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Machine Component Design and Mechanics

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Mechanical design process

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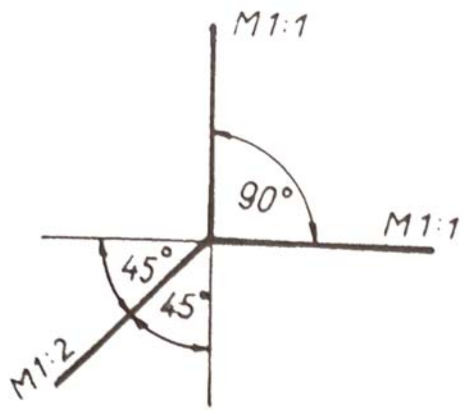
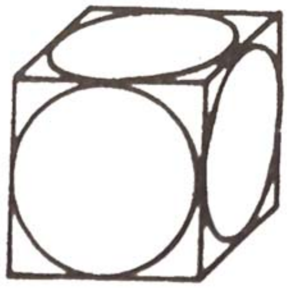
1. THE RULES OF AXONOMETRIC PROJECTIONS[1,2]

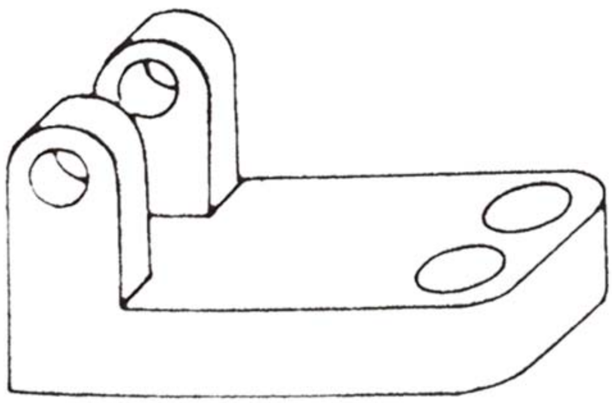


When drawing objects, you must represent the 3-dimensional shape in a plane. This changes the dimensions and proportions of the object. In order for our drawing to be read by others, we have to follow certain rules. To represent the three-dimensional shapes in a plane, we will use projections. For engineers, technologists and skilled workers, knowledge of plane representation is essential. Until a part is made, it is only seen in its planar projections on a drawing board or screen.



An axonometric image of a component is more similar to the image we see in space than to its image in a plane. By taking three axes, the dimensions of the object are plotted along the axes and the object is drawn. The scale along the axes can be constant, this is called one-dimensional axonometry. There are also ways of plotting where the dimensions along one axis are shortened (half the actual size is taken), these are called dimetric projections(two-dimensional axonometries) The angles enclosed by the axes also differ in each axonometric representation. The different axonometric representations are used to provide a more visual representation for easier recognition of the part.

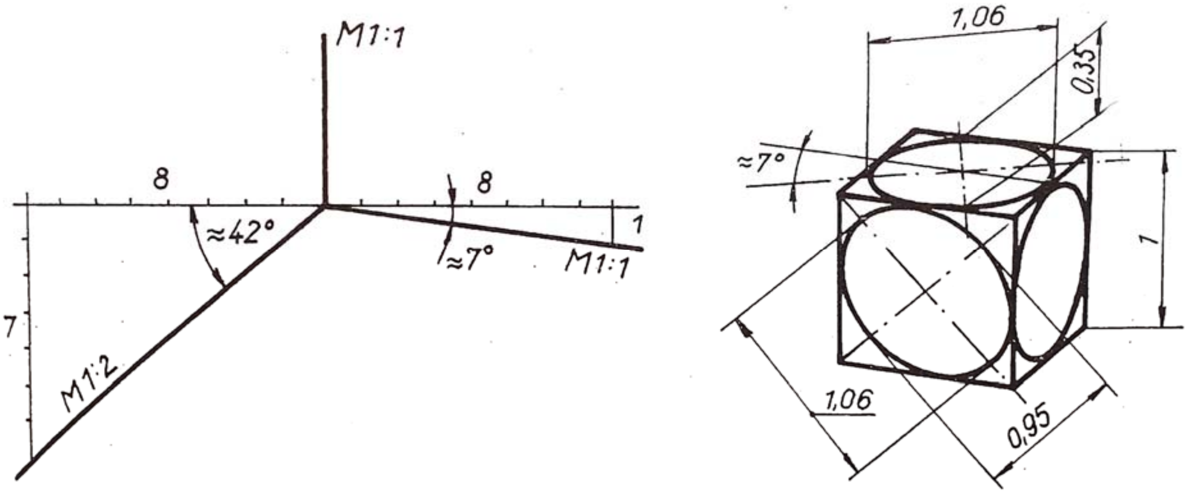
1.1 OBLIQUE FRONTAL DIMETRY



In this representation (*Figure 1*), the vertical and horizontal axes are perpendicular to each other and the extent of the object along these axes is scaled (M1:1). A size reduction is used along the oblique axis and the axis angel is usually 45° with the other two axes. If the interpretation is disturbed by the fact that a line of the part lies on the oblique axis, a 30° oblique axis may be used. This representation is also known as Kavalier axonometry. An oblique axonometric representation of a component is shown in *Figure 2*.

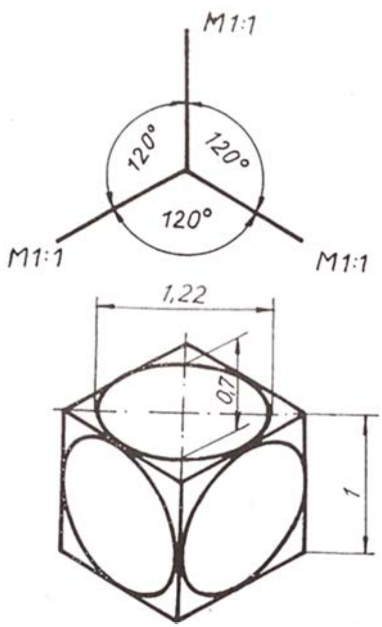
1.2 RECTANGULAR DIMETRY

In the dimetric or two-dimensional axonometry, the axes are oriented with a slope of 1:8 and 7:8 using auxiliary lines. These directions are taken by adding 8-8 units to the left and right of the horizontal auxiliary straight line from the origin. We then take 1 and 7 units downwards, respectively, to define a point on each axis, which we connect to the origin to obtain our oblique axes. The scale along the vertical and the 1:8 axis is a true scale (M1:1) and along the 7:8 axis a half scale (M1:2). As shown in *Figure 3*, the magnification of the drawing is 1.06, which gives a more true to scale sense. It is therefore preferred in engineering practice.



3. Figure Rectangular Dimetry

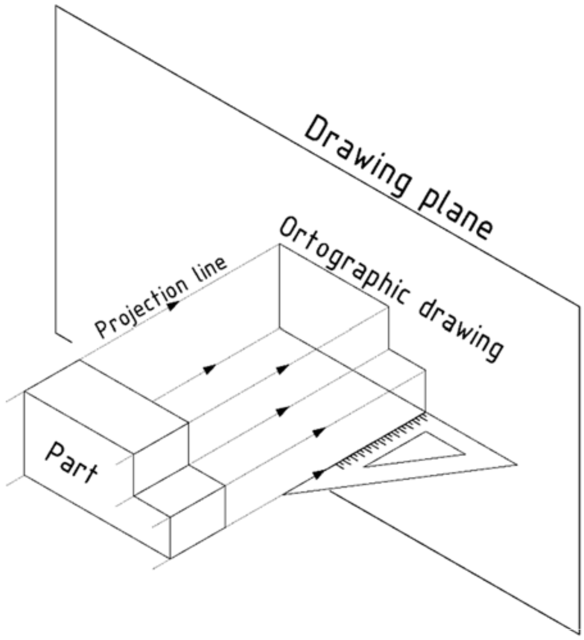
1.3 RECTANGULAR ISOMETRY



The picture planes axes are at 120° to each other and the scale is the same along the axes. The real lengths are measured along the axes. Figure 4 shows a cube in isometric view which have one unit long edges. It should be noted that the real dimensions of the object are only shown along the axes of the picture planes, the spatial elements are distorted. The image of the circles drawn on the faces of the cube in *Figure 4*, for example, becomes an ellipse in axonometry. The ellipse has a major axis of $\sqrt{3/2} \approx 1{,}22$ and a minor axis of 0.7. So the object is seen at 1.22 times magnification.

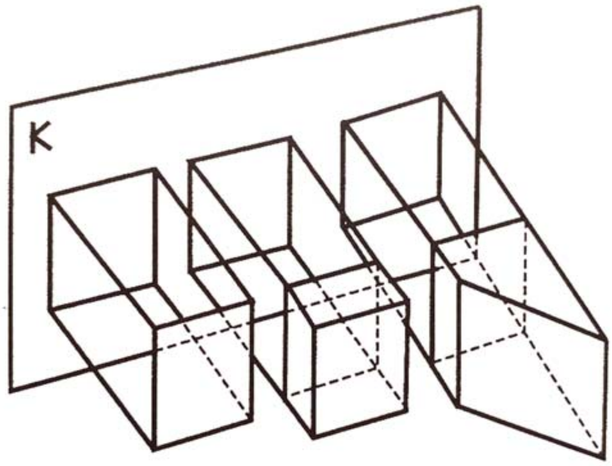
2. THE RULES OF ORTOGRAPHIC PROJECTIONS

The axonometric representations discussed in the previous chapter provide illustrative "pictorial" representations. The editing is more complex, which is no longer a problem with CAD systems. However, specifying dimensions, tolerances, surface properties, technological symbols would be difficult in axonometry and would give an unclear picture. This would make it much more difficult to read the drawings and therefore also to produce them. For this reason, the drawings are made using ORTOGRAPHIC PROJECTIONS, which is carried out by projection to a plane. After projection, the picture of the object on the plane is the PROJECTION. *The rules for projection methods are described in the standard EN ISO 5456.*

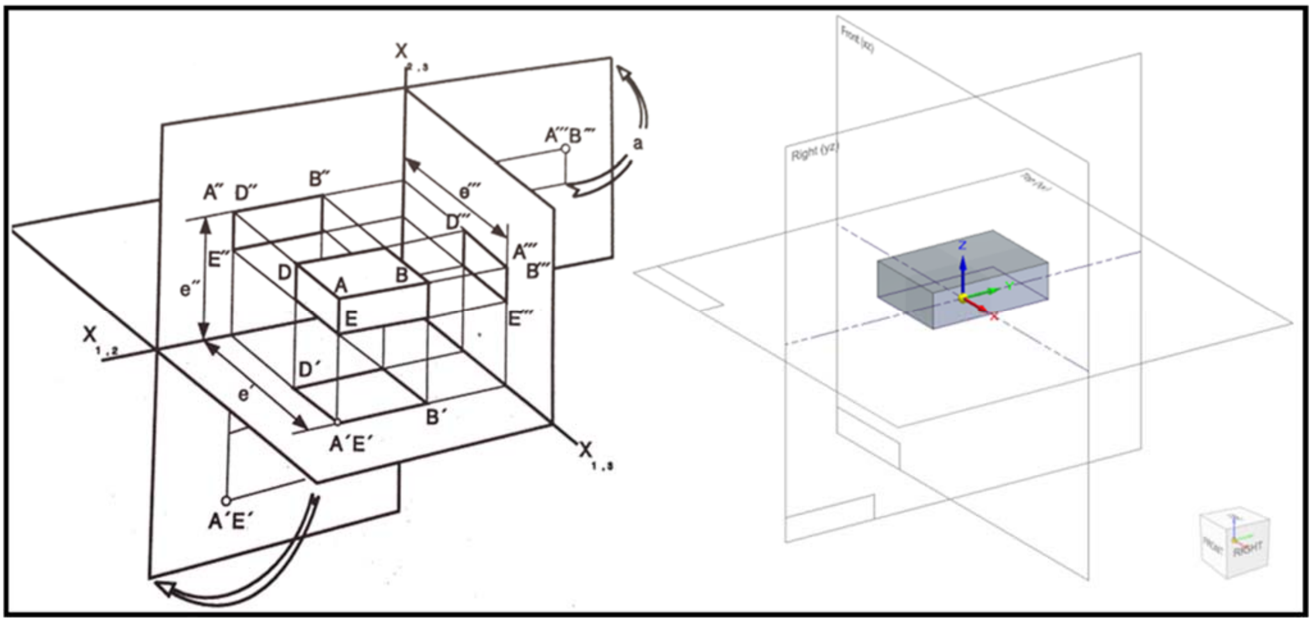


2.1 VERTICAL PROJECTION

In technical practice, the projection is mainly perpendicular, because in most cases there is no angle and no distortion on the projection (*Figure 5*). The projection beams are perpendicular to the image plane and parallel to each other. The dimensions of the projection are the same as the dimensions of the object. The resulting projection is called a perpendicular projection. Different objects can have the same projection, so several projections are drawn from one part. Draw more than three projections of an object only if absolutely necessary. The same information given more than once can be confusing to interpret.



French engineer Garpard Monge (1764-1818), "the father of descriptive geometry", created the method of projection, which has been used unchanged ever since. When we draw a part in the 3D modelling environment of CAD software, we see an image generated according to the laws of projection on the computer's flat screen(*Figure 7*).

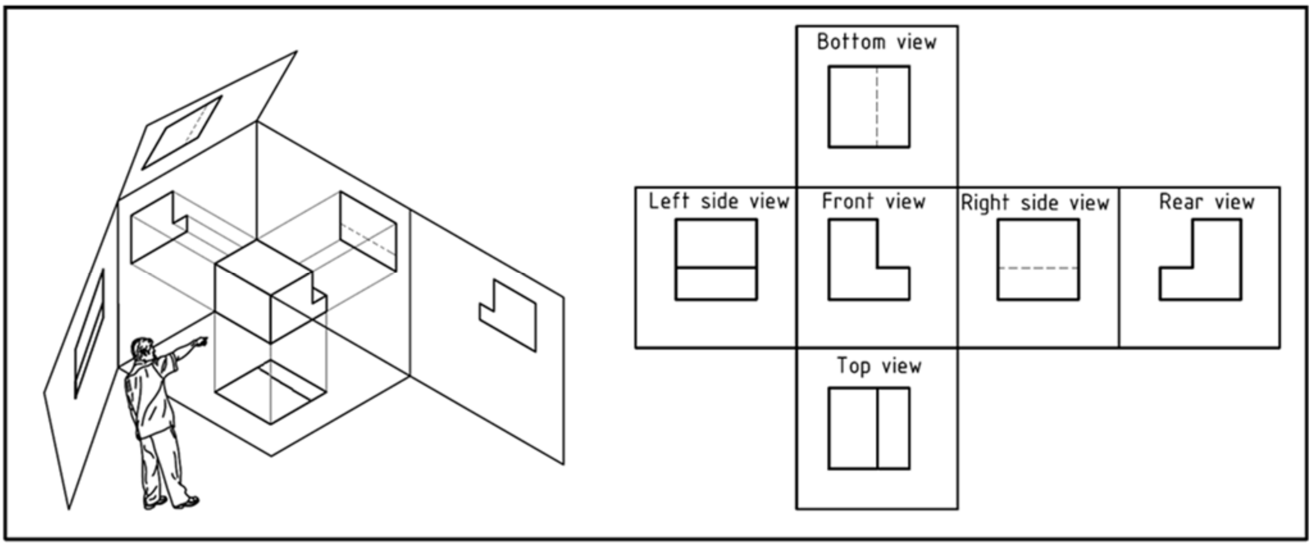


7. Figure Monge plane system

The picture plane system consists of at least two perpendicular planes. The intersection points of the planes build the axes of the picture planes. The projections of the points are identified by the capital letters of the alphabet and are given an index indicating which plane they lie on. The index can be a comma or a number. If you have few projections on the drawing page, you use a comma as an index, but if you have many projections, you use Arabic numbers to indicate the letter of the points.

2.2 STANDARD PROJECTIONS

Imagine that the object is placed in a square box (Figure 8). By projecting rays perpendicular to the object onto the faces of the square, a projection of the object is made on each of the six faces of the box. By cutting the edges of the box, the sheets can be laid out in a plane, so that 6 projections are seen in a single plane. The 6 views are called front view, top view, left view, etc., based on their position relative to the object, as illustrated in *Figure 8*. The main view of the object is the front view, which carries the most information about the object. The other views are arranged around the front view. Always draw as *many views* of an object as are *sufficient* and *necessary* to identify, scale and construct the object.



8. Figure Orthographic projection and European Standard Views

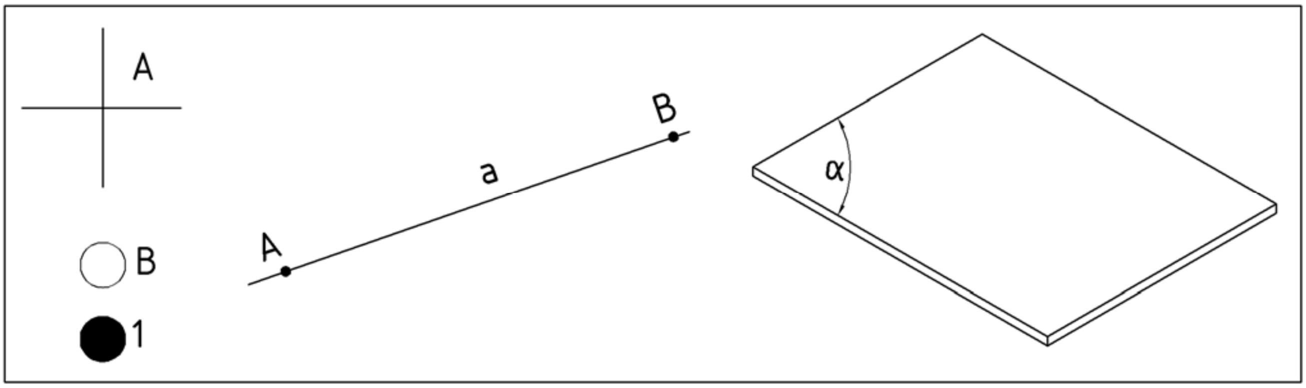
In the case of graphical representation, the axes of the image planes, image planes, axes of transformations are not indicated. When designing, representational geometric constructions can be very important, but their axes and construction lines are not indicated on component drawings and assembly drawings because it would be confusing.

3. GEOMETRY OF SPACE

Descriptive geometry is concerned with the representation of spatial shapes in a plane according to a defined method. Knowledge of the technique of representation is of paramount importance in engineering practice. When designing components, we often use 3D modelling CAD software that knows the rules of projection. We will not be able to design, optimise for production and produce a understandable view of complex shapes if we do not know the basic principles of technical drawing and ortographic projection.

3.1 BASIC KNOWLEDGE OF ELEMENTS OF SPACE

In order to represent solids in Euclidean space, it is essential to understand the concepts of *point*, *line* and *plane* as the building blocks of space. The point is the simplest element without extension, which can be defined as the intersection of two lines on a plane. Several points can form geometrical elements as lines, curves, planes. The positions of the points are marked by a cross or a circle and are denoted by capital letters(A,B,...) or Arabic numbers (1,2,...). To denote the line, we use small letters(a,b,...) and the planes are denoted by Greek letters(α,β,...). See the signs in *Figure 9*.



9. Figure Drawing and marking point, line and plane

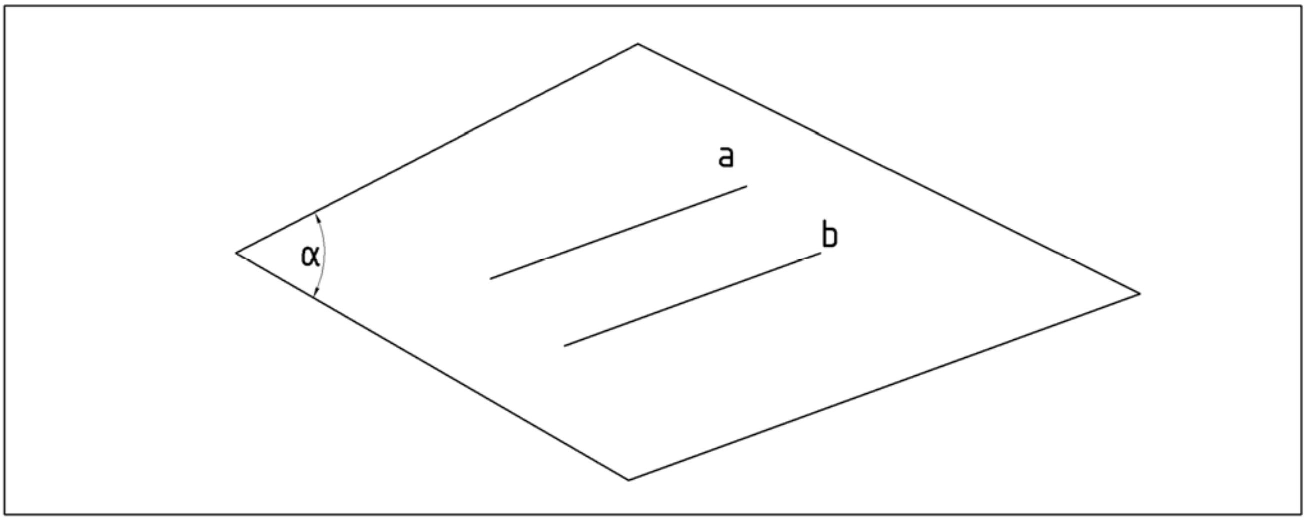
The following fundamental theorems about the properties of spatial elements are accepted without proof:

1. Only one line can be drawn through two points.
2. A single plane can be laid across three points if they are not on a straight line.
3. If 2 points of a line lie on a plane, then all points of the line lie on that plane.

Thus, a line is perfectly defined by two points, and a plane is perfectly defined by three points not lying on a line. For example: 'AB' is a line or 'ABC' is a plane. Also fundamental element is the *segment*, which is defined by the distance between two points on a line. So the distance between points 'A' and 'B' is the distance of 'AB' or 'AB' segment. Using the sign of a line, we can also use a small letter to denote the segment, e.g. segment 'a'.

