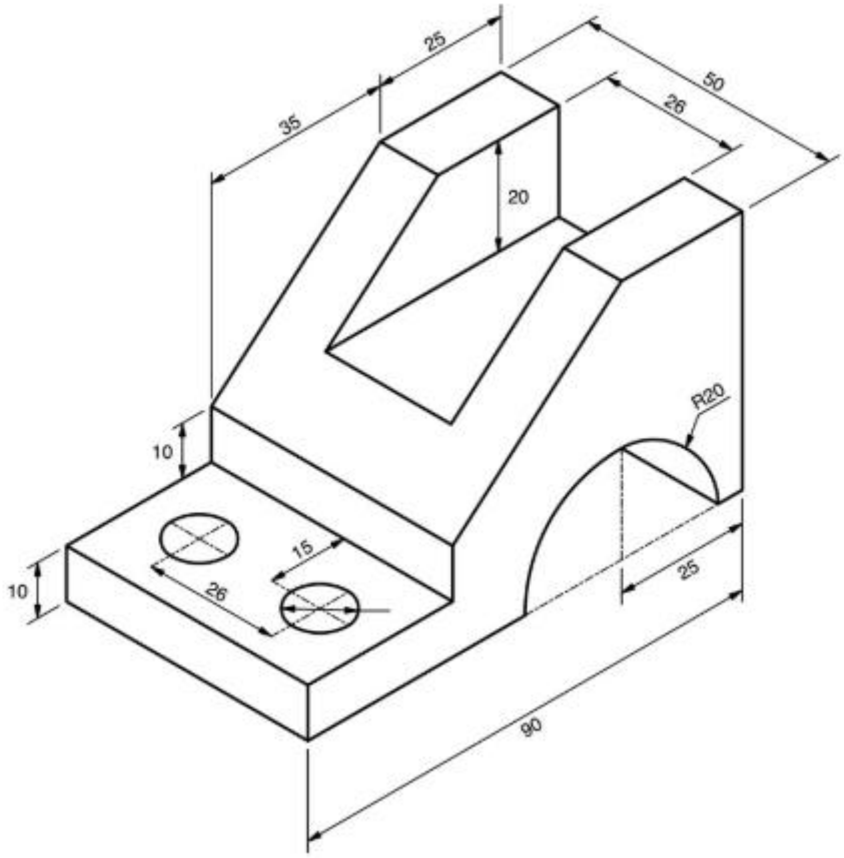
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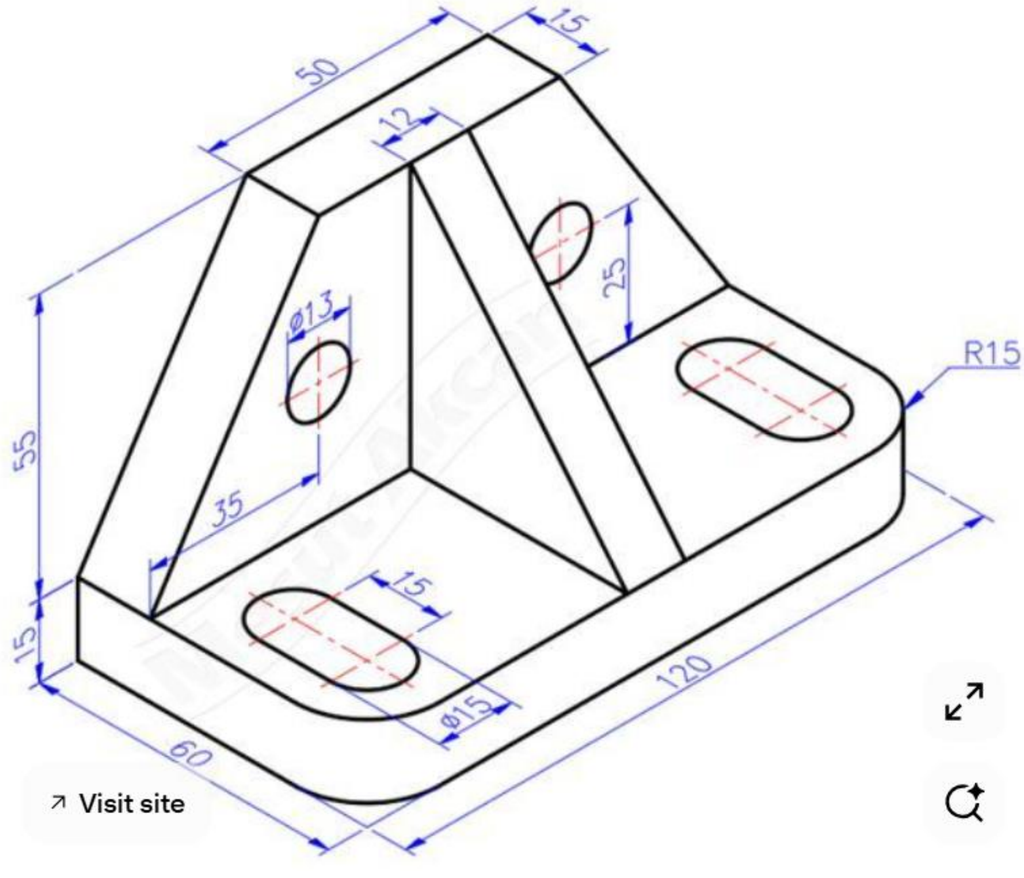
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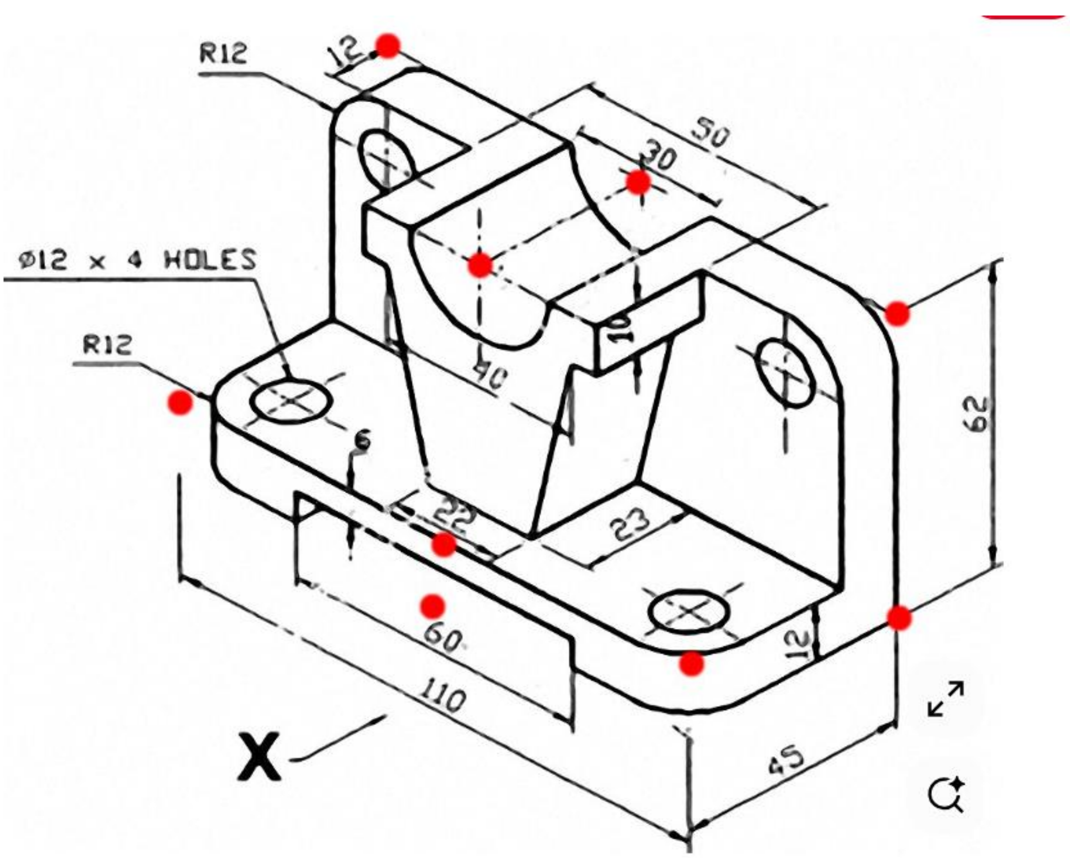
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