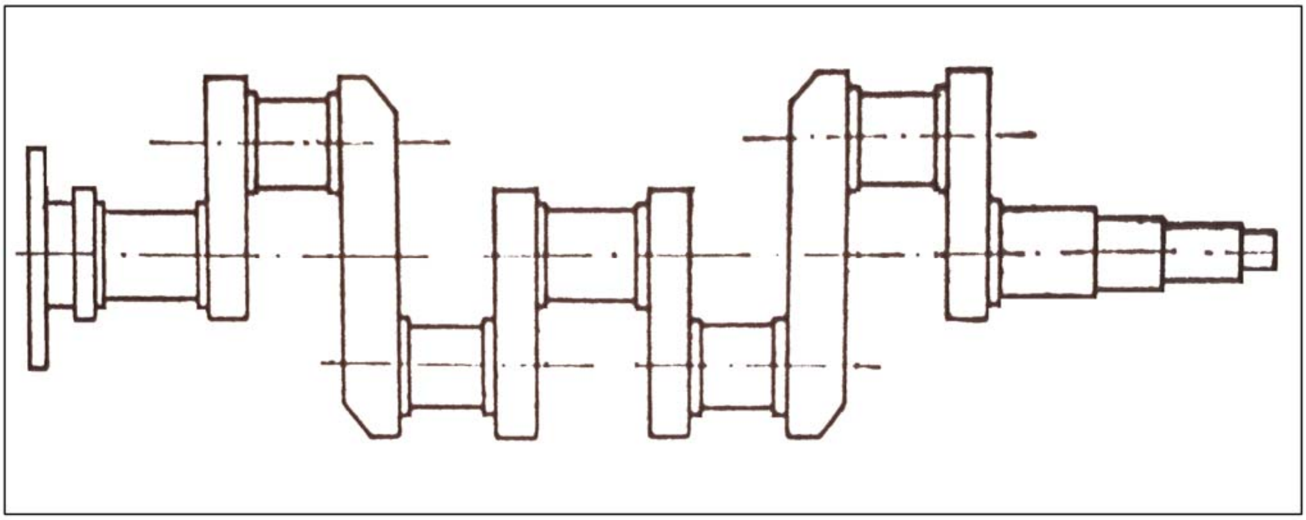
To continue the list of basic items:

4. Two lines are *parallel* if they lie in the same plane and do not intersect (*Figure 10*).



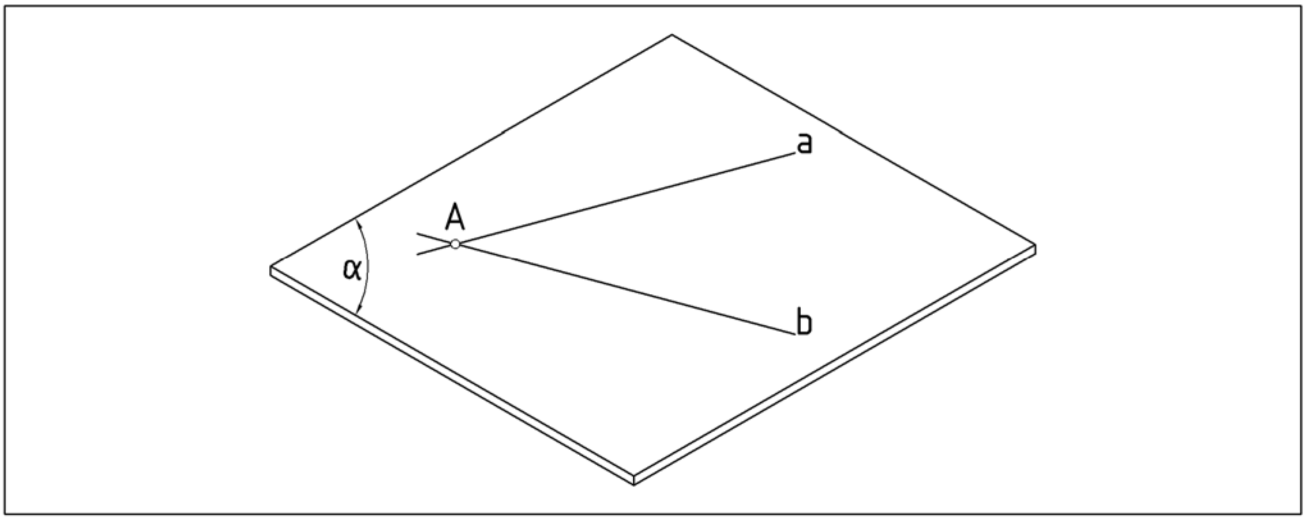
10. Figure Paralel lines

Parallel lines can be observed in many places on machine parts. A good example of this is the crankshaft of a motor vehicle, where parallel and coincident lines can be observed at the bearing seats (*Figure 11*).



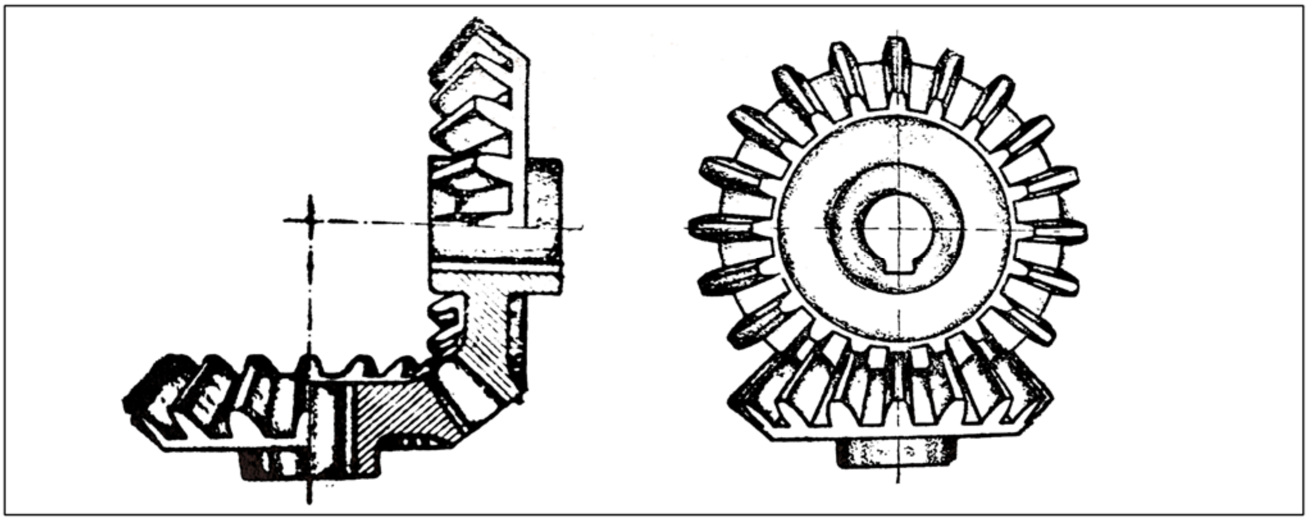
11. Figure Vechicle crankshaft

5. *An intersection* is defined as two lines that have a single point in common. A plane can be laid on two intersecting lines (*Figure 12*). The angle subtended by the intersecting lines has no effect on the position of the plane laid on them.



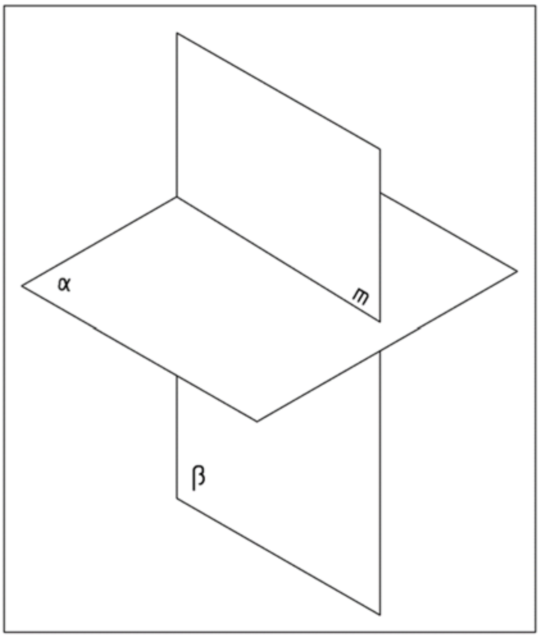
12. Figure Intersecting lines

A good example of intersecting straight lines is the shaft arrangement of a bevel gear. The output and input shafts intersect(*Figure 13*).

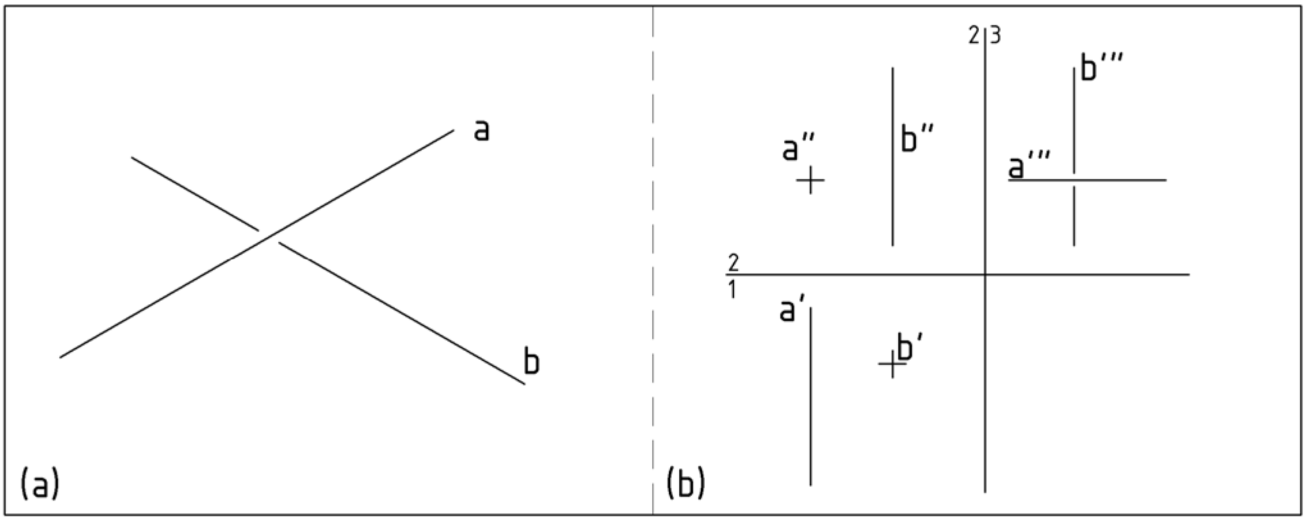


13. Figure Bevel gears

6. If two planes have a common point then they have a common line too. These two planes make an intersection line defined by the common points(*Figure 14*). To explain the notation in Figure 14, the planes α and β are intersecting planes, their common points form the *intersection line of the two planes*.

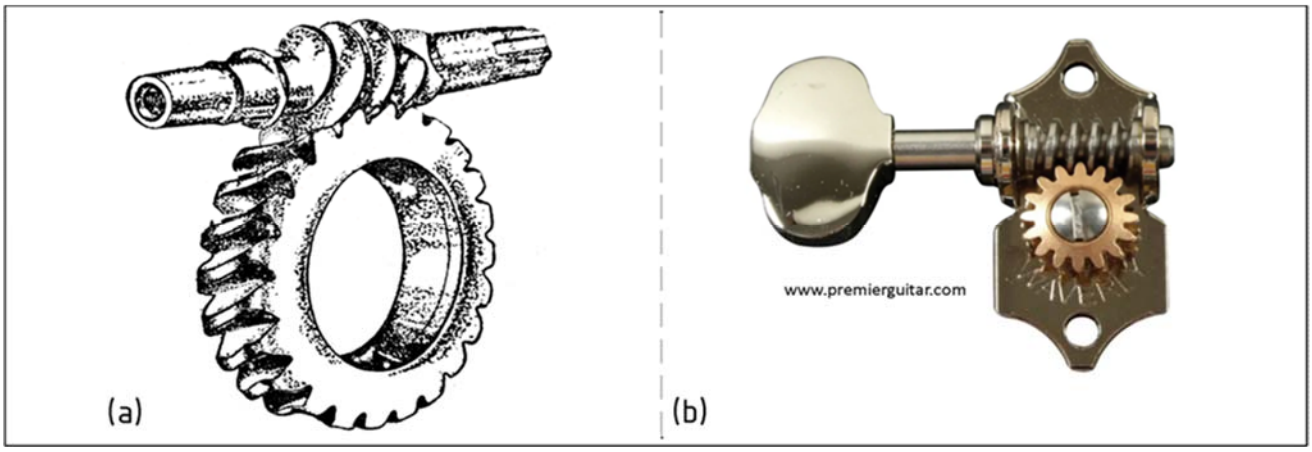


7. The *skew lines* are non-parallel and non-intersected. They are not in the same plane. In *Figure 15a*, you can see two skew lines in axonometric view, and in *Figure 15b*, they are shown in three planes according to the rules of projection. The notation and naming of the axes of the plane of view is illustrated by the example of the axis of view one-two '12'. Axis one and two is the intersection of plane one 'P1' and plane two 'P2'. The picture plane axis is labelled '1' on picture plane one 'P1' and '2' on picture plane two 'P2'.



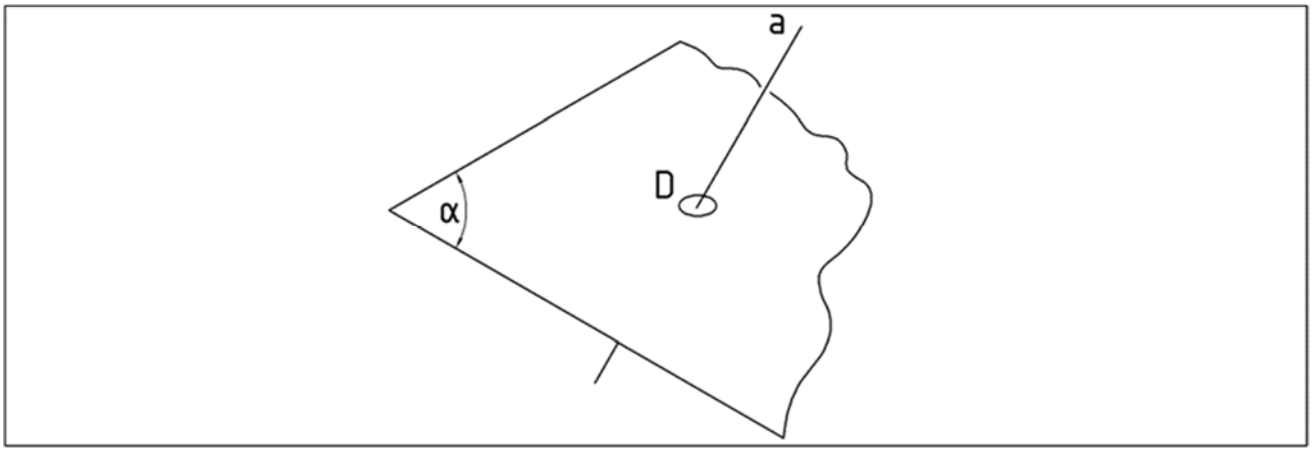
15. Figure Skew lines

An example of skew lines is the worm gear shown in *Figure 16a*, where we can observe that the axes of the wormshaft and the worm wheel are neither intersecting nor parallel. *Figure 16b* shows a guitar tuning mechanism[3], which is in fact a worm gear.



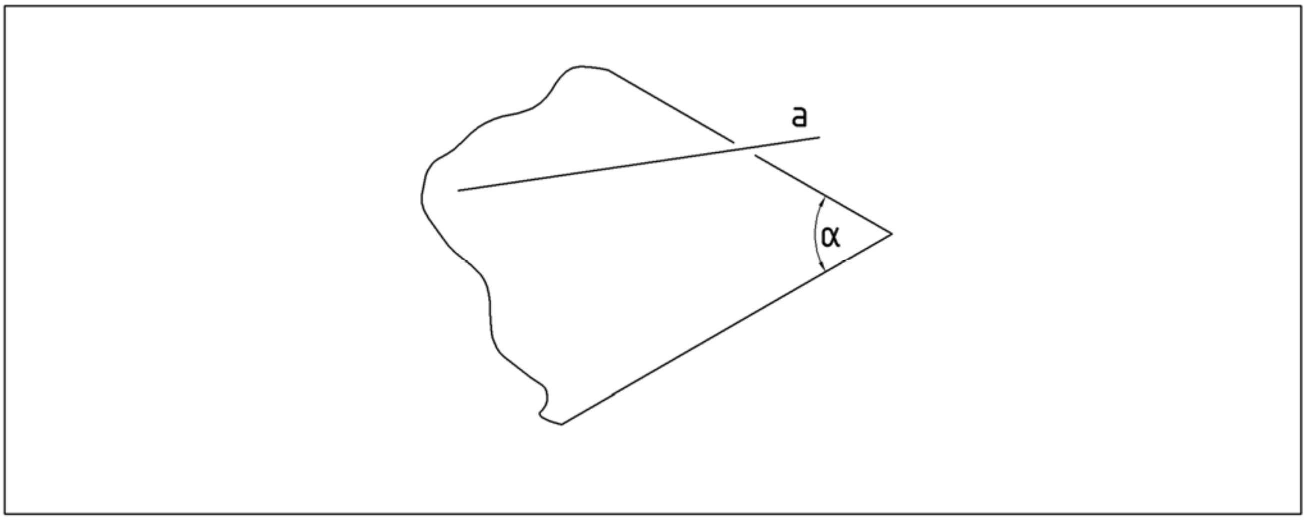
16. Figure Worm gear mechanism

8. The common point of a plane and a line is called the *intersection point* (*Figure 17*).



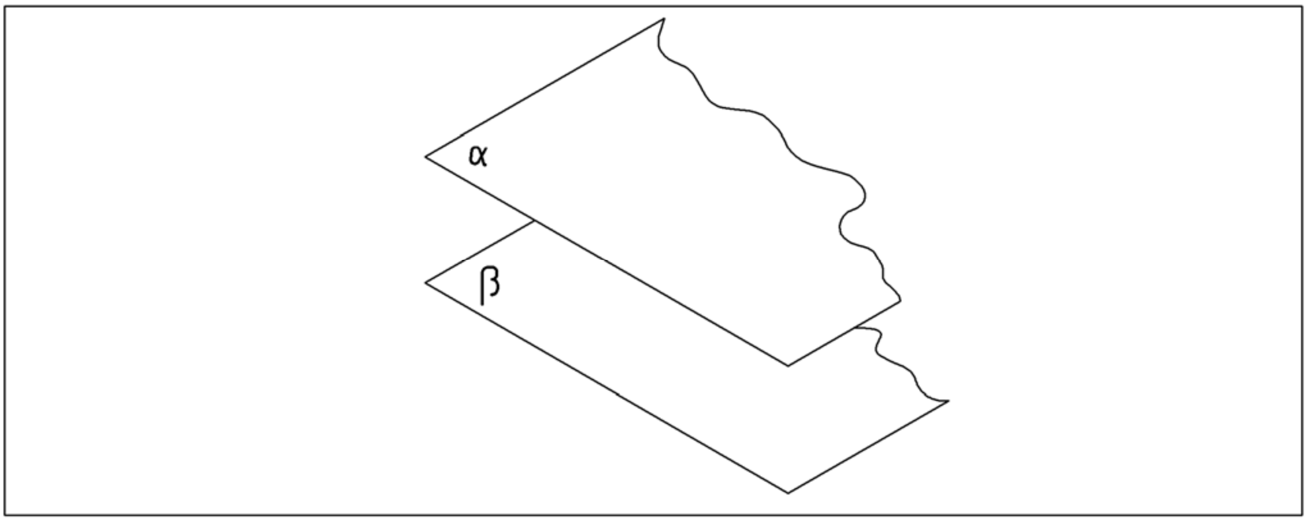
17. Figure Intersection of a line and plane

9. A line is parallel to the plane if it has no common point with the plane (*Figure 18*).



18. Figure Parallel line and plane

10. Parallel planes have no common point, they have no intersection.(*Figure 19*).



19. Figure Parallel planes

It is worthwhile to continue to look at the world around us by looking for the connections we make in the environment, in the parts we touch. We look for planes, axes, edges, intersecting, parallel and skew lines, intersections, etc. By constantly observing nature and its creations, geometries, and looking for connections, we will notice patterns that become embedded in our problem-solving mechanisms and often unnoticed, smuggle the solution steps into our minds.

3.2 ANGLE AND DISTANCE OF ELEMENTS

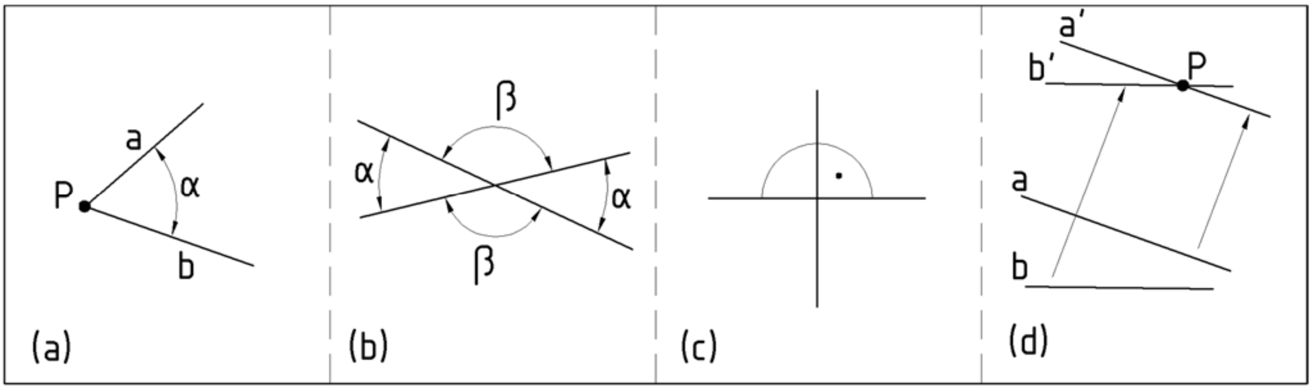
3.2.1 ANGLES

An angle is formed by two straight lines with the same starting point. The vertex of an angle is the origin and the position of the lines determines the size of the angle.(*Figure 20a*).

When two lines intersect, four angles are formed, where the two opposite angles are equal, and the smaller of the two (the acute angle) is called the *angle of the lines*. In *Figure 20b*, the angle of the lines 'a' and 'b' is angle α.

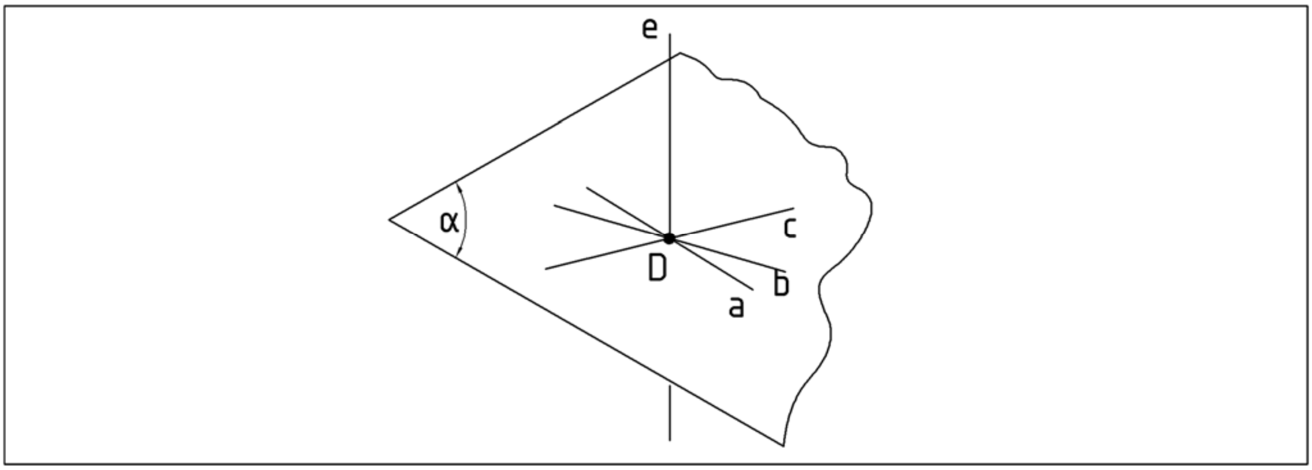
If the adjacent angles around the intersection of the lines (*Figure 20c*) are equal, the two lines are called *perpendicular*. Their angle is 90°.

To determine the angle of skew lines (*Figure 20d*), the two lines are shifted to any point in space (parallel to themselves). The angle of the shifted lines is equal to the angle of skew lines.



20. Figure Angles of the intersected lines and skew lines

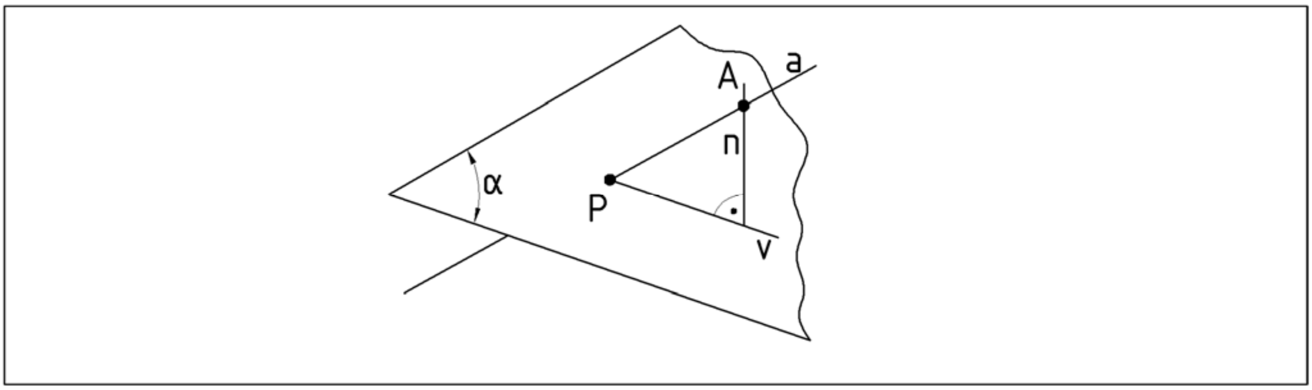
To find the angle of inclination of an intersecting line and plane, we need to know when a line is perpendicular to a plane. A line will be perpendicular to a plane if any line in the plane drawn through the intersection of the line with the plane at its base is perpendicular to that line (*Figure 21*).



21. Figure Line and plane intersection

Lines perpendicular to a plane are called the normals of the plane.

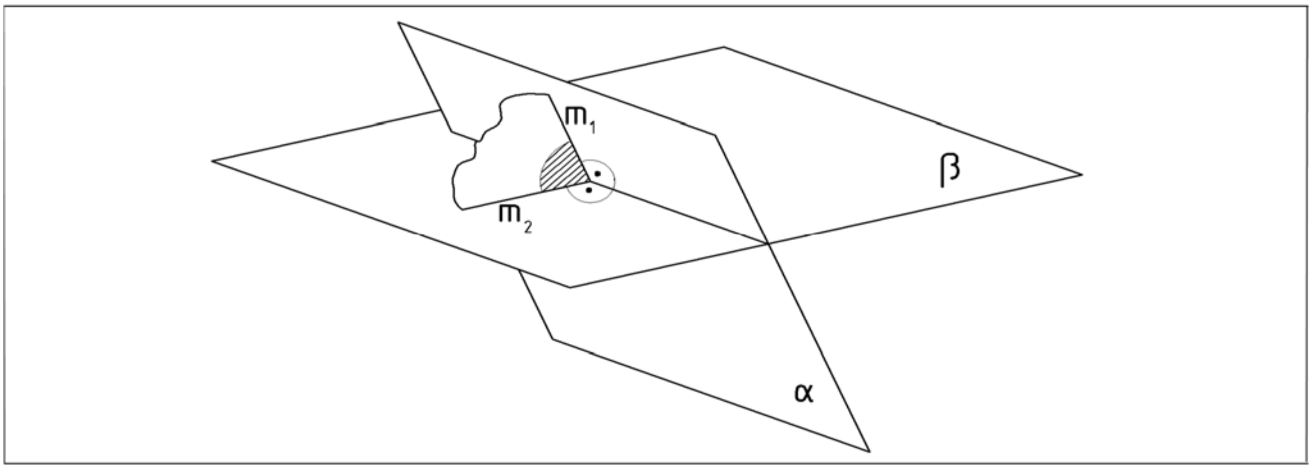
If the line is not perpendicular to the plane, its angle can be determined as follows: (*Figure 22*)



10. Figure Angles of a plane and a non-perpendicular straight line

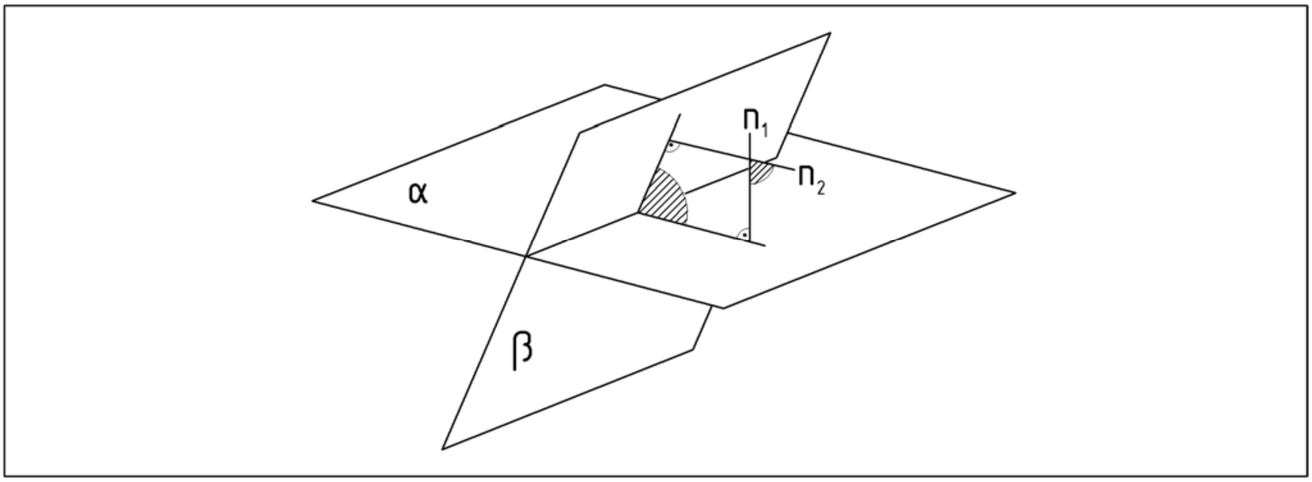
From an arbitrary point on a given line 'a', set a perpendicular straight line 'n'(normal line) to the plane 'α'. Here we got an intersection point of the normal line and the plane 'α'. If we connect the intersection point with the 'P' point we are given a projected line 'v' that lies in the plane. The angle of the line 'a' and the plane 'α' is the angle between line 'a' and line 'v'.

The angles of two planes are determined (*Figure 23*) by establishing a new plane that perpendicular with the plane 'α' and 'β'. The first step is to create a new line 'm1' that is perpendicular to the intersection line and lies in the plane 'α'. Repeat this in the beta plane we create the line 'm2.' On the two lines('m_1' and 'm_2') we can set the new plane which will be perpendicular to the plane 'α' and 'β'. Then the angle of the planes(angel between the line 'm_1' and 'm_2') can be mesured.



11. Figure Measuring the angle of planes

By constructing the normal lines of the intersecting planes, we can also determine the angle of the two planes as shown in *Figure 24*. The angles of lines('n_1' and 'n_2') perpendicular to the planes are equal to the angles of the plane 'α' and 'β'.



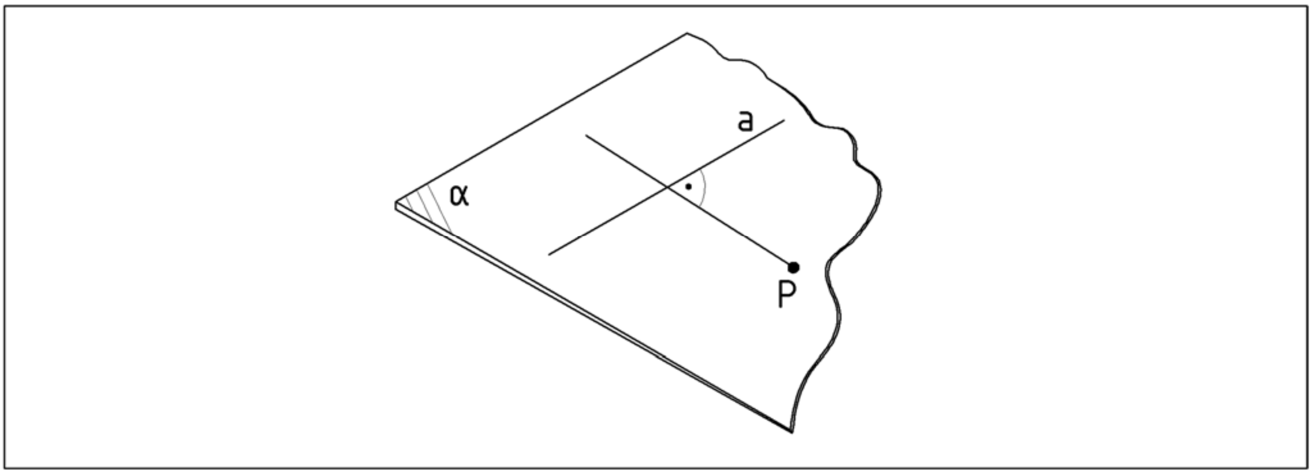
12. Figure Measuring the angle of planes with normal lines

The angle of inclination of two planes is a right angle, i.e. the two planes are perpendicular to each other if one plane contains a line perpendicular to the other plane.

3.2.2 DISTANCES

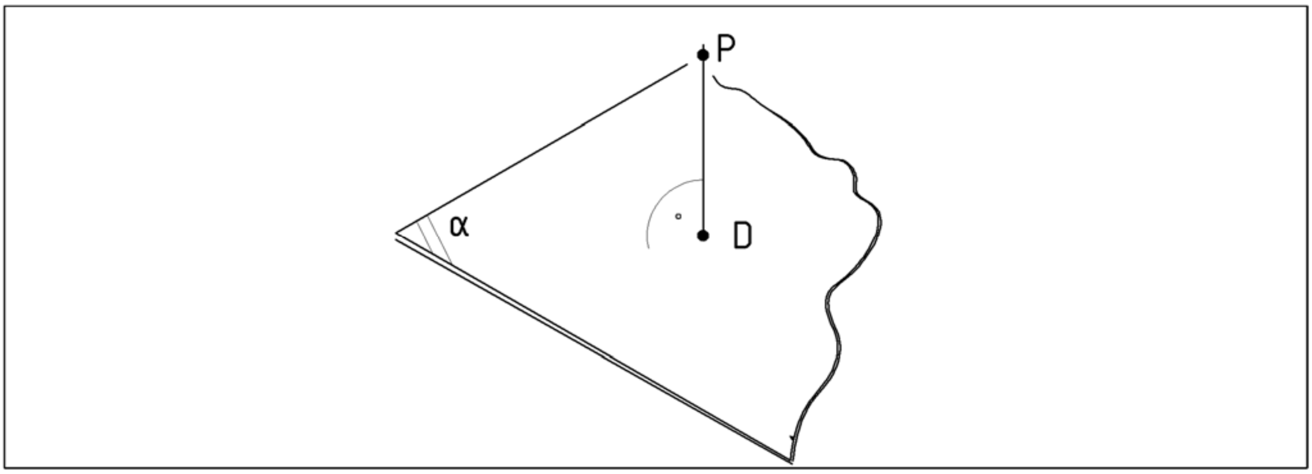
The distance between two points is called the straight line segment between them, or its length.

As stated earlier, a point and a line define a plane. In this plane, the length of a perpendicular segment from the point to the line gives the distance from the point 'P' to the line 'a'(*Figure 25*).



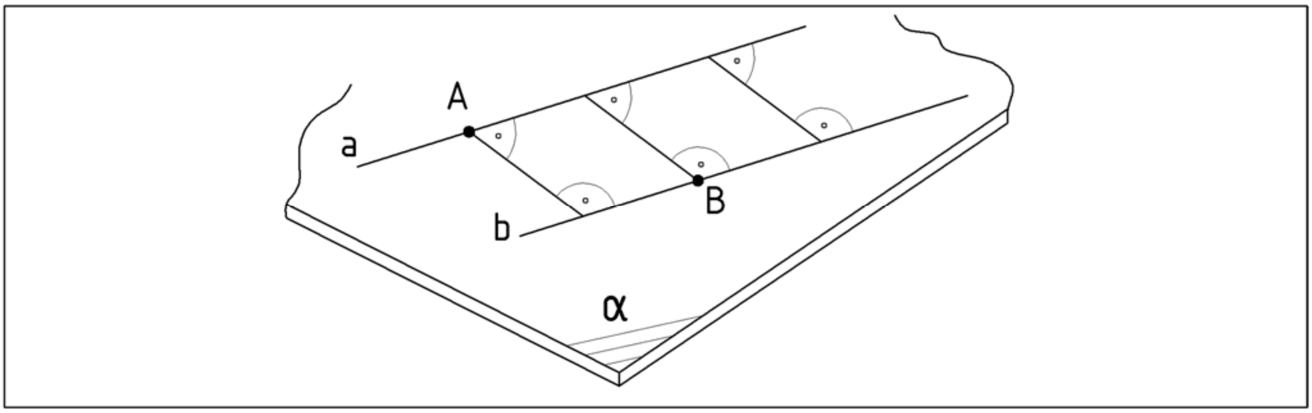
13. Figure Distance between a line and a point

The distance of a point from a plane is the length of the perpendicular segment from the point to the plane. As illustrated in the example in *Figure 26*, the segment 'PD' between the point 'P' and its intersection with the normal plane 'D'.



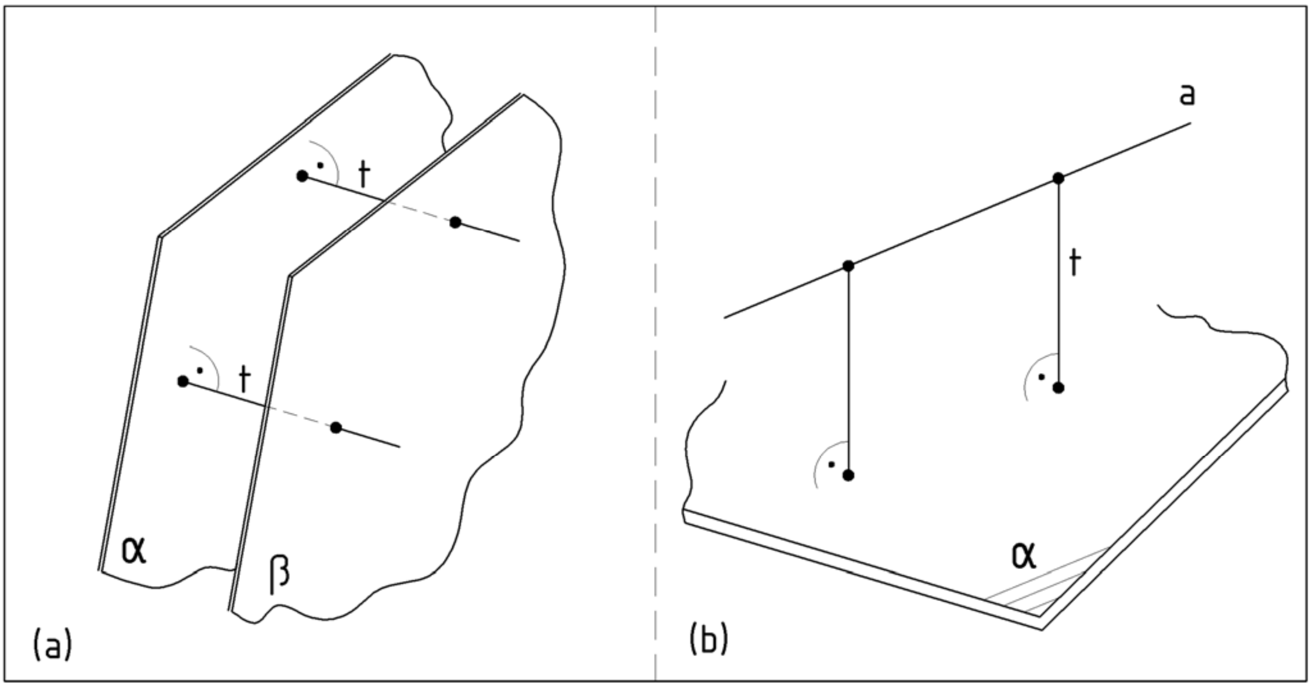
14. Figure Distance of a point from a plane

The distance of two parallel lines is equal to the distance of any point on one line from the other line (*Figure 27*).



27. Figure Distance between parallel lines

Figure 28a shows two parallel planes. At any point, a segment perpendicular to a plane gives the distance between the two parallel planes. The distance between a plane and a parallel line can also be described by segments of equal size(*Figure 28b*).



28. Figure Distances of parallel elements

3.3 EXAMPLES OF SURFACES IN TECHNICAL PRACTICE

In our studies we have made our drawing in the plane of our drawing paper, using a ruler and a compass. In space we cannot work with these tools, so we have to make our spatial geometry constructions in our heads, in our minds - and then we can record them on a drawing paper using the rules of descriptive geometry.

Firstly we have to define the rules of spatial drawings making. We need to introduce some new concepts.

3.3.1 DRAWING PLANES

A PLANE is considered to be constructed if the spatial elements which clearly define the position of the plane in space have been found.

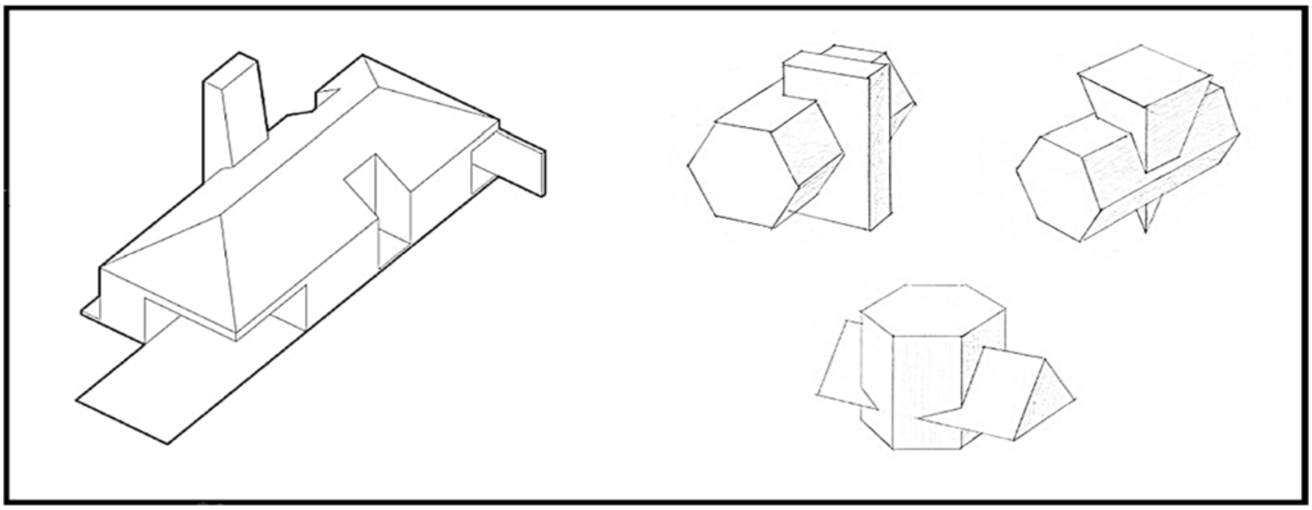
We can draw a plane:

- with three points
- on a straight line and an external point
- an intersecting pair of straight lines
- a pair of parallel lines

In the case of two intersecting planes are given, their intersection lines are given thus we can determine the intersection of two planes in space. Once we have defined a plane in space, we can do all the drawings in this plane what we do in descriptive geometry.