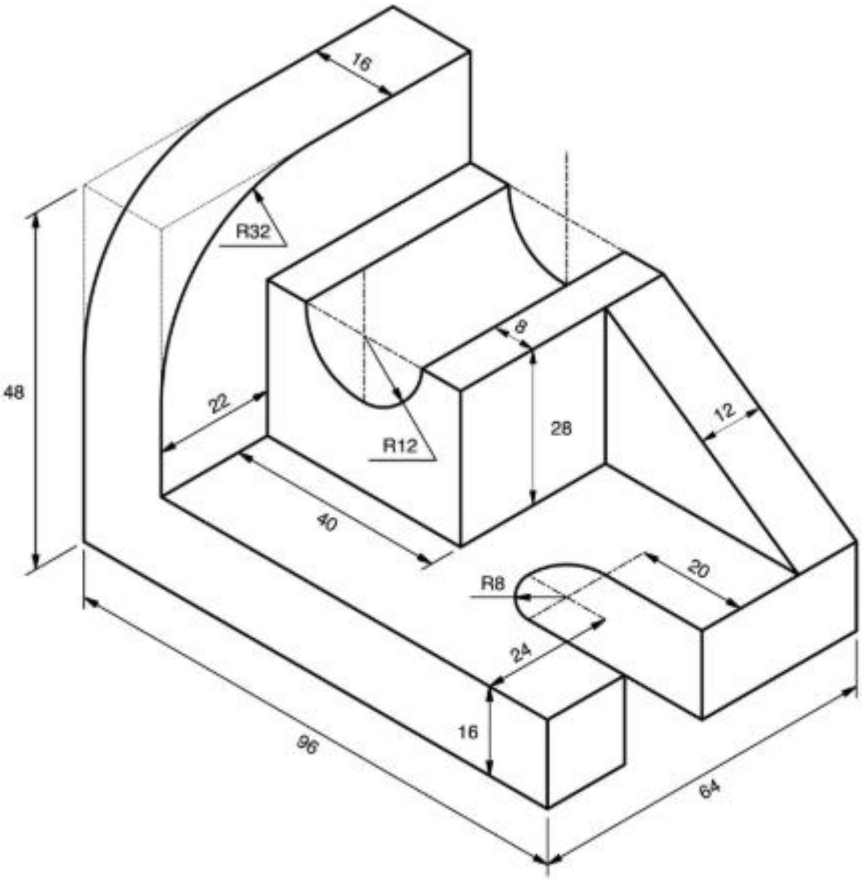
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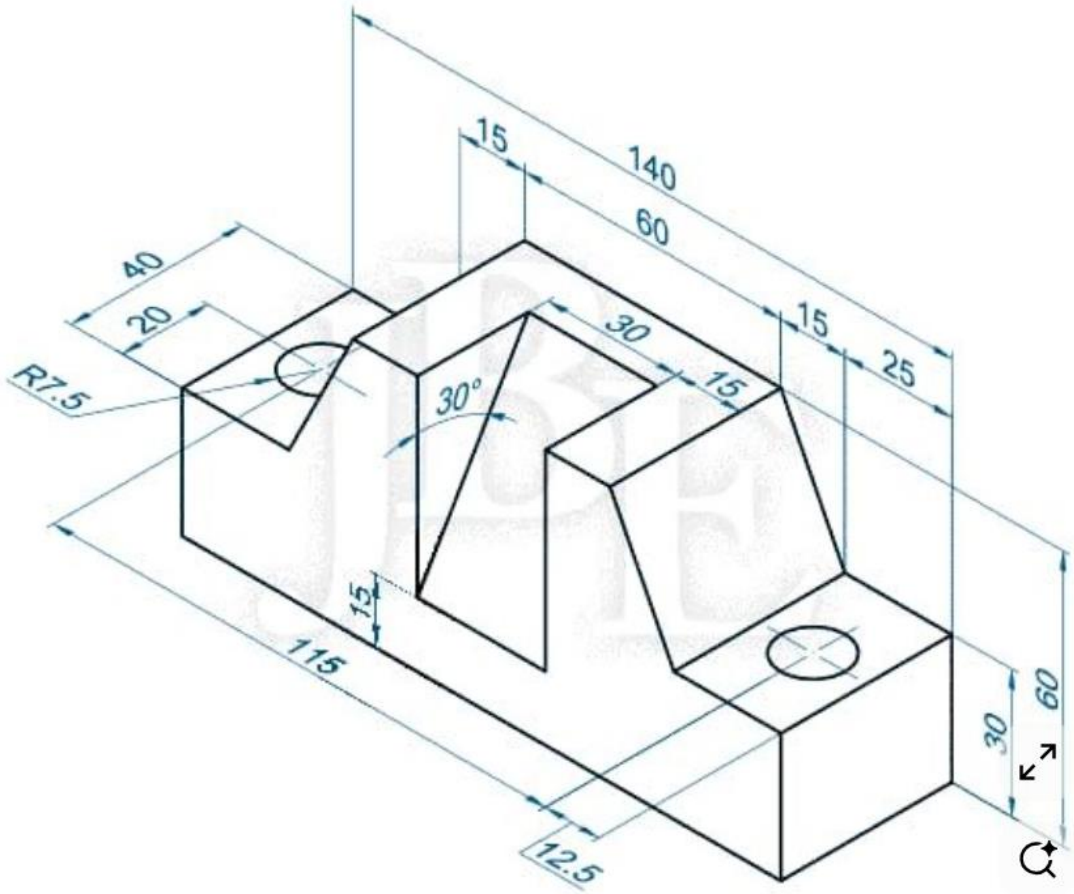