3.3.2 DRAWING OBJECTS WITH FLAT LINE SHAPES

The FLAT LINE SHAPES are prsim, cube, pyramid. The prism or the cube can laying on their any planes but the pyramid just can only stand on its base plate. The standing object has a vertical axis and its ending plane is horizontal. The vertical edges look like point on the base plane.



29. Figure Objects build from flat surfaces

Various engineering components can be designed using the geometric forms of cubes, rectangular prisms (or cuboids), and pyramids(See *Figure 29*):

- Cubes: Being equal in all dimensions, cubes can be used in certain modular designs or components that require symmetry. Examples include:
    - Square shaft ends
    - Structural blocks for assemblies or constructions.
    - Calibration blocks in metrology.
    - Certain types of weights or counterbalances.
- Rectangular Prisms (Cuboids): With their three distinct dimensions, these are one of the most common shapes in mechanical design. Components or structures derived from this shape include:
    - Casings or enclosures for electronics or machinery.
    - Shipping containers or storage boxes.
    - Battery cells in certain configurations.
    - Base structures for platforms or machinery.
- Pyramids: In buildings and building services engineering, pyramid or conical shapes can be observed in various applications due to their distinct structural and functional advantages:
    - Roofs: Pyramid-shaped roofs, often seen in traditional or historic architecture, can aid in water runoff, offer a distinctive aesthetic, and provide additional space beneath.
    - Ventilation and Exhaust: Conical ducts or vents, used in HVAC systems, help in regulating and directing airflow. Their tapering design can increase or decrease the velocity of air or other fluids, depending on the application.
    - Light Fixtures: Pyramid or conical shapes in light fixtures can help direct light in a particular direction, providing focused illumination or creating specific ambient effects.
    - Acoustics: In some spaces, conical structures or surfaces can be implemented to manage sound reflection or absorption, optimizing the acoustic properties of a room.

3.3.3 DRAWING OBJECTS WITH SOLIDS OF ROTATION

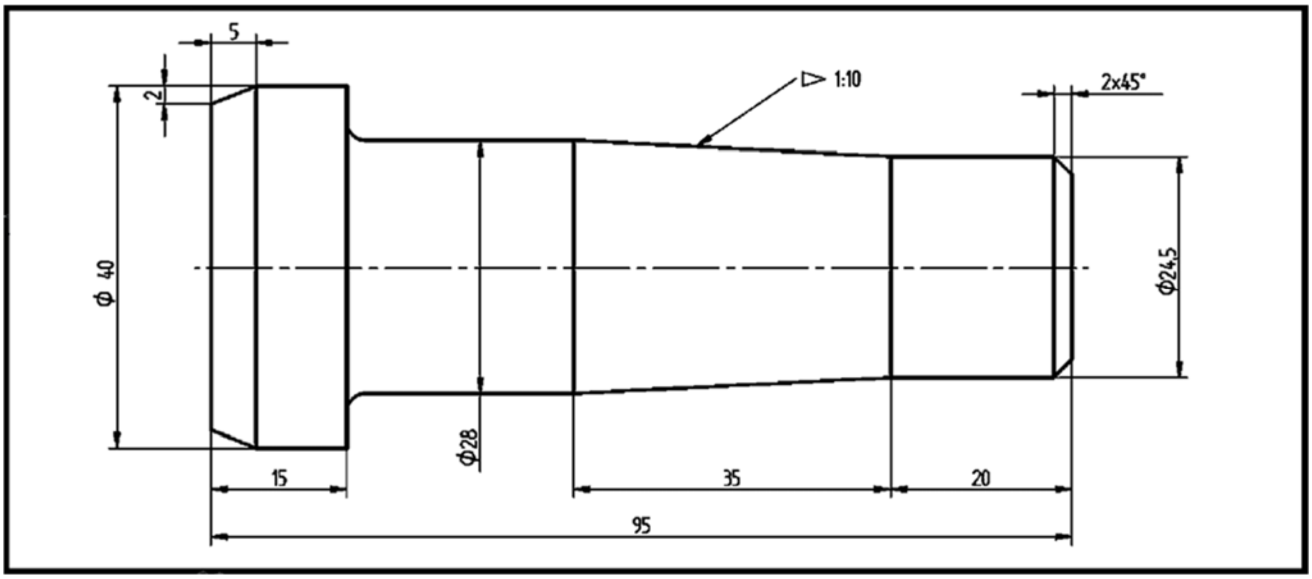
The SOLIDS OF ROTATION are cylinder, cone, sphere and the circumferential ring. Combinations of these can produce many of the shapes used in engineering practice. Examples include the junction of tubes of different diameters, cylindrical and conical sheet metal parts or a solid shafts with cylindrical bores.

Various components can be designed with cylindrical, conical, and spherical surfaces.

- Cylindrical surfaces are commonly used in parts such as shafts, rods, barrels, rollers, and sleeves. They provide a uniform cross-section and are typically utilized for rotating elements or parts that need to slide within other components.

- Conical surfaces, having a tapering shape, can be found in parts such as nozzle tips, tapered bearings, and certain types of gears. Their design often serves specific functions, like guiding or centering components, or enabling tighter fits between parts. The tapering design offers unique advantages in various components. Some applications include:
  - Conical filters, funneling substances through a decreasing cross-sectional area.
  - Certain types of nozzle or vent designs, directing flow in a particular direction.
  - Spikes or pointed feet for machinery or equipment to ensure grip or stability on a surface.
- Spherical surfaces are seen in components like ball bearings, ball joints, and certain types of lens. They provide omnidirectional movement or rotation, making them ideal for parts that require unrestricted movement in multiple directions.

Each of these geometric designs offers unique advantages depending on the application and the specific requirements of the component in the larger mechanical system. The *Figure 30* below shows a shaft designed as a combination of cylinders and cones.

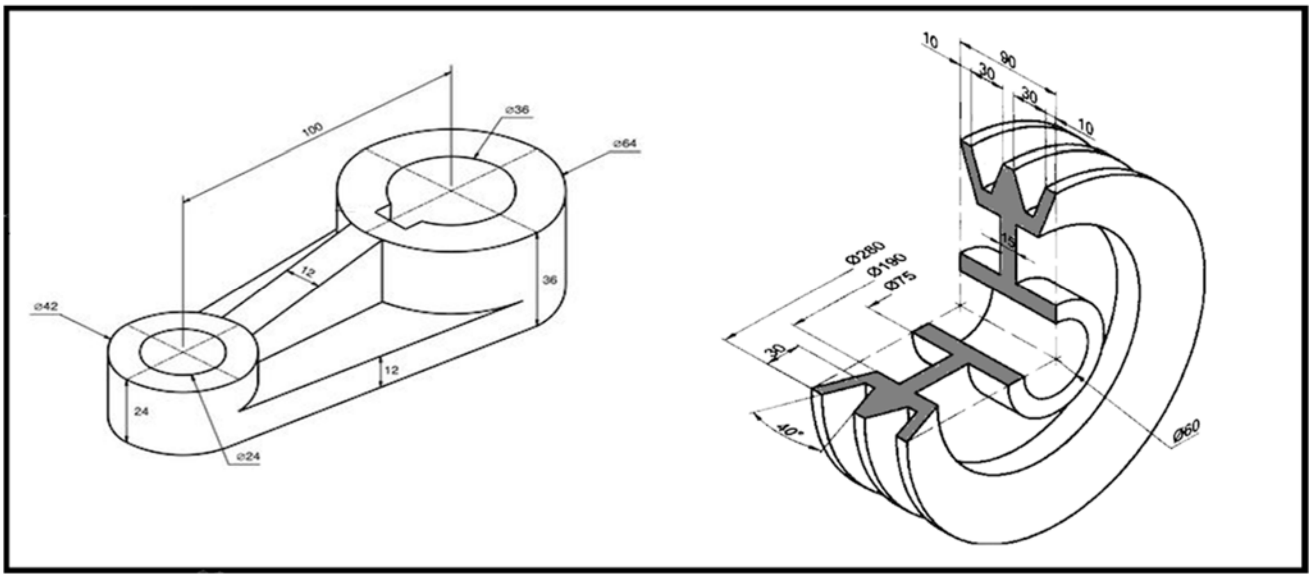


30. Figure Shaft made up of cylinders and cones

3.3.4 COMPLEX SHAPES OF PARTS

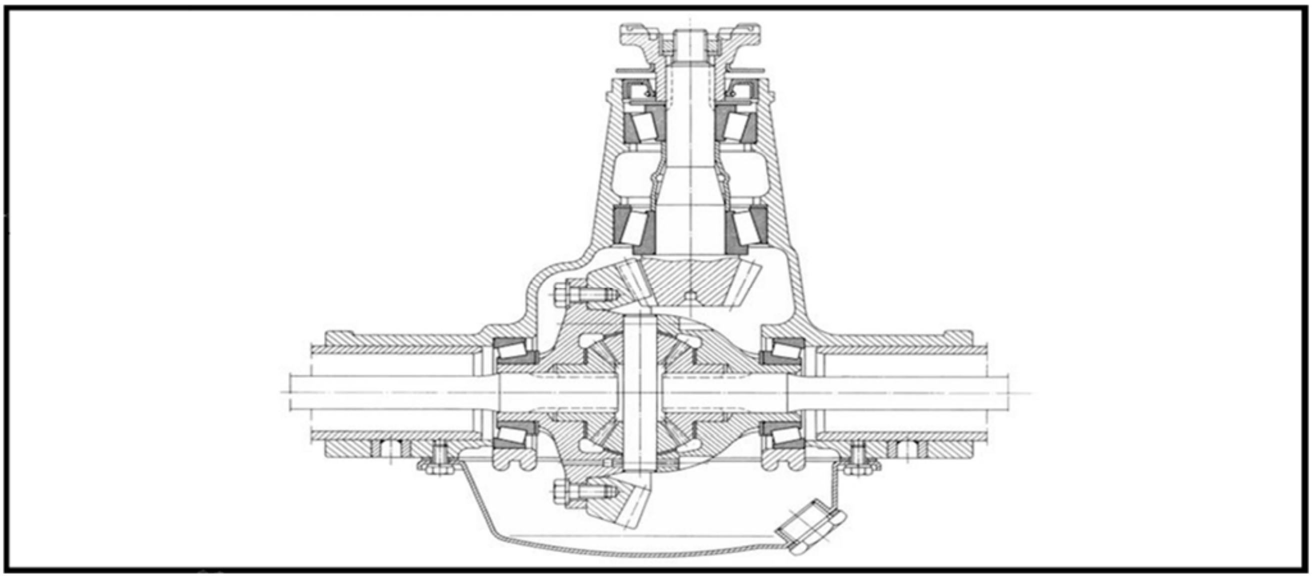
In mechanical engineering, most surfaces are born from a combination of flat planes and revolution bodies(*Figure 31,32*). The design and development of components and structures often involve a harmonious blend of flat planes and bodies of revolution. While flat planes provide stability, ease of manufacturing, and simplicity in assembly, bodies of revolution, generated by rotating a curve about an axis, offer smooth transitions, efficient flow dynamics, and uniform stress distribution. Cylinders, cones, and spheres, all examples of revolution bodies, are frequently combined with flat surfaces to create parts like shafts with flanges, conical nozzles with mounting bases, or spherical tanks with planar supports.

The melding of these two fundamental geometries allows engineers to tailor designs to specific functional requirements while optimizing manufacturing processes. This synergy between flat planes and curved surfaces is a testament to the adaptive and innovative nature of mechanical engineering, ensuring both functional efficiency and design elegance.



31. Figure Complex parts

In the differential mechnaism shown in *Figure 32*, the components formed using complex surfaces can be clearly observed. When looking at the axes of the components, parallel, intersecting or skew lines(axes of the parts) are clearly visible. The axes of the parts are marked with a dotted line.



32. Figure Differential mechanism

4. TECHNICAL DRAWING

The representations described so far have shown the construction of bodies by superimposing or substituting certain building blocks. The external and internal geometry of the object can be represented well with the knowledge we have acquired so far, but even so the drawing does not provide enough information about the part for manufacturing. To be able to make a machine drawing from a diagram, you need to know the rules of sectional representation, dimensioning, symbolic representation, standard notation.

4.1 THE PURPOSE OF MECHANICAL DRAWING[4]

In industry, they can make different objects and parts from drawings. These drawings are called TECHNICAL DRAWINGS. In technical drawings we record information about the shape, dimensions, etc. of objects according to the rules of technical representation. We also record administrative data (date, designer's name, editor's name, signatures, validity, version number).

In engineering, we often make SKETCHES, which are usually made freehand, not necessarily true to scale and proportion. Such sketches are usually *temporary drawings*, made during production in response to a problem that arises. We may supplement a drawing of a prototype. In agreement with the technology and design, any modifications must be recorded immediately in the valid production documentation.

A special type of technical drawing is a DRAWING, used in the field of engineering. A machine drawing carries several pieces of information that refer to the manufacture and purpose of the part. It contains the necessary information about the manufacturing technology, material quality, machining accuracy, surface treatment, coating, moving part positions, etc. in the form of inscriptions, instructions, drawings.

TYPE OF TECHNICAL DRAWINGS

Machine drawings can be further classified according to the purpose for which they are intended and the type of information they are intended to convey. The following list also reflects the steps in the implementation of a product, from the drawing board to operation.

- Conceptual drawings (sketches)
    - Flow chart
    - Roadmap
    - Wiring diagram
    - Proposal drawing
    - Calculation sketch
    - Preliminary design
- Editorial drawings
    - Assembly drawing
    - Dimensioned assembly drawing

- Production drawings
  - Component drawing
  - Workshop drawing
- Establishment drawings
  - Layout drawing
  - Machine foundation drawing
- Operational drawings
  - Maintenance drawing
  - Handling drawing

The system of representation and notation is standardised to ensure that the interpretation of drawings is clear around the world. In many cases, the design office and the manufacturing company are not even on the same site and the designer and the technologist do not even interact personally. A component may have several suppliers and all of them must provide the same quality of product. It is also common for a component to go through several specialised factories during its production. This shows how important it is to be able to interpret a machine drawing we produce, regardless of the language.

4.2 STANDARDS[4,5]

Standardisation is the result of common agreements that define rules, standardise methods, machine components and systematise our technical knowledge in a particular field.

A standard is a technical specification that fixes:

- parameters
- properties
- specifications
- requirements
- test and inspection methods

It can be subject to standardisation:

- product, produce, installation, equipment
- concepts, definitions, designations, symbols, methods of representation, measurement and calculation used in technical and economic activities
- safety at work, technical requirements for the protection of life, health, physical safety and the environment
- organisational, administrative and documentation methods and tools
- technical requirements for services
- procedures and methods for quality assessment and certification

The level of standards:

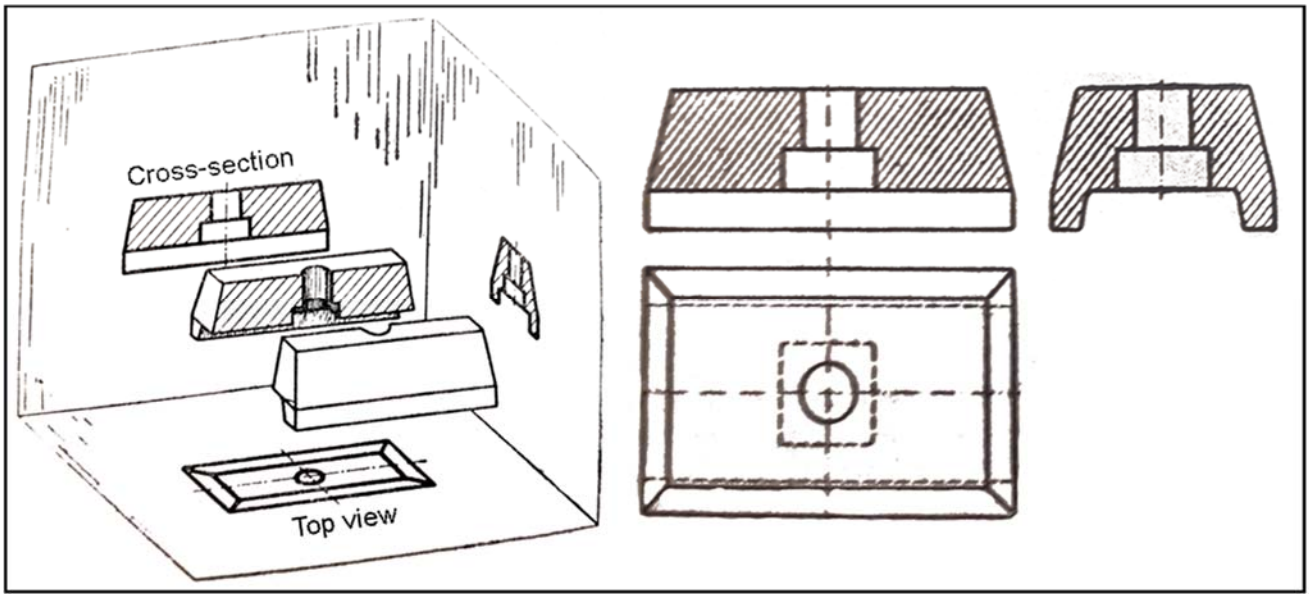
- International standards- ISO (International Standard Organisation)
- - Regional standards
  - o EN(European Standard)European standard; Issuing body: CEN(Comité européen de normalisation)
- National standards
  - o MSZ(Hungarian Standard)
  - o DIN(Deutsches Institut für Normung)- German National Standard
  - o ANSI(American National Standards Institute)- USA National Standard
  - o GOST(GOsudarstvennyy STandart)- Russian National Standard
- - Company standards

4.3 CROSS-SECTIONS IN MACHINE DRAWING[6]

The representation of spatial objects in the plane is well captured by the geometry, but the jagged lines of internal edges and articulations (holes, cavities, grooves) not visible in the view are difficult to interpret and often confusing. With the help of the sectional representation, however, some of the pithy shapes and shaped surfaces can be clearly shown.

4.3.1 CONSTRUCTING SECTIONAL VIEWS

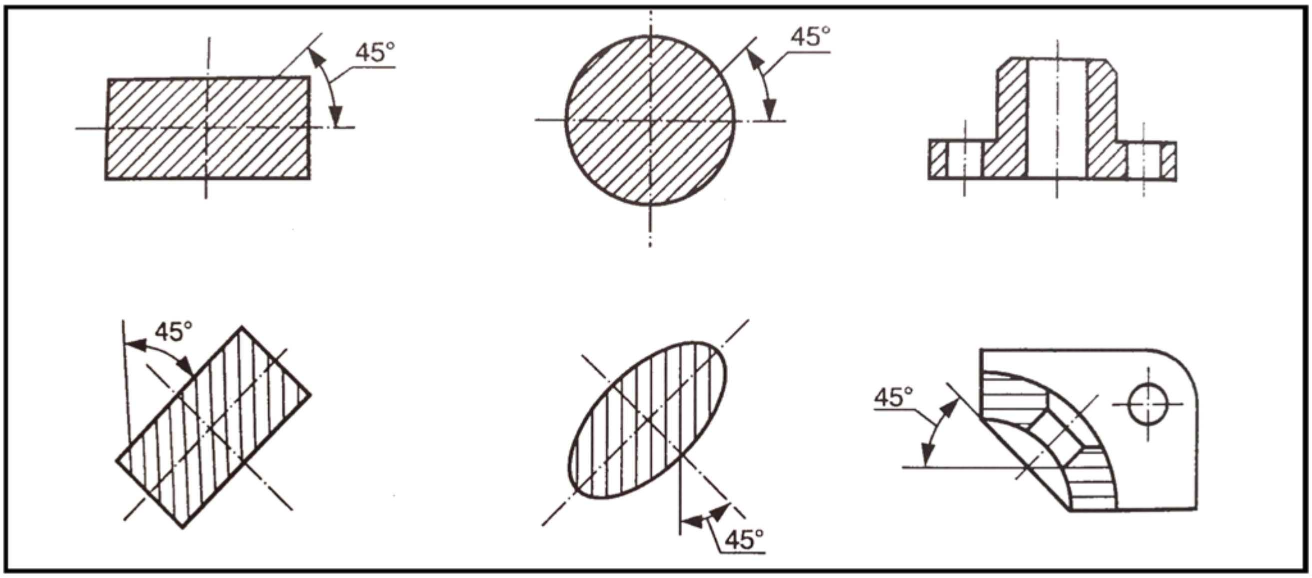
With an *intersection plane*, we cut our part in imagination and, removing the part in front of the intersection plane (closer to us), we represent the part of the object(*Figure 33*) behind the intersection plane *according to the rules of projection*. The intersected parts of the material are called *sections* and are marked (hatched) with line drawing. It is very important that *the sectional view includes a plan view of the parts of the material beyond the section*.



33. Figure Rules of prjection represented on a part

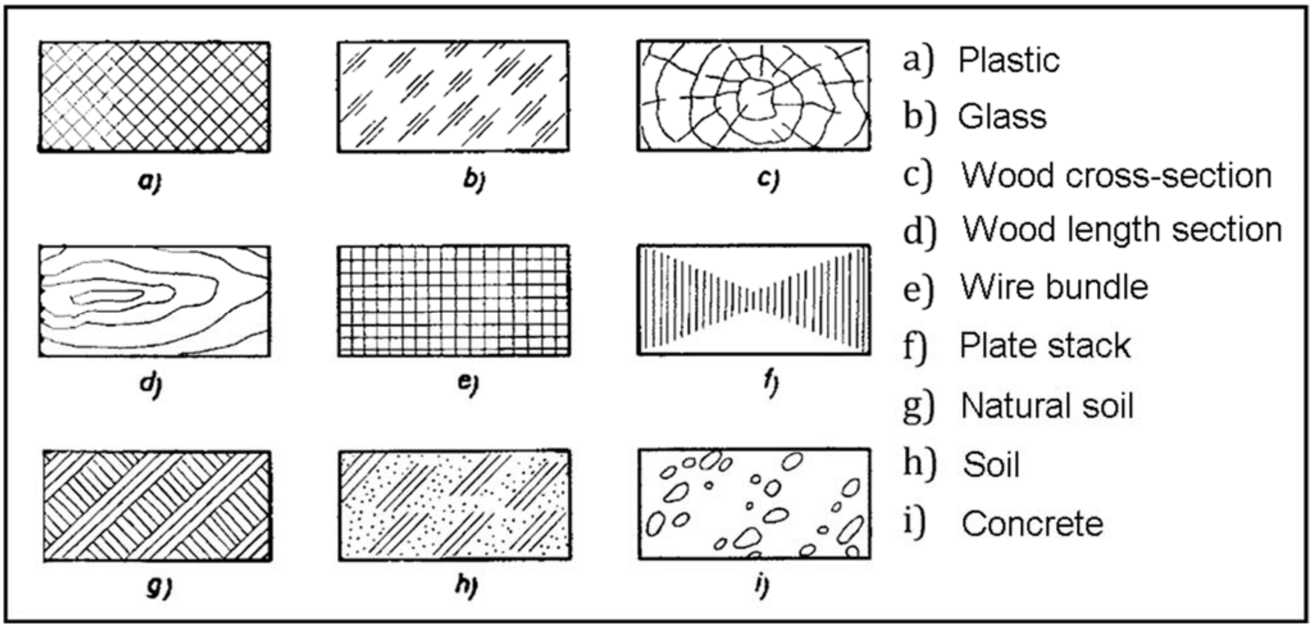
The line direction of the section, section should be 45° to the:

- with a contour line or,
- the axis of symmetry,
- if a curved element is drawn, with the chord of the curve.



34. Figure Types of sections

Within a part, the sections should be aligned in the same size and orientation. On assembly drawings, the parts in contact shall have different hatching. The direction and spacing of the different hatching may be different. The hatching is usually indicated by lines with a 45° slope, but this may be deviated from if the material quality is to be illustrated in the sectional view. Simple line scribing usually indicates a metallic part. *Figure 35* shows the other section patterns that can be used, depending on the type of material. This used to be more important. Today, because of the variety of materials, the standard material grade is given in the bill of materials anyway. To aid interpretation, it is useful to use at least these few notations on our drawings.[4]



35. Figure Section patterns

4.3.2 GROUPING OF SECTIONS

There are three groups of sections that can be created with WITH AN INTERSECTION PLANE

1. Full sections
    a. drawn on a projection (unmarked)
    b. marked with lettering
2. Patrial sections
    a. half section (half of the object is drawn on two sides of the axis of symmetry in section and the other half in view)
    b. breakout (intersections are made at certain points on the view of the object)
    c. inverted section (an oblique section plane rotated to a horizontal or vertical position)
3. Section representation

Above, the section is mentioned in the sectioning, which is nothing more than an infinitely thin slice of a piece of material falling in the section plane. Therefore, we do not even represent the parent parts behind it if we simply represent a section.

Section placement can occur:

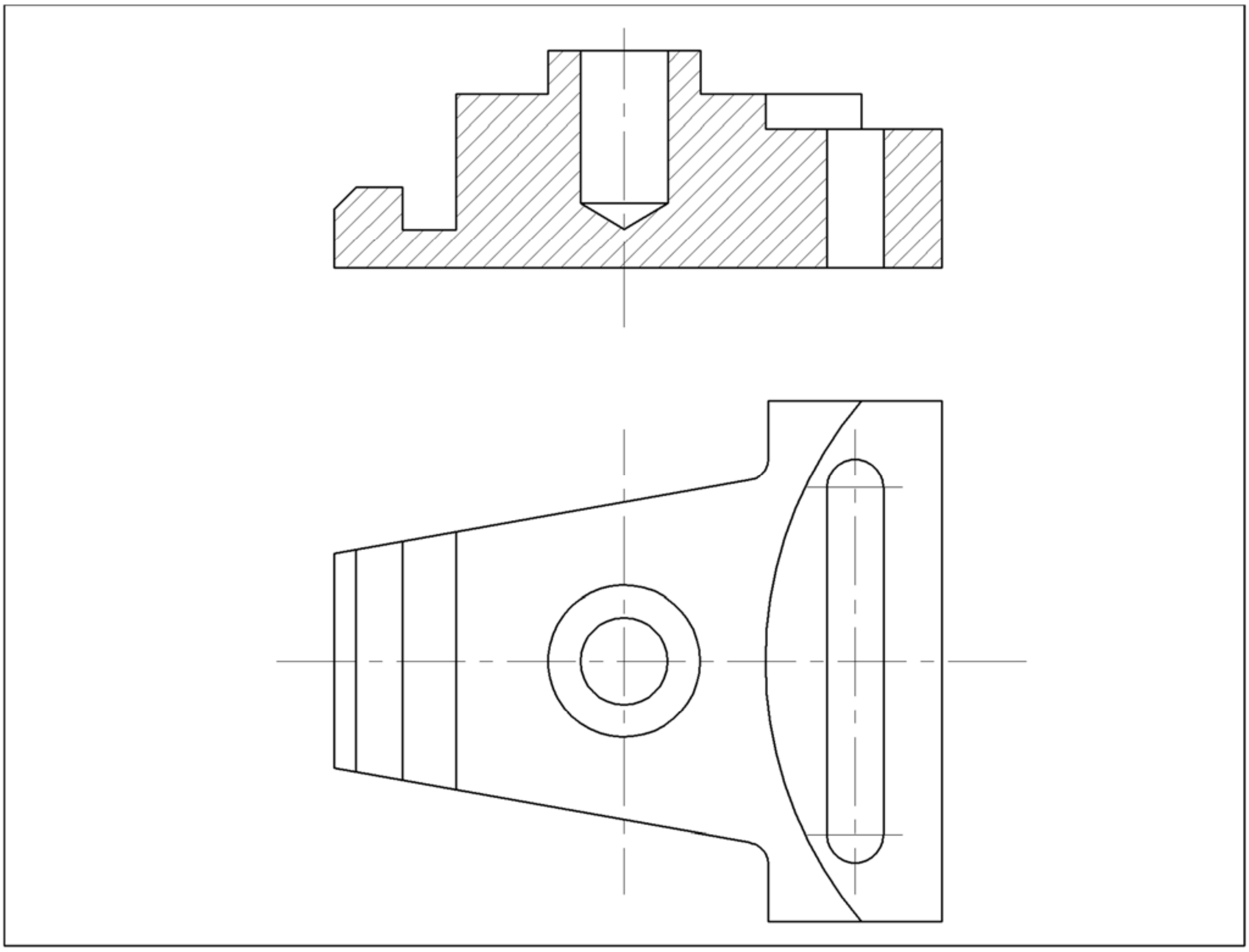
a. within a projection,
b. outside the projection (neatly)
c. in any position (marked)

We distinguish three groups of sections that can be created with MULTIPLE INTERSECTION PLANES:

1. Step intersection (using several parallel intersection planes and drawing them together)
2. Inverted section
3. Inverted step intersection

4.3.3 FULL SECTIONS

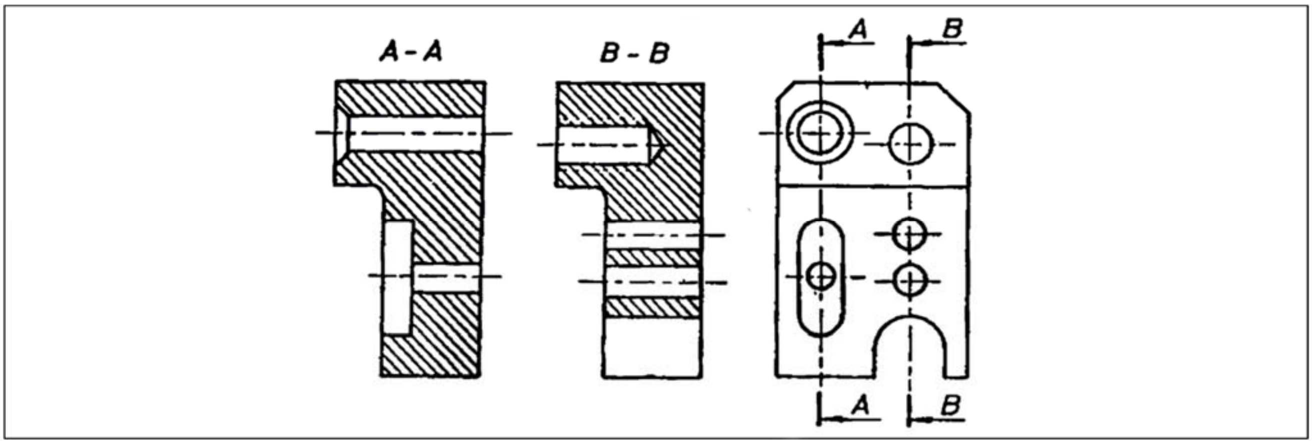
The plane is fully immersed in one aspect of the object. The projection is represented according to the projection order, the section does not need to be marked.



36. Figure Full section of a part

In the case of a full section, the following should be marked:

- the plane of intersection is not in a plane of symmetry,
- the intersection is not positioned according to the projection order,
- several sections are taken from the same view (in this case, several identical projections may be placed next to each other) *Figure 37*



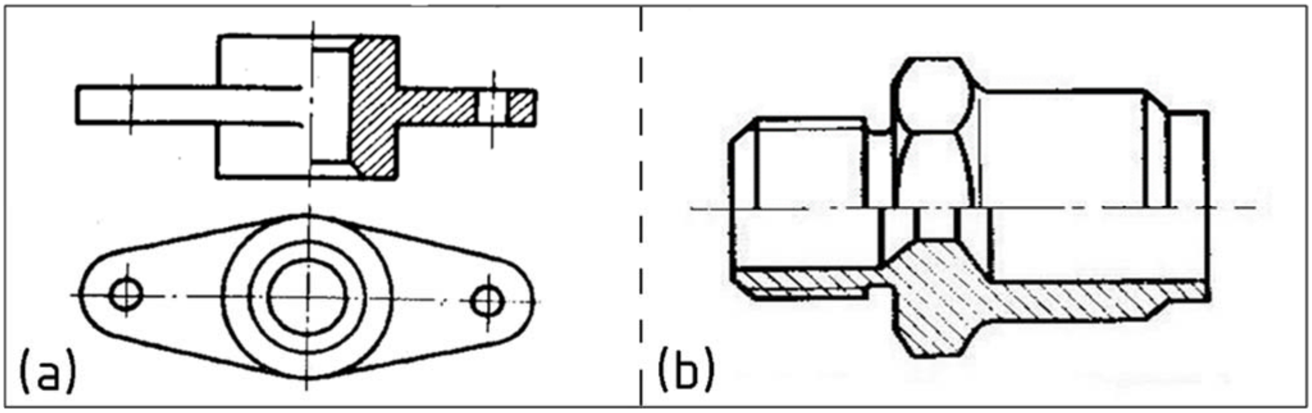
37. Figure Different sections of a part

Rules for marking the intersection plane:

- mark the trace of the intersecting plane with a thin line of thickened dots at ends and changes of direction,
- the direction of projection (direction of view) is indicated by an arrow drawn at the end of the thickened trace,
- Intersections and intersecting planes are marked with the capital letters ABC.

4.3.4 SUBSECTIONS

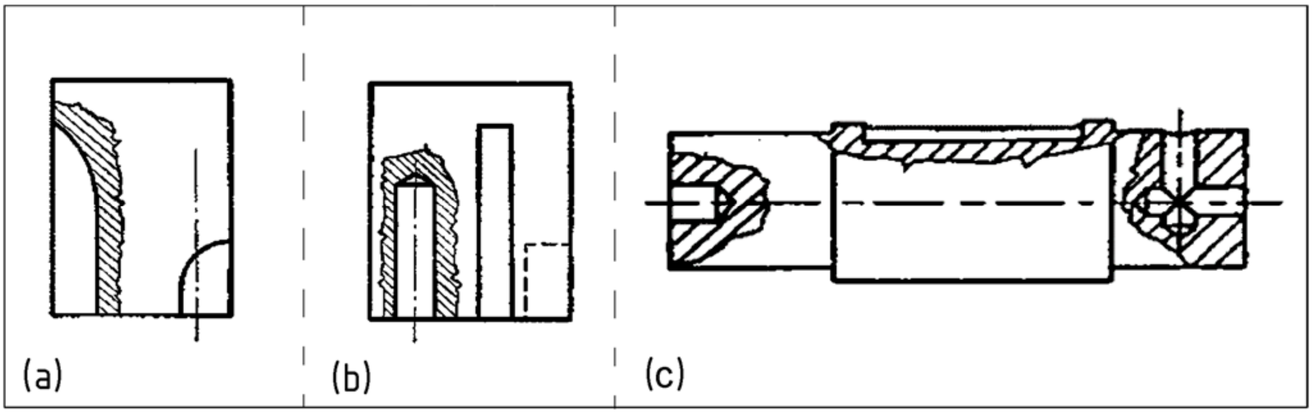
We usually draw a HALF VIEW - HALF SECTION for symmetrical parts(*Figure 38*). The semi-projections of the section and view images are separated by the axis of symmetry of the drawing.



38. Figure Subsections

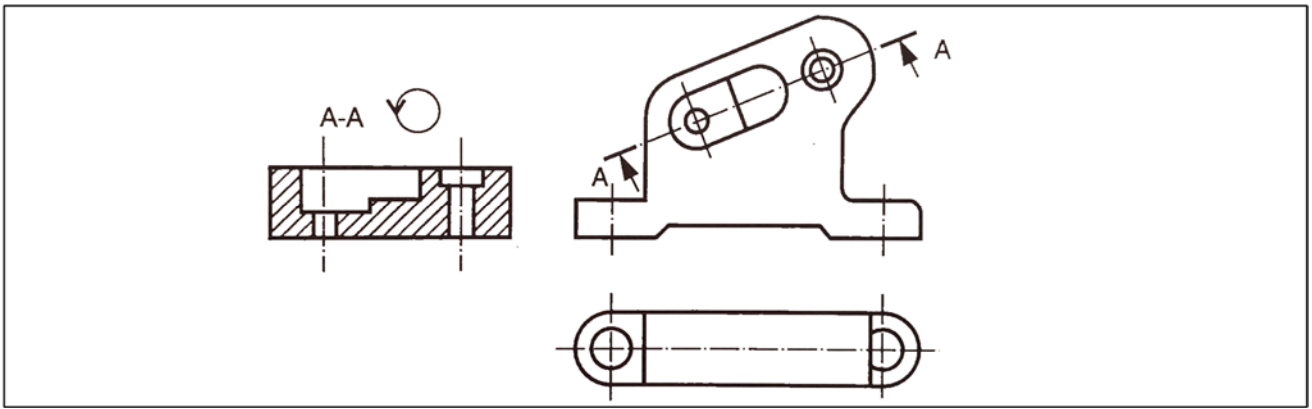
In some cases, an edge line may be drawn on the axis of symmetry, in which case more than half of one view is drawn and bounded by a freehand break line.

BREAKOUT is used when it is not necessary to use a full or half section for interpretation. In this case, only a small part of the part is cut out within the view drawing(*Figure 39*). The boundary line of the section is usually a freehand line or a straight break line.



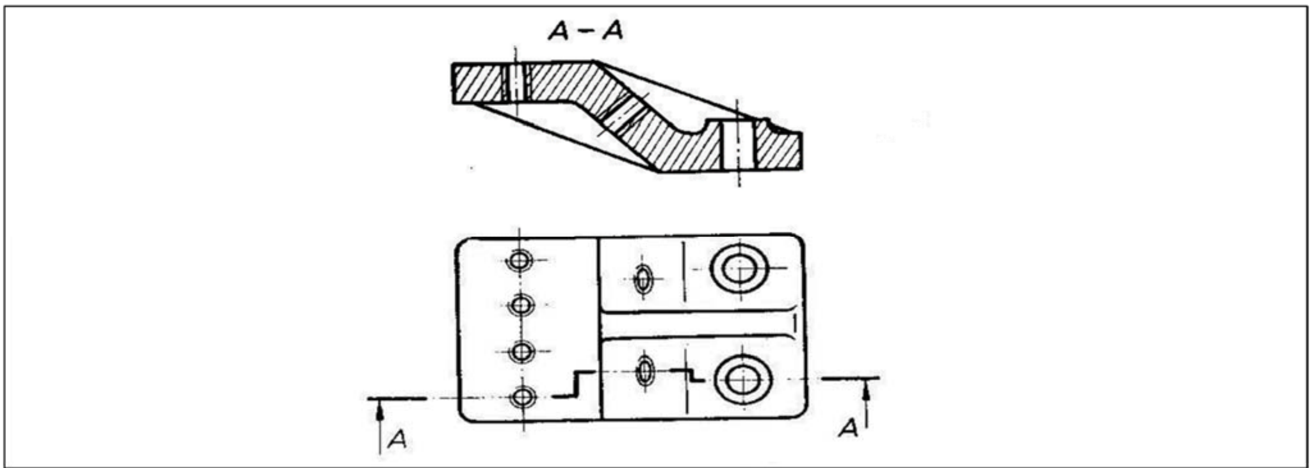
39. Figure Breakout sections

In cases where your intersection plane is inclined (neither vertical nor horizontal), you can use a ROTATED SECTION. In this case, the inclined section is rotated to a horizontal or vertical plane. Of course, the section and the plane of intersection must be marked(*Figure 40*).



40. Figure Breakout sections

For a part where you would need to use several parallel intersection planes and form several intersections, you can use a STEPPED INTERSECTION. In this case the parallel staggered intersection planes are arranged in a line. In this way, we can arrange several sections in one projection. The intersecting planes are marked as discussed earlier and the direction breaks between the planes are also marked with a thick line.See *Figure 41*.



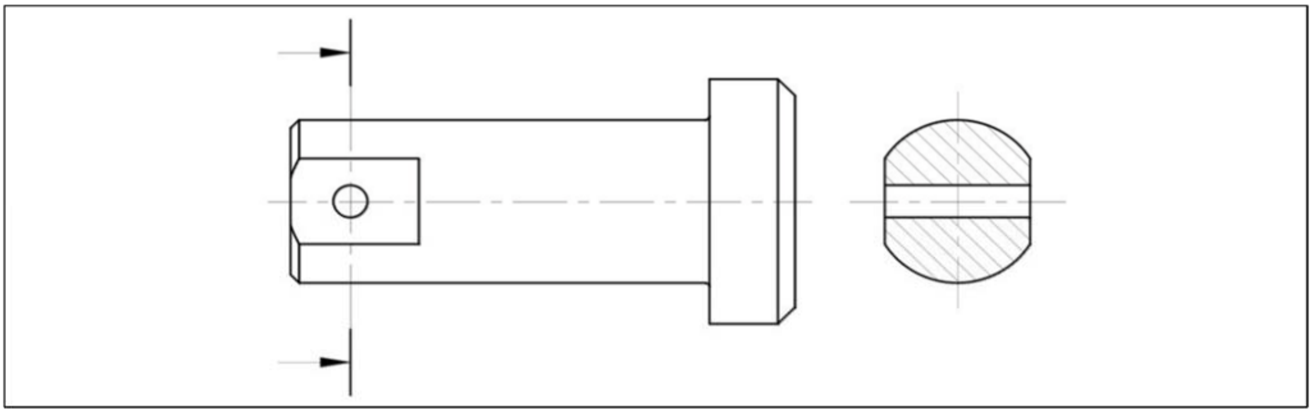
41. Figure Stepped intersection

4.3.5 RULES OF PROFILE REPRESENTATION

A section alone is used when it is not necessary to represent the parts behind the intersection plane(*Figure 42*).

- If the direction of view of the section is not indicated, it is drawn in the right-view or bottom-view plane, because this is the only way to draw it.

- In order to prevent the section from being "disjoint", i.e. to make the section a continuous surface, we can draw the lines behind the intersecting plane.
- In an identical section of an object, the direction of the lines and the distance between the lines should be the same.
- If you have to draw several identical sections, you draw only one and mark the others with a letter.
- The intersecting plane must always be drawn in such a way as not to show a distorted image of the geometry to be shown.