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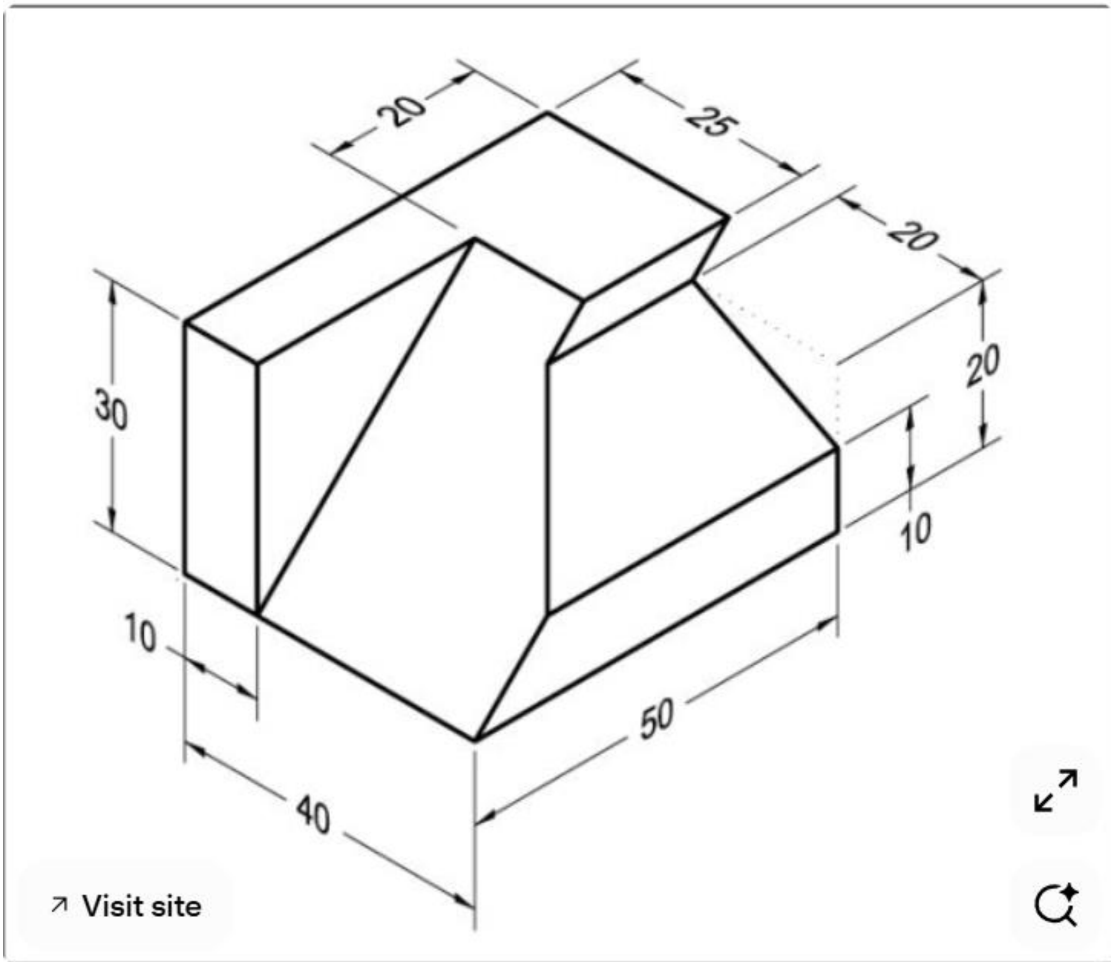
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