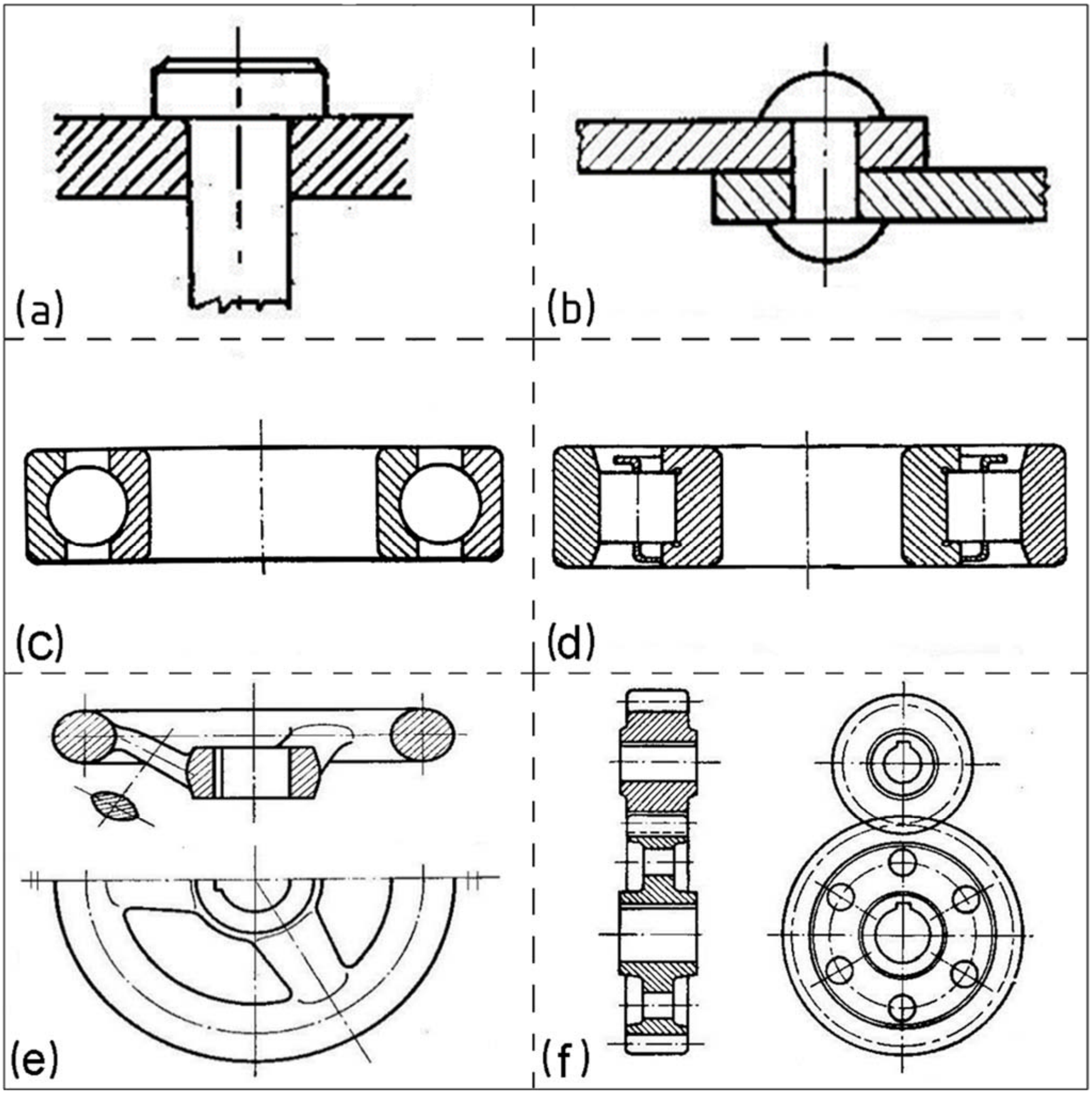


42. Figure Profile representation

4.3.6 ELEMENTS THAT CANNOT BE REPRESENTED IN SECTION

Generally speaking, we do not depict objects in an engraving that have a more visual appearance. These will be the PARTICULARS THAT CANNOT BE INTERPRETED.

- solid cylindrical stems, pins,
- pins, rivets,
- shafts,
- balls, rollers,
- ribs, spokes,
- teeth.



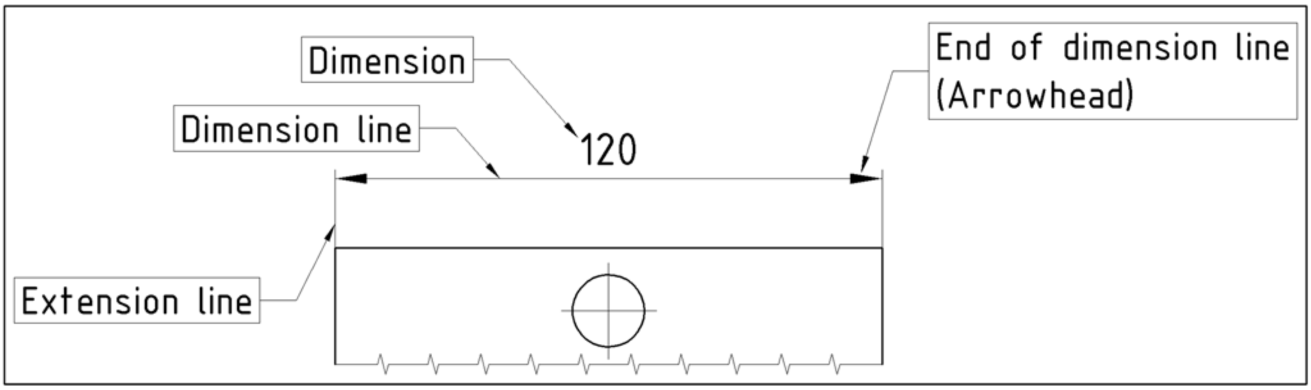
43. Figure Parts of sections

4.4 THE RULES OF GIVING DIMENSIONS [7]

Our parts must be sized on our technical drawings so that they can be manufactured. The basic principle is that we do not take dimensions from drawings. Dimensions are given in mm without any indication of the unit of measurement.

4.4.1 THE ELEMENTS OF SIZE SPECIFICATION

- dimension line,
- scale reference line,
- indicator line,
- dimension line delimiter,
- end point and starting point of dimension line,
- dimension number.



44. Figure Elements of dimensions

The DIMENSION LINE is given parallel to the direction of the dimension, by a straight line or a circular arc, with a thin solid line. No other lines shall cross and dimension lines shall be at least 6-8 mm apart and at least 10 mm from contour lines. Size lines for dimensions should be broken only when necessary.

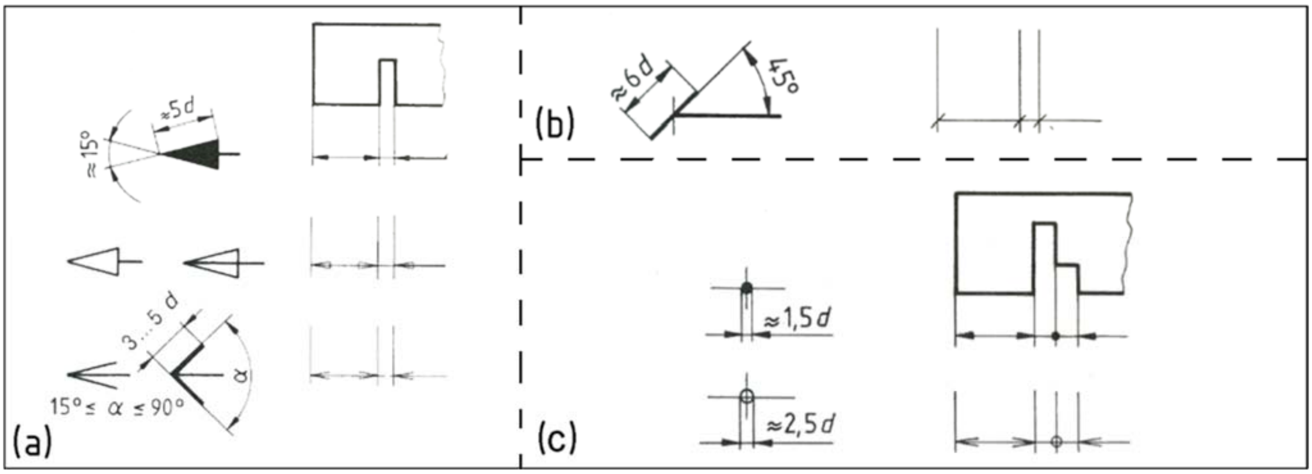
Draw the SCALING REFERENCE LINES with a thin solid line so that it extends beyond the dimension line boundary by at least 2 mm. The dimension lines do not always enclose 90° to the dimension line. You can draw the scale lines at an angle, but they must still be parallel to each other.

Information on the characteristics can also be given with a INDICATOR LINE. The line can be joined:

- with a *point*, if you point inside the contours of the object,
- an *arrowhead*, if you point to the contour of the object,
- *without end* (without point and line), if you point to the dimension line.

The end of a scale line is terminated by a SCALING LIMIT, which can be:

- the *dimension arrow*, with an opening angle of 15°, with a minimum length of 2,5 mm, not crossed by any line other than the line of the sections,
- the *oblique line* is used when the size itself is small and space is limited, the size arrow is drawn at an angle of 45° with an oblique line at least 3,5 mm long,
- The dimension point may be empty or filled and is also used when space is limited.
  - o The empty circle is also used to indicate the starting point when scaling from a common base. A minimum circle of 3 mm (blank point) is used to mark the point.



45. Figure Elements of dimension arrows

When entering the DIMENSIONS, please prefer writing in the perpendicular (vertical) direction. Letters appearing in dimensions should be written obliquely.

4.4.2 SPECIAL MARKINGS FOR DIMENSIONS

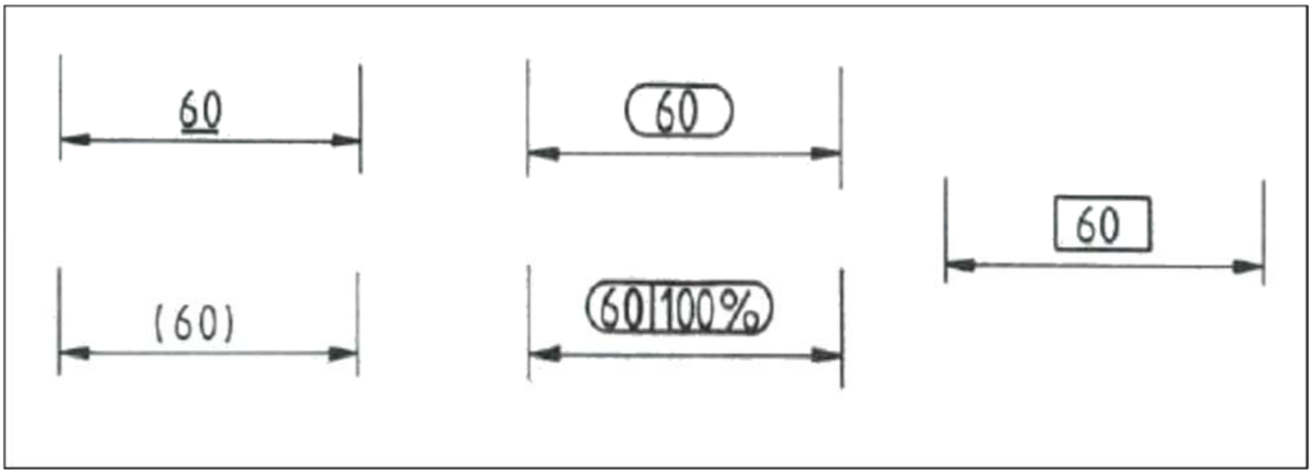
Dimension numbers can be provided with special markings to give additional information about the dimension.

The *underline* below the scale number symbolises that the representation is not to scale. It is not used in principle for scaling parts in foregrounds and interrupted plots (e.g. long axes).

Dimensions that are *drawn around* (placed in a bubble) are given special attention by the customer. Usually we mark them when we work with several suppliers in a production company. On receipt, the dimensions marked in this way will be checked (100%) to make sure that they are correct.

Auxiliary dimensions are put in *brackets*. These dimensions are not required for production and are not subject to general tolerances. They are only intended to facilitate interpretation by the reader of the drawing.

The theoretical dimensions, which are the geometrically desirable location of a point, line or surface, are given by *framed* dimensions.

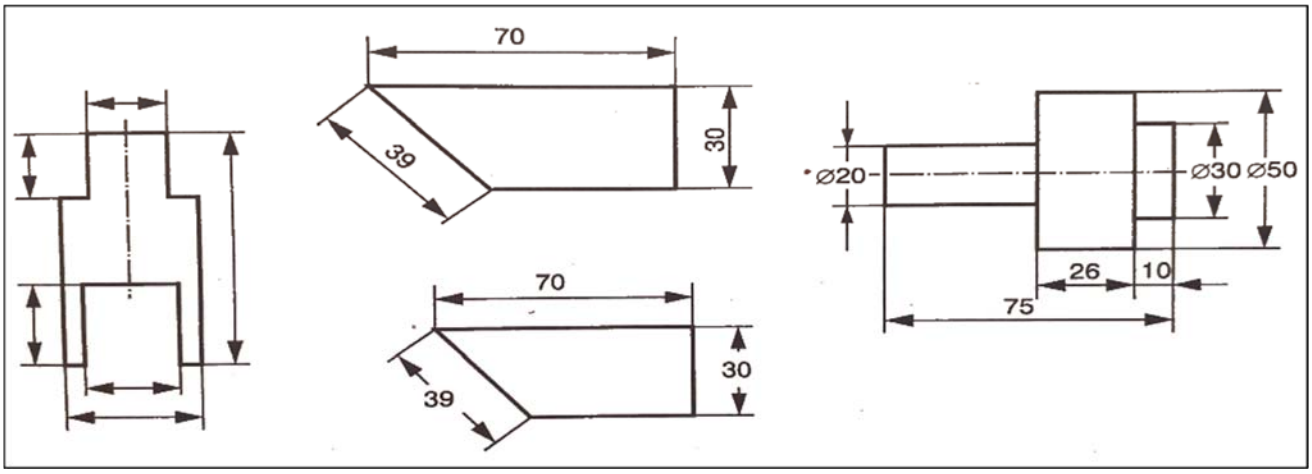


46. Figure Special marks of dimensions

4.4.3 ENTERING DIMENSIONS

There are two ways to enter the dimensions:

1. The dimensions are placed in the middle of the dimension line, legible from left to right or bottom to top. If they do not fit on the scale line, they may be placed at the extended end of the scale line.
2. Horizontal sizes are placed in the middle of the scale line, and non-horizontal sizes are placed in the middle, interrupting the scale line. The dimensions read from left to right.

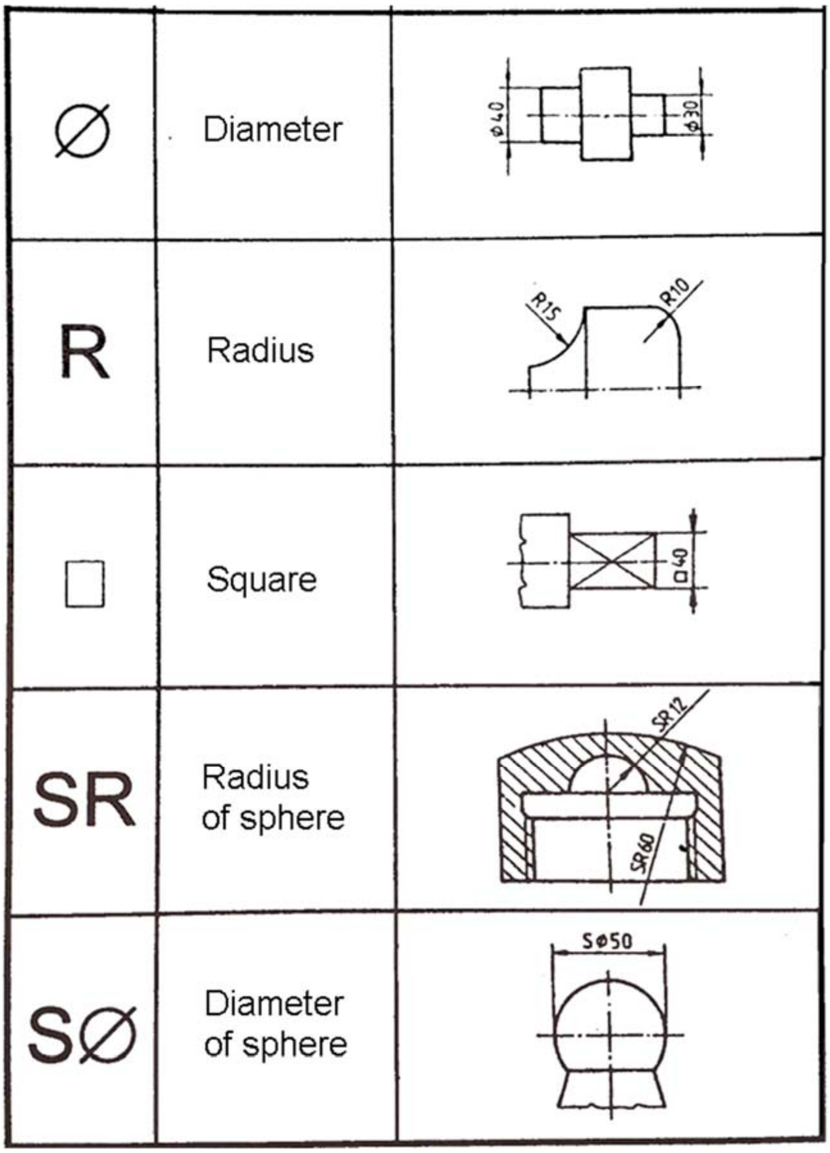


47. Figure Entering dimensions

4.3.4 SUPPLEMENTARY SYMBOLS

The dimensions given are in mm, if different, an additional symbol must be placed after the dimension number, e.g.: 10°, ½", 15 m . The radius R, diameter symbol, etc. is placed before the dimension number. In the case of a square, the size number always refers to the span. When indicating radius and diameter, the additional drawing symbols must always be indicated (even if the projection shows the whole circle).

Instead of the square (□) sign, it is also allowed to use the inscription e.g.: 25x25. When indicating the arc length of circular arcs, an arc symbol (⌒) must be placed above the size number. If the flattened flat surface on the projection is visible from the front, a cross on the surface, when two diagonals are drawn in, indicates that a flattening is visible. This is necessary because in side projection, a cylinder and a brick body show the same image.



48. Figure Supplementary symbols

To define spherical areas, use the sphere radius (sign:SR) and sphere diameter (sign:SØ).

4.4.5 STRUCTURE OF THE MEASUREMENT NETWORK

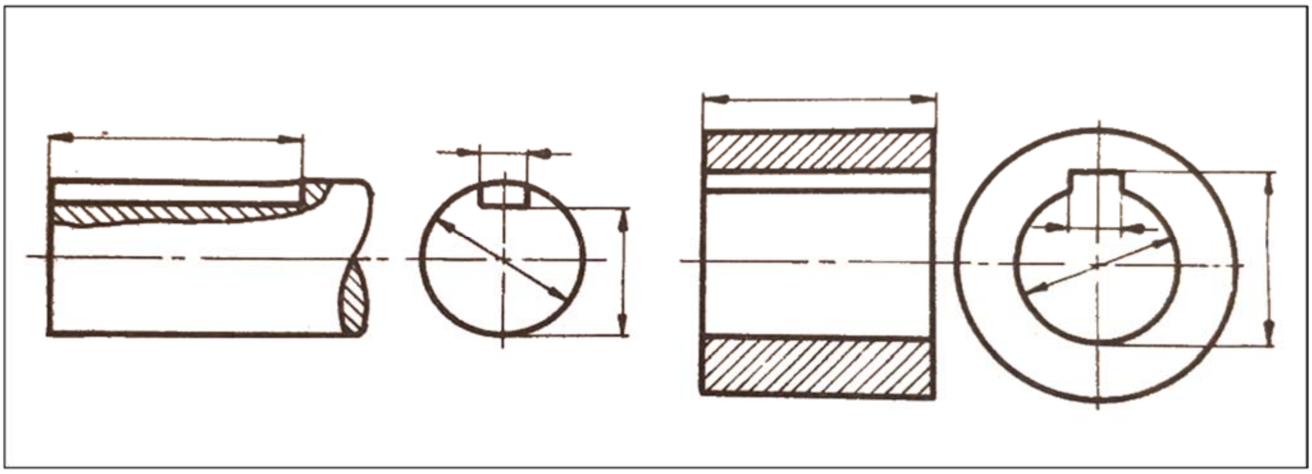
To show the dimensions of the part, place the dimensions in order.

THE MECHANICAL DRAWING SHOWS ONLY THE NECESSERY AND SUFFICIENT DIMENSIONS. DO NOT USE MORE DIMENSIONS WHAT YOU NEED DESCRIBE THE COMPONENT!

The design of the measurement network must take into account the production and operation of the component. Consequently, each surface may have different properties. It may be necessary to specify the position of certain surfaces relative to each other in order to determine the position of connecting elements.

Dimensions should preferably be given in such a way that they can be measured on the workpiece as it is mounted on the machine tool. Take account of the manufacturing process. Try to design the part to minimise the number of times it has to be clamped in the machine tool during machining, as each clamping can introduce inaccuracies into the workpiece.

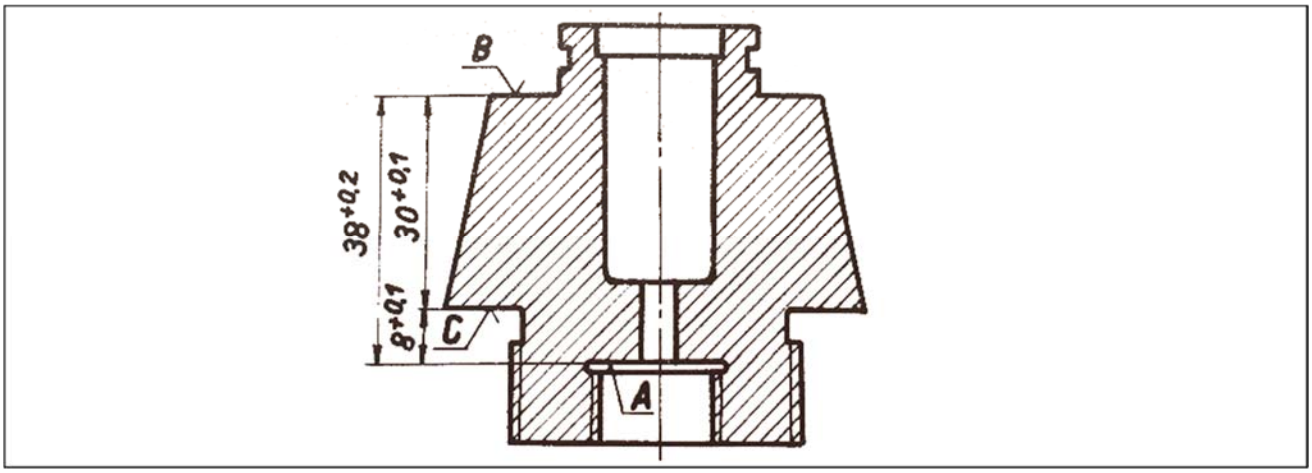
The dimensioning in *Figure 49* is adapted to the application of the tool, the machine tool and the clamping device. In the figure on the left, the spindle hook was formed with a finger milling machine, and in the figure on the right, a wedge hook was formed with a chisel in a brain. The dimensions in the drawing are given so that the manufactured size can be easily measured.