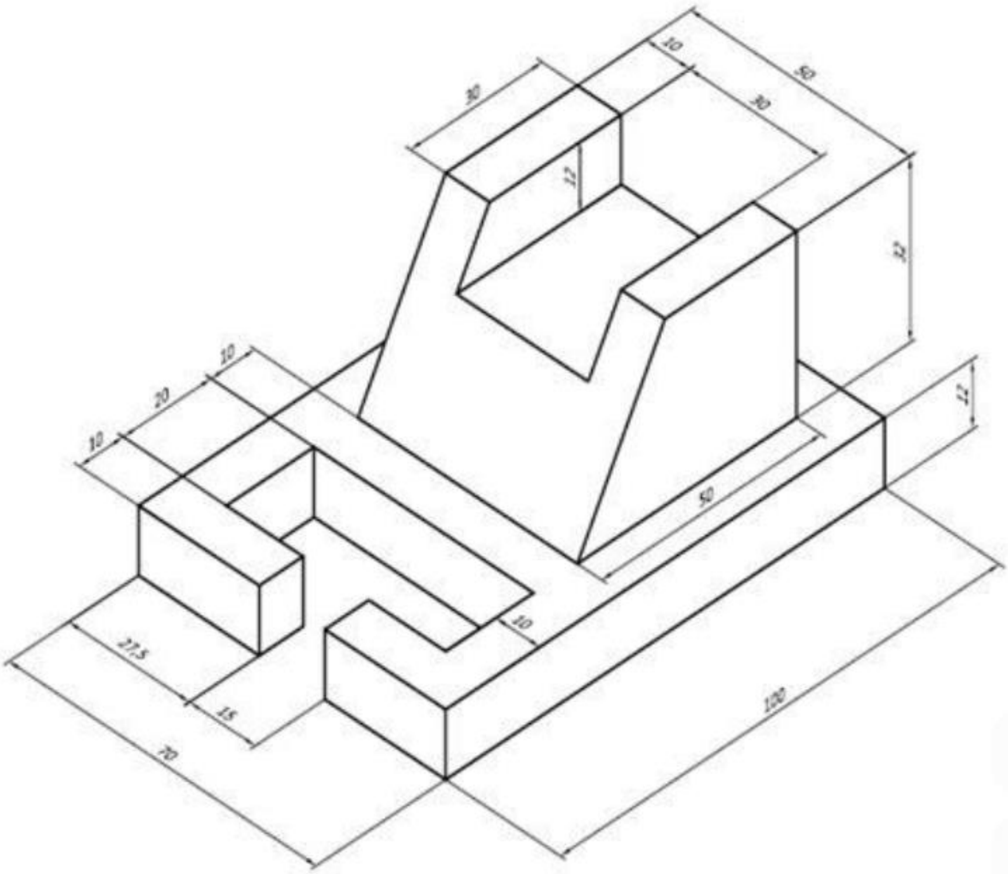

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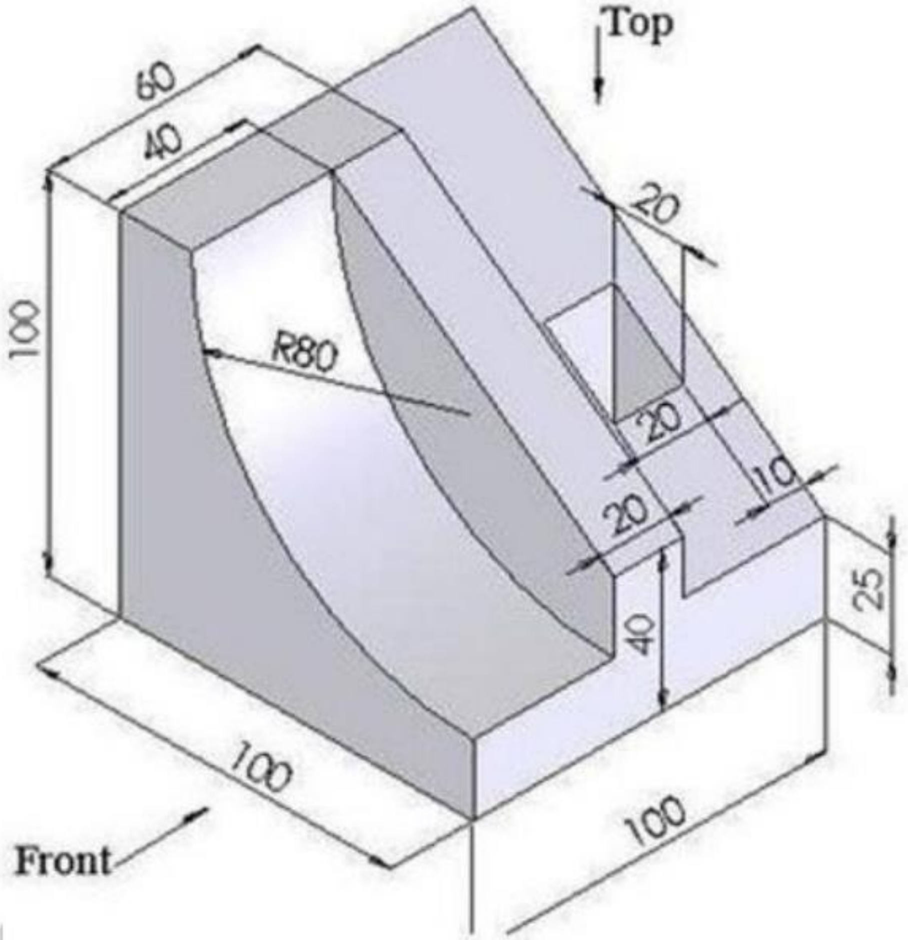

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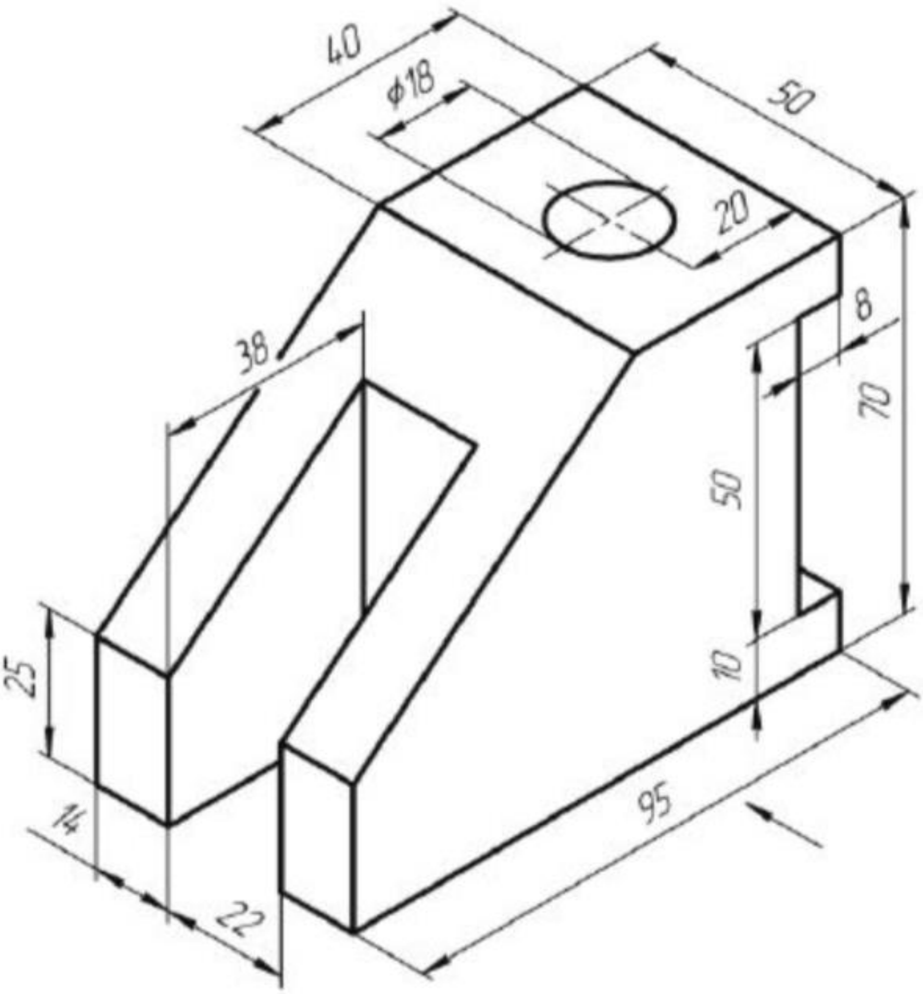