49. Figure Supplementary symbols

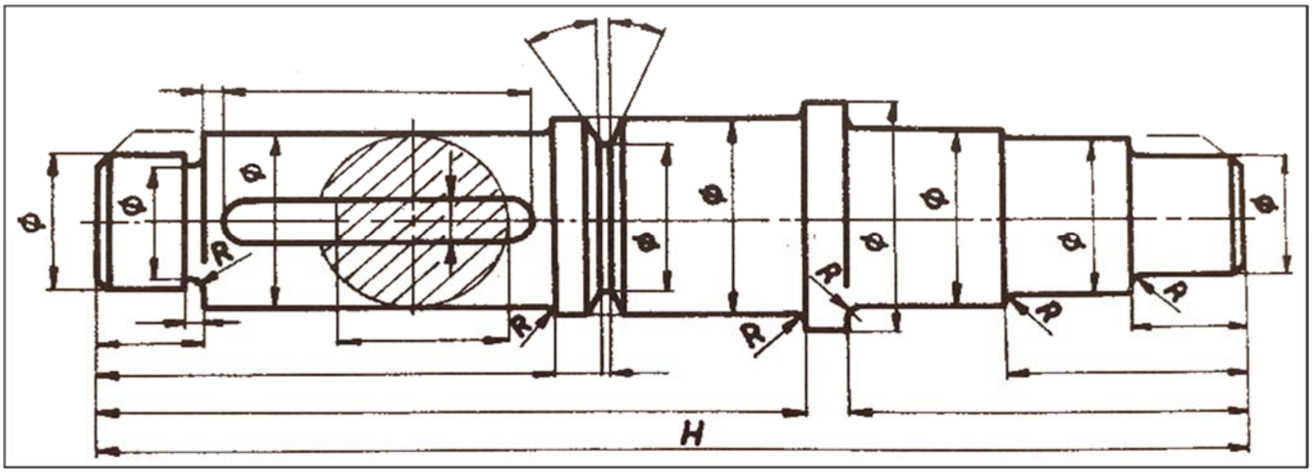
In each case, the boundary dimensions are given in the main direction and the dimensioning baseline or base (base plane) is chosen, which gives the best starting point in production and from which most of the dimensions with a narrow tolerance are to be made in the first step. On the drawing of the workpiece, preferably immediately adjacent to the boundary dimensions, the distance of the baseline from the edge of the part that is most relevant for operation is given. The distance of the surfaces to be machined from the base line shall be given with high accuracy, as well as the distance of subordinate surfaces that can be conveniently machined from the base line. In addition, surfaces that are not operationally relevant should be specified with the size that is easiest to prepare.

If a working size is difficult to produce, an alternative size should be sought. When substitute dimensions are specified, the substituted dimension becomes the resulting dimension. In *Figure 50*, the base of the part dimensioning is, by operation, the surface marked B, from which the surface marked A must lie 38^(+0,2)mm. It is difficult to machine A and B in one pass due to clamping and measuring difficulties, so surface C is chosen as the starting base, for dimensioning the 38^(+0.2) dimension is divided into 38^(+0.1) and 8^(+0.1) dimensions, both naturally being narrower. Thus, in one session, surfaces A and C and threads can be produced; then, by tightly wrapping the piece in the apparatus up to surface C, surface B can be produced.



50. Figure Dimensioning from base surface

After the surfaces created in the first step, in the second step you can specify the distance of additional surfaces that can be measured well and that may lie more inaccurately from the baseline. In further steps, dimensions can also be specified, but you should be aware that these dimensions will be even more inaccurate relative to the baseline, since their tolerance will be equal to the sum of the tolerances of the steps taken. This can be observed in *Figure 50*.



51. Figure Dimensioning of shaft

The first, second, etc. steps form an open dimensional chain that gives clear instructions for the machining sequence. Between the open size chain and the *overall dimension* there is a dimension (not a given size chain mesh) that is output during machining. It is forbidden to specify this, as it may be perceived as a workpiece to be produced, and would interfere with the instruction given for the sequence of operations to be performed and make the tolerance of the dimensions inconsistent. *It is therefore forbidden to calculate and prepare the dimensions to be issued from the other dimensions*. *Figure 51* shows an shaft. After the boundary dimension (H) has been accurately made, first length and diameter measurements are made on one side, then the axis is turned over on the lathe.

5. DRAWING OF MECHANICAL PARTS

The detailed graphical representation of machinery components is an important aspect of engineering practice. This encompasses the precise dimensions, tolerances, materials, and other specific details that are essential for manufacturing, assembly, and maintenance. These drawings serve as a blueprint for engineers, technicians, and manufacturers to ensure that parts are produced to exact specifications. They play a crucial role in industries like automotive, aerospace, and manufacturing, ensuring consistency, functionality, and safety in products. Proper documentation of these drawings is imperative for quality control, revisions, and future reference.

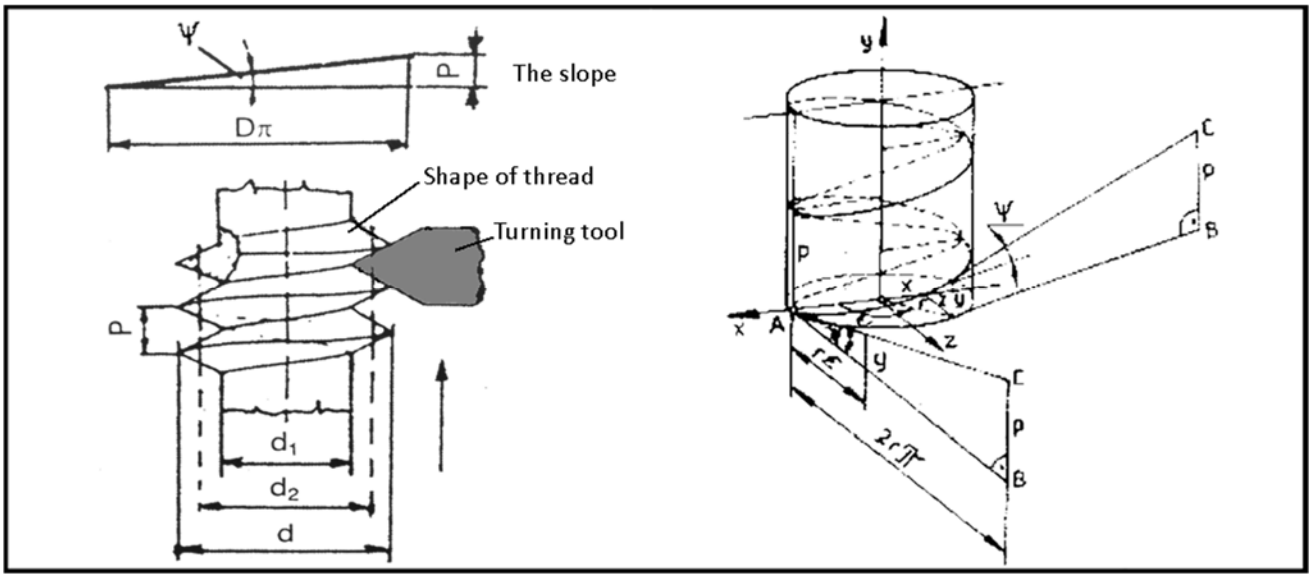
5.1 FASTENERS AND THREADED JOINTS

The elements of threaded joints are the best known fastener components. The bolts and screws are used in any device. If you want to make a connection between parts the threaded joints give you a reliable option. These connections are removable without damage of parts.

By converting rotational movement to linear motion, they allow for precise adjustments and positioning in mechanisms. This function is particularly vital in applications like lead screws in machinery, where minute adjustments can drastically affect performance. Additionally, threads play an integral role in fastening, ensuring components remain securely joined. Their design and pitch can be tailored to specific applications, making them versatile tools in the realm of mechanical engineering.

5.1.1 DIMENSIONS OF THREADS

Figure 52 shows a “V” shape thread whick is perfect for describing the main information of threads. The thread is basically a slope which is rolled up on a cylinder surface. The length of the slope os equal to the circumference of the cylinder and the height is equal to the pitch. A rotation causes the screw nut to move up the slope of the cylinder(thread) by as many milimetres as the height of the slope(pitch).

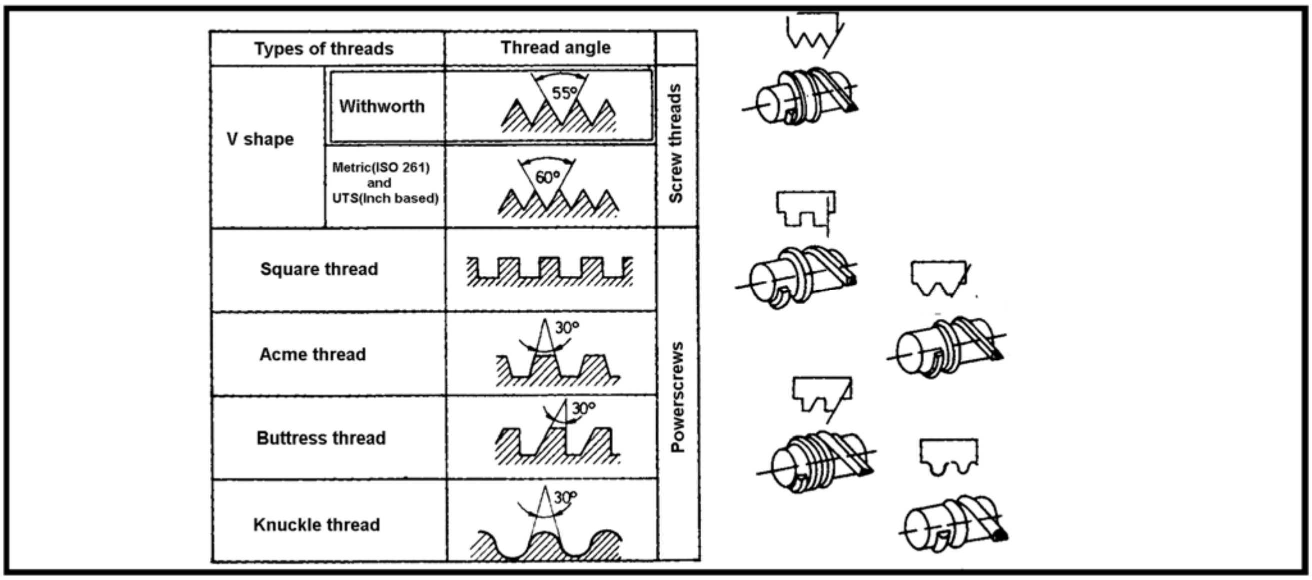


52. Figure Dimensions of thread

The main dimensions are standardised:

d- nominal or major diameter
P- pitch
d1- minor diameter
d2- pitch diameter
Ψ- angle of the pitch

5.1.2 TYPES OF THREADS



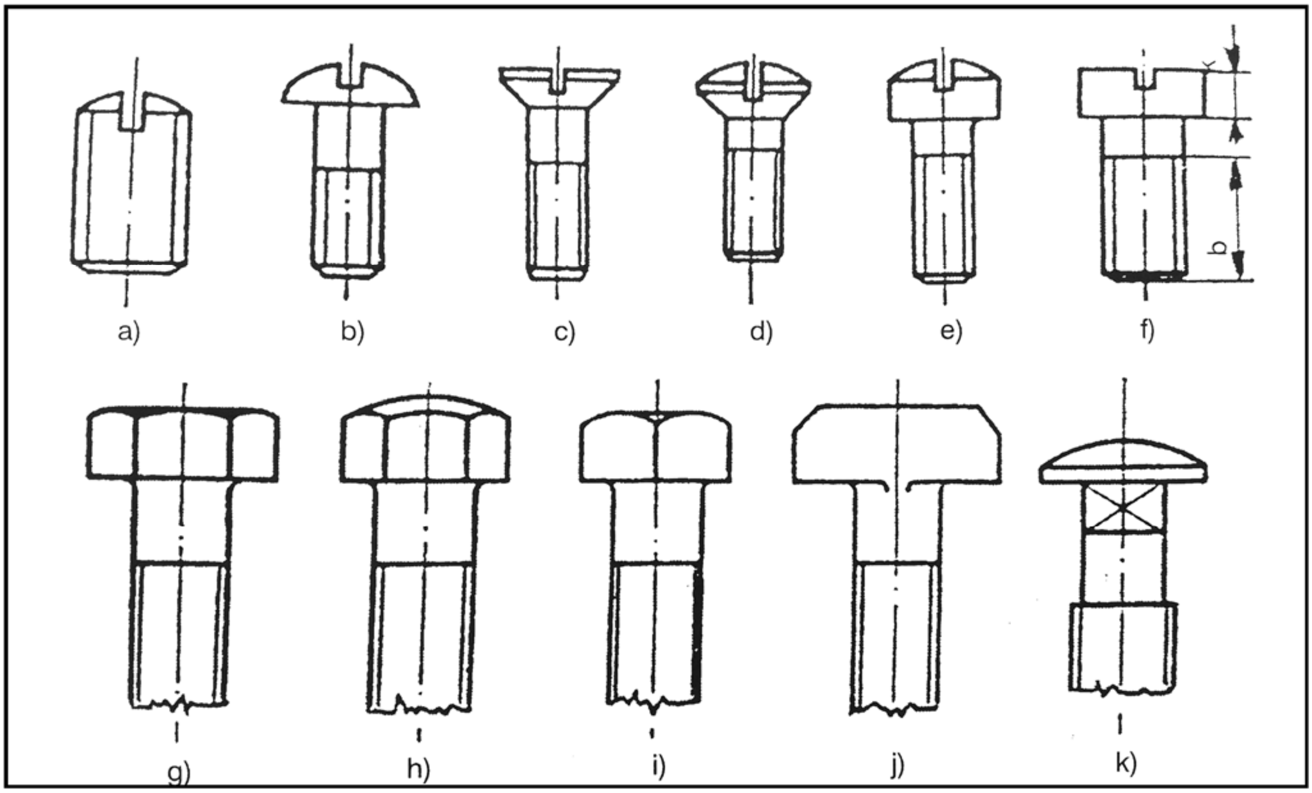
53.Figure Types of threads

- Metric screw: The best-known type of “V” shape thread. Dimensions are in milimeters. The all of dimensions are required by standard.

- Withworth screw: The next type of "V" shape tread. Dimension are in inchs. Usually it is used for pipes and fittings.
- Knuckle thread: The edges of thread shapes are rounded. In this way the screw has smaller amount of strees in the material.
- Square thread: Used for moving spindles. Rarely used nowdays.
- Acme thread: Most commonly uses power screw. It is a trapezoidal thread form. This construction can take more force and stress.
- Buttress thread: This type of thread can withstand high one-way forces well.
- Wood screw thread: It is used for timber.

5.1.3 TYPES OF SCREWS

Screws are made in many lengths and with many head designs(*Figure 54*).

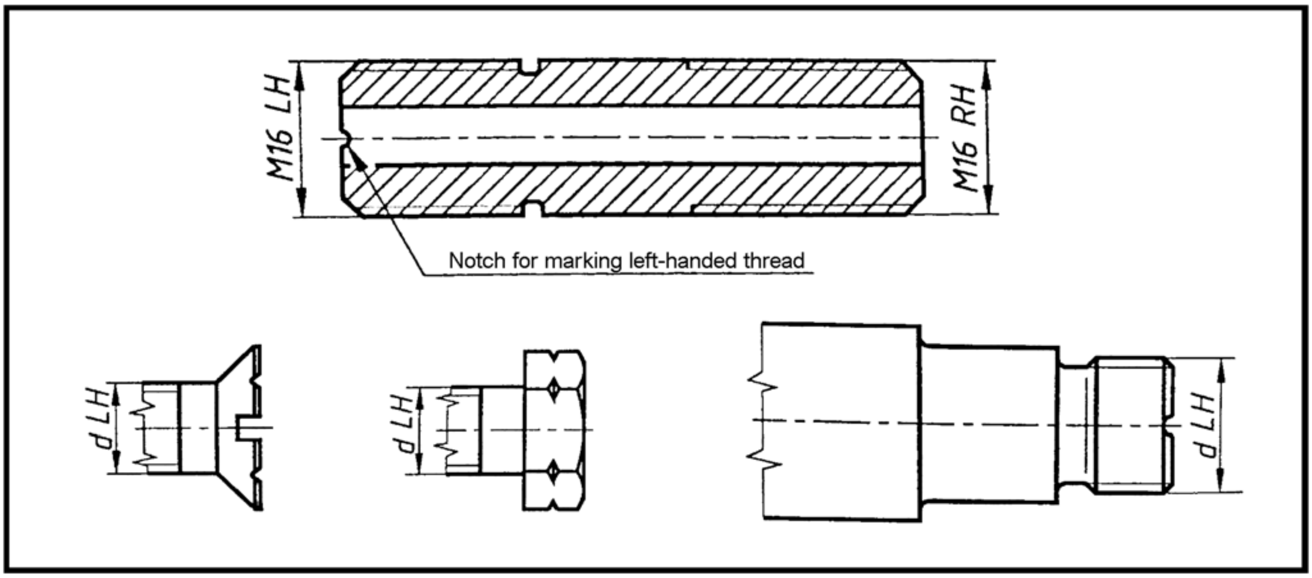


54. Figure Types of threads

a) Worm screw
b) Screw with hemispherical head
c) Flat(Slotted) head
d) Oval head
e) Filister head
f) Cheese head
g) Hexagon head
h) Button hexagon head
i) Squaere head

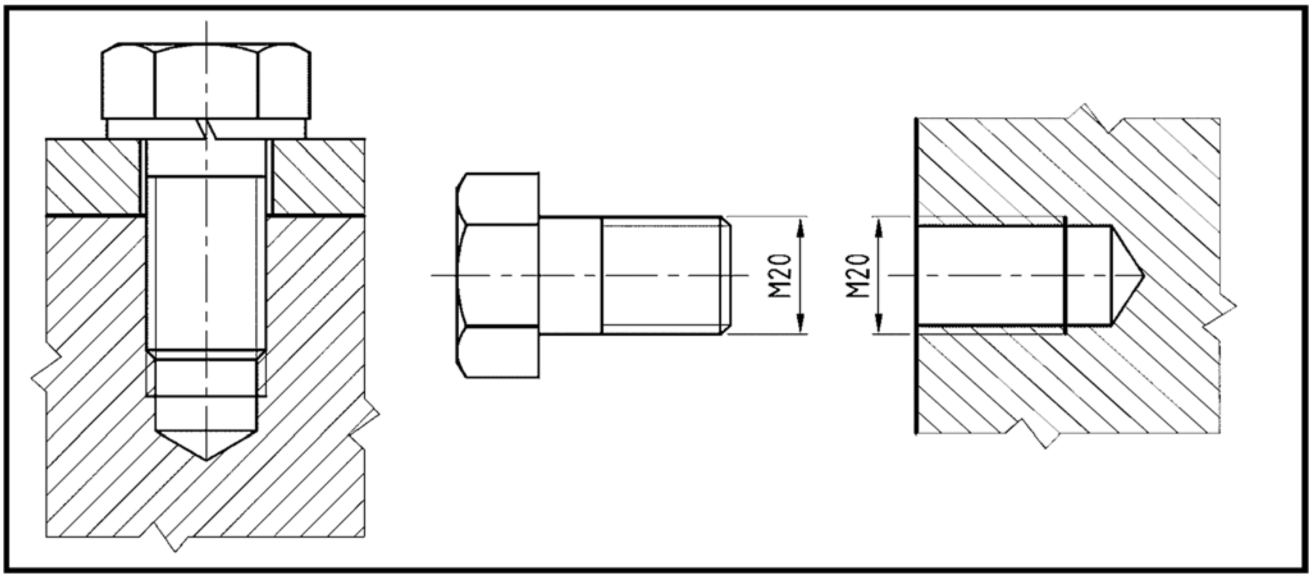
j) T-head
k) Round head square neck

Most of the screws are right-handed. They do not need any marking. If the screws are left-handed extra sign is neccessary. These are turned signs on the external surfaces of the bolts and heads of screws.



55. Figure Marking of left-hand threaded parts

The true form of the thread is not drawn. Symbolic notation is used to represent threads on the drawings. *Figure 56* shows the way of dimensioning and notation of thread.

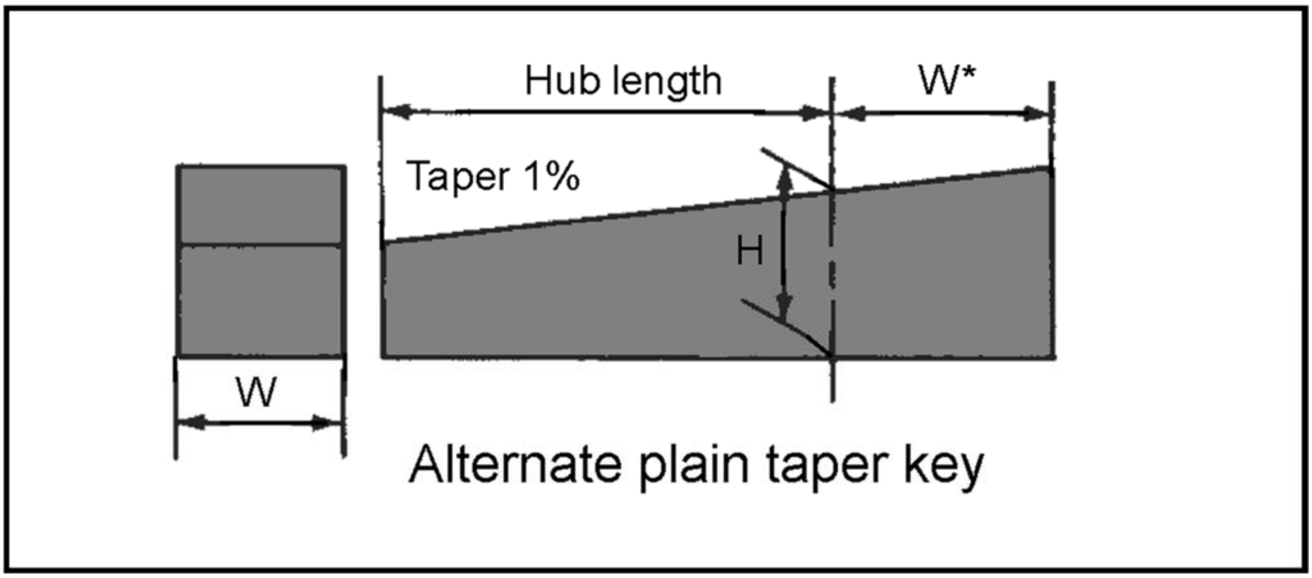


56. Figure Screw connection

The thread is symbolically marked with a light weight continuous line. Screw external contour and the threaded hole internal contour are heavy lines. The hatching lines are light weight lines and they can cross the threaded holes threadlines.