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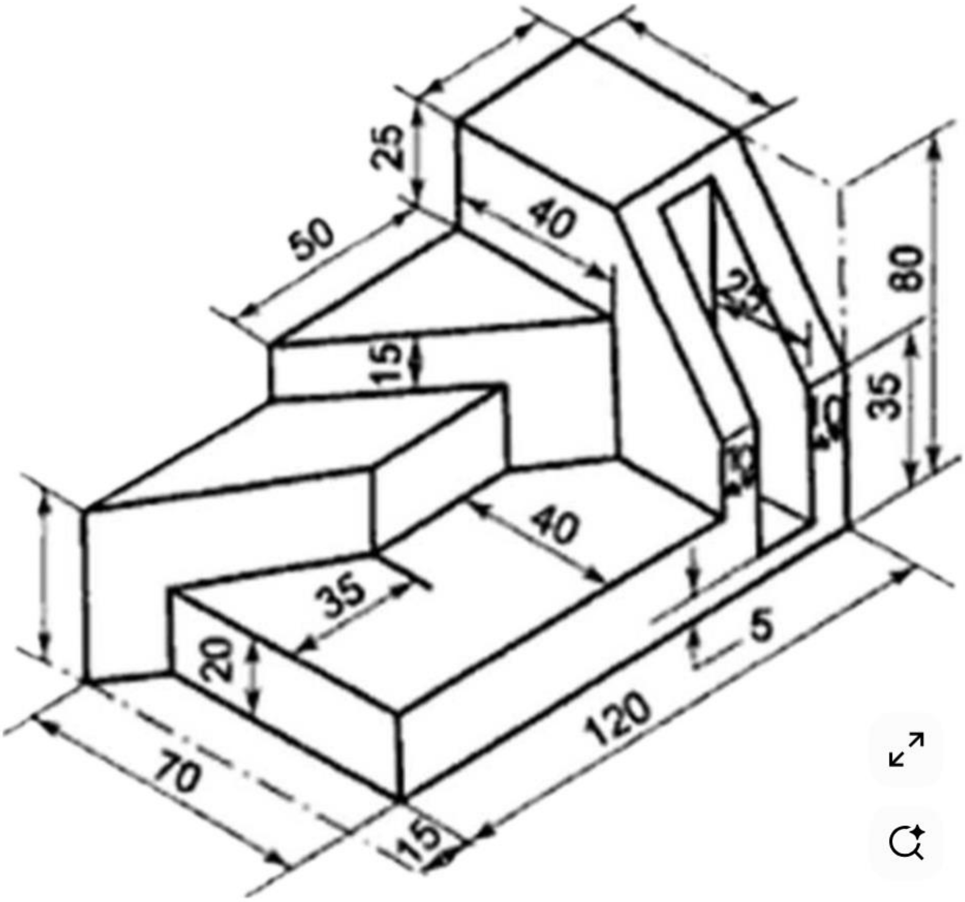

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