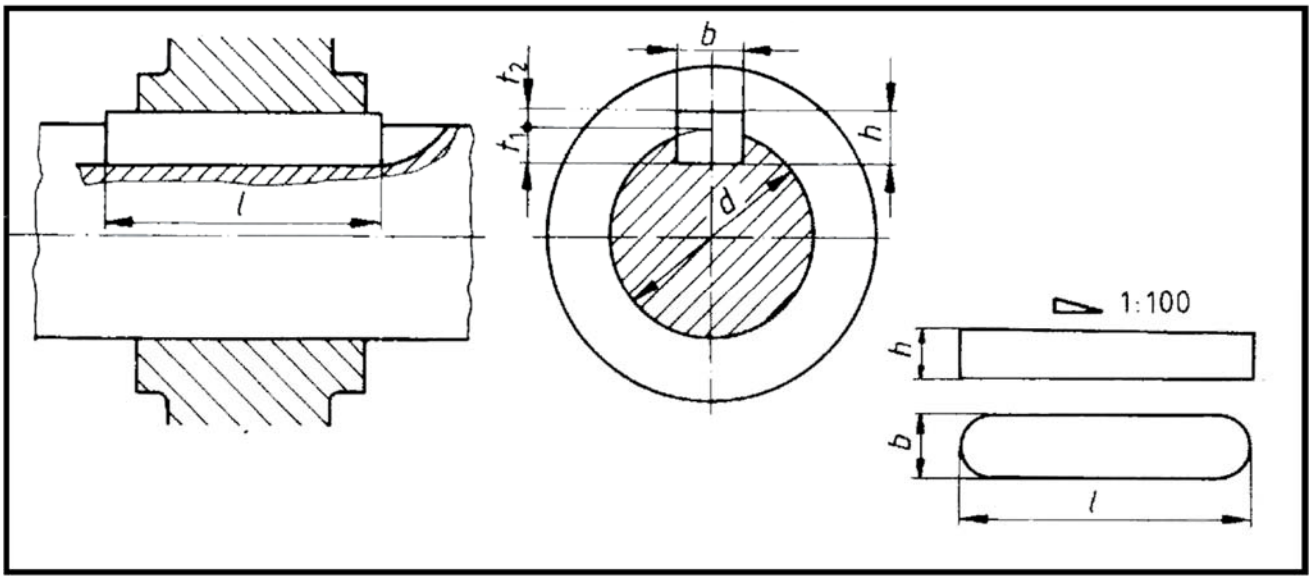
5.2 TAPER KEYS

A key is a mechanical part situated at the junction between a shaft and the hub of an element that conveys power, serving to transfer torque. This key can be removed to simplify the assembly and disassembly of the shaft mechanism. It fits into a longitudinal groove crafted in the shaft, known as a keyseat. In many cases we fix pulleys and hubs with keys. The most of taper keys have 1% taper (see *Figure 57*). We do not draw the true shape of taper key. We draw a square key and write to close the taper of the key(see *Figure 58*).



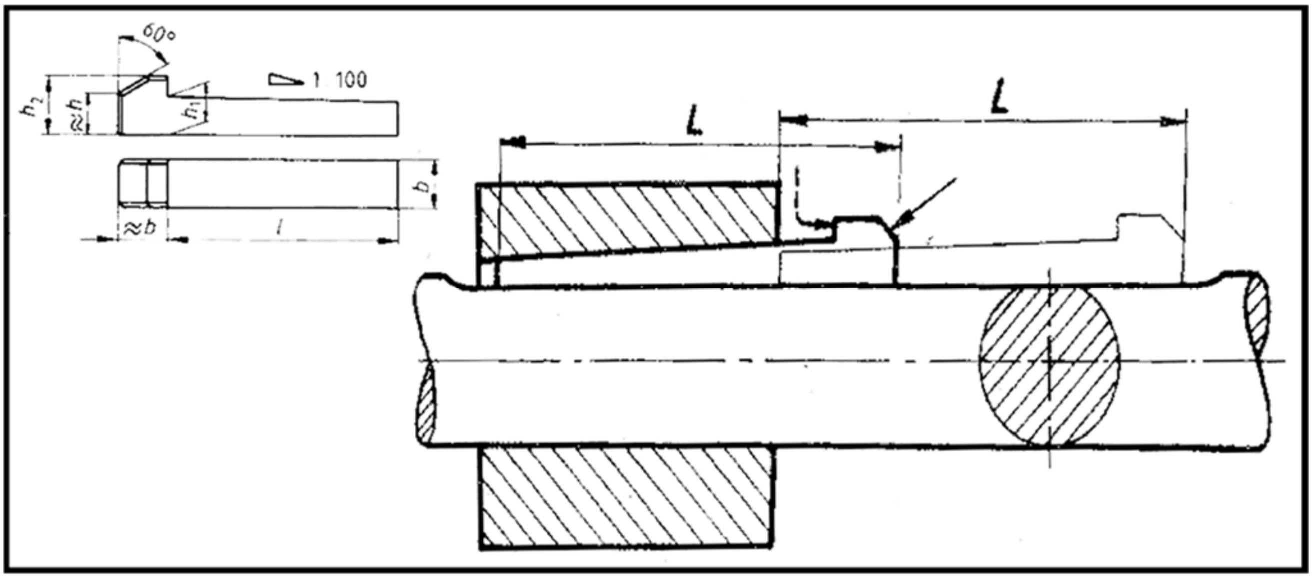
57. Figure Screw connection

The taper key has a symbol which reminds a slope. After the sign there is the gradient of the slope(taper) which is shown with a percentage(1:100).



58. Figure Screw connection

The gib head key, as depicted in *Figure 59*, features a tapered design within the hub, mirroring the plain taper key's shape. However, its elongated head allows for the key's removal from the same side it was inserted. This feature proves especially beneficial when the other end isn't reachable for key extraction. A great advantage of the gibhead key is that it can be removed with a suitable tool by clinging to its protruding part.



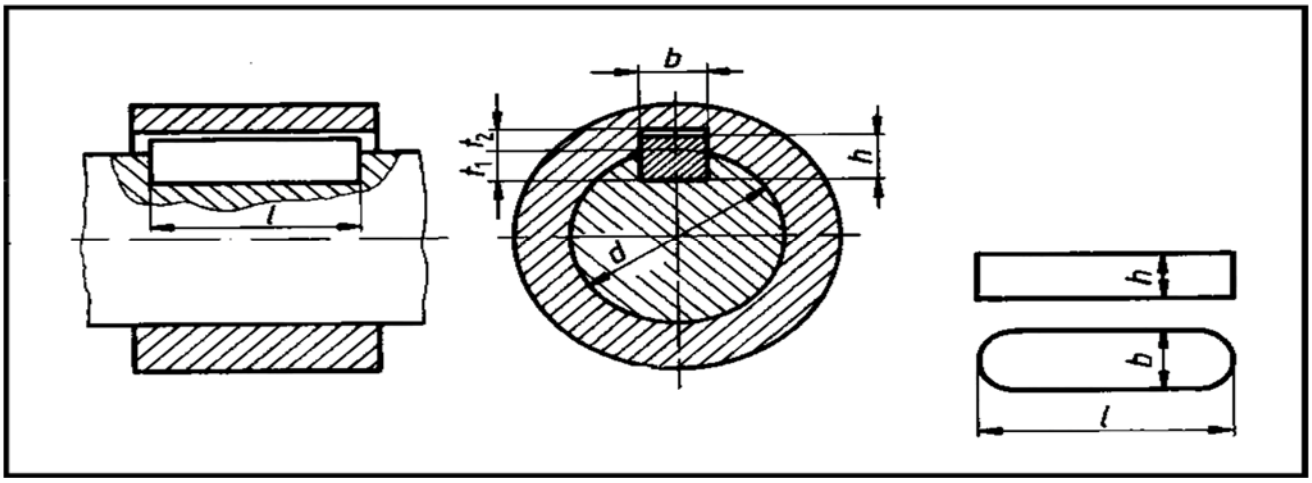
59. Figure Screw connection

THE DISADVANTAGES OF TAPER KEYS:

- They require a lot of force to dismantle,
- The loose fit causes the hub to fit loosely on the shaft, so after assembly, the geometry and center of rotation may not coincide,
- The location of the taper key connection is not exact,
- The stress from the force can cause deformation,
- The taper key moves the hub out of its perpendicular position.

5.3 SQUARE AND RECTANGULAR PARALLEL KEYS

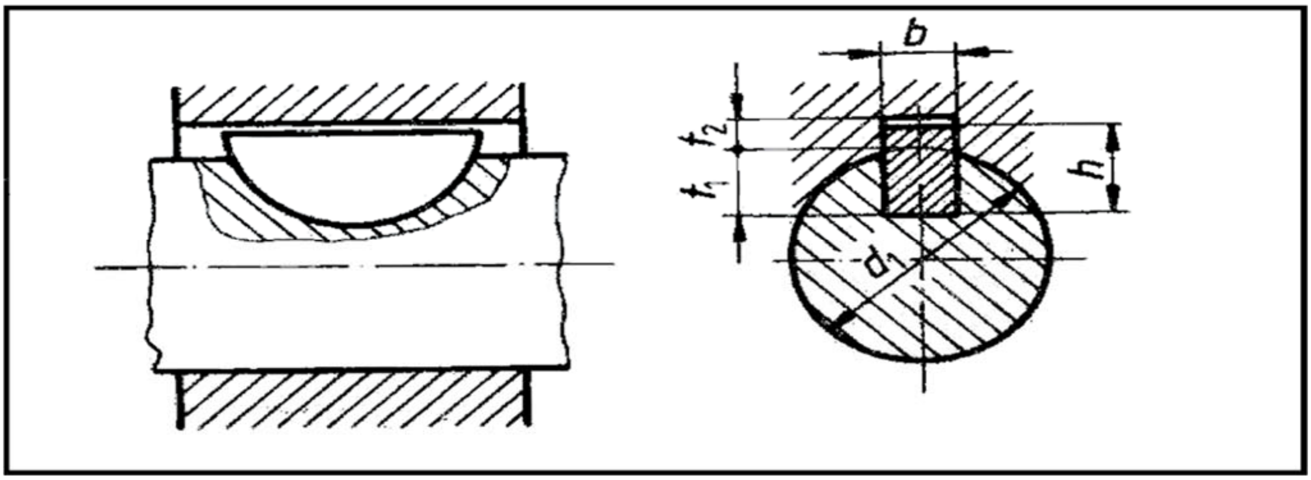
For shafts with diameters ranging up to 8-50 mm, the square key is typically used, depicted in *Figure 60*. The rectangular key is advised for more extensive shafts and can also be used for smaller shafts when a reduced height is acceptable. Both the square and rectangular keys are known as parallel keys due to the parallel nature of their top and bottom, as well as their sides.



60. Figure Square key joint desgn and shape

The design of the keyseats in both the shaft and the hub ensures that half of the key's height is supported by the side of the shaft keyseat, while the remaining half is supported by the side of the hub keyseat. The resulting design is depicted in *Figure 60*. Typically, keyseats in shafts are crafted using either an end mill or a circular milling cutter, resulting in the profile keyseat or sled runner keyseat, respectively.

When there's a preference for light loading and straightforward assembly or disassembly, one might think about using the Woodruff key. Refer to *Figure 61* for its typical design. The key remains in place within the shaft's circular groove while the corresponding part is slid onto it. Stress evaluation for this key follows the approach used for parallel keys but factors in the unique shape of the Woodruff key. The dimensions for numerous standard Woodruff keys and their respective keyseats can be found in the ISO and ANSI standards.



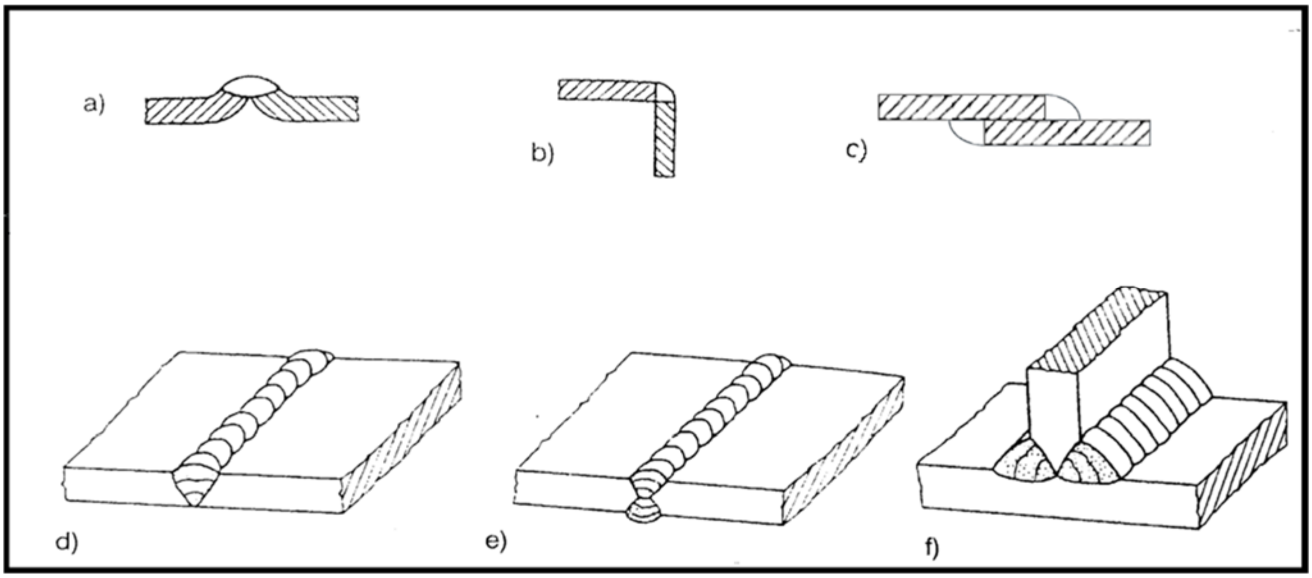
61. Figure Mechanical drawing of woodruff key

5.4 WELDED JOINTS

Welded joints(*Figure 62*) are among the most common and essential connections in the field of manufacturing and construction. These joints are formed by merging two metal surfaces using heat, and often with the addition of a filler material, to create a bond that's typically stronger than the original materials. The process of welding provides a permanent union, ensuring structural integrity and continuity between the interconnected elements. With a variety of welding techniques available, each tailored to specific materials and applications, understanding the fundamentals and intricacies of welded joints is crucial for anyone involved in the design, fabrication, or inspection of metal assemblies.

Repair welding procedures are specialized techniques employed to rectify defects, damages, or wear in metal components. These methods involve the careful application of heat and filler material to restore the integrity of the original part without compromising its strength or functionality. Depending on the severity and type of defect, different welding techniques may be utilized. Such procedures are crucial in industries like aerospace, automotive, and heavy machinery, where the safety and longevity of components are paramount. Proper repair welding can extend the life of equipment, reduce replacement costs, and ensure continued safe operation.

5.4.1 Types of welding joints



62. Figure Types of welding joints

The main types of welding joints are:

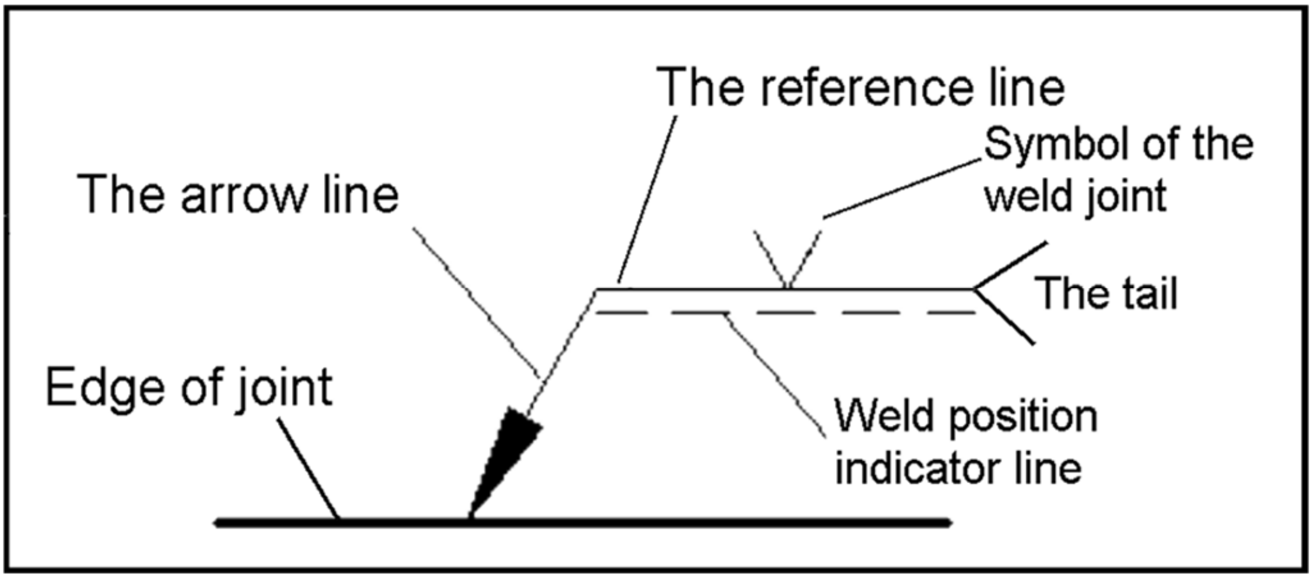
a) Edge Joint: The edges of two pieces are set side by side and then welded.
b) Corner Joint: Two pieces are joined at their ends, forming a corner.
c) Lap Joint: Two pieces are overlapped and then welded where they overlap
d) V-Groove, Butt Joint: Two pieces are joined end to end.

e) Double V-Groove joint: It is a specialized type of welding joint used for joining thicker plates or workpieces. As its name suggests, this joint utilizes two V-shaped grooves on both sides of the workpieces.
f) T-Joint (or Tee Joint): One piece is joined to the middle of another piece, forming a "T" shape.

Each of these joints can be used in various applications depending on the requirements of the structure and the materials being welded.

5.4.2 WELDING SYMBOLS

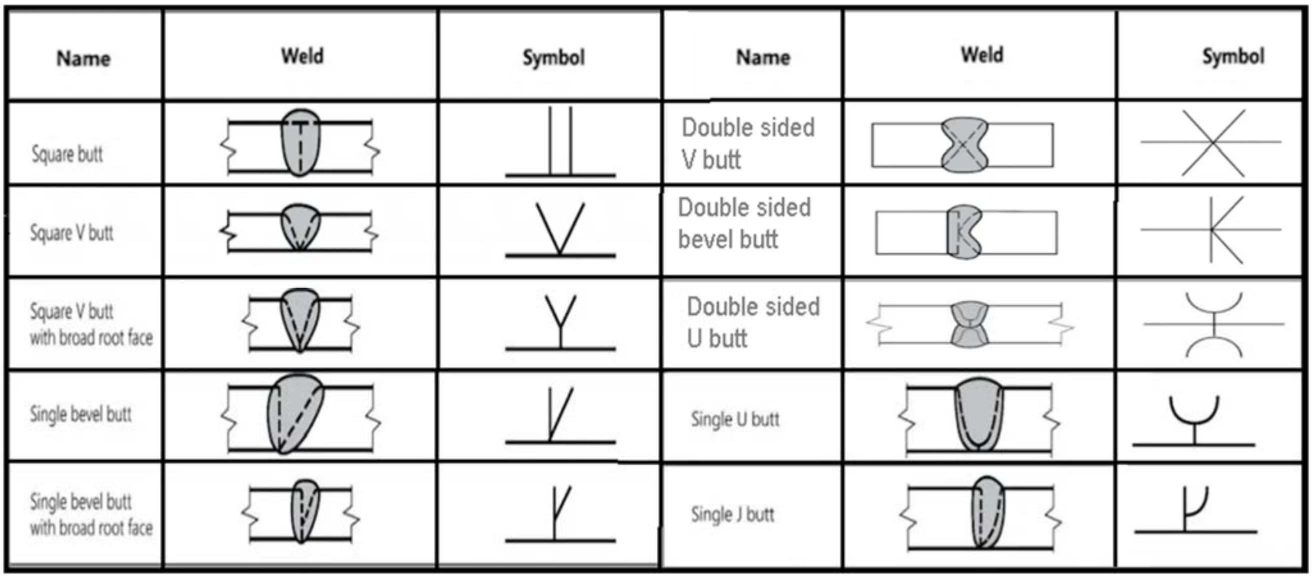
While some welding symbols(*Figure 63, 64*) may initially appear complex, they become straightforward when dissected. These symbols represent side views of the pre-weld joint, much like viewing a cross-section. Each symbol comes with a detailed explanation, paired with its weld profile.



63. Figure The base platform

This symbol serves as a basic framework to showcase the features and related details of your welds. It consists of three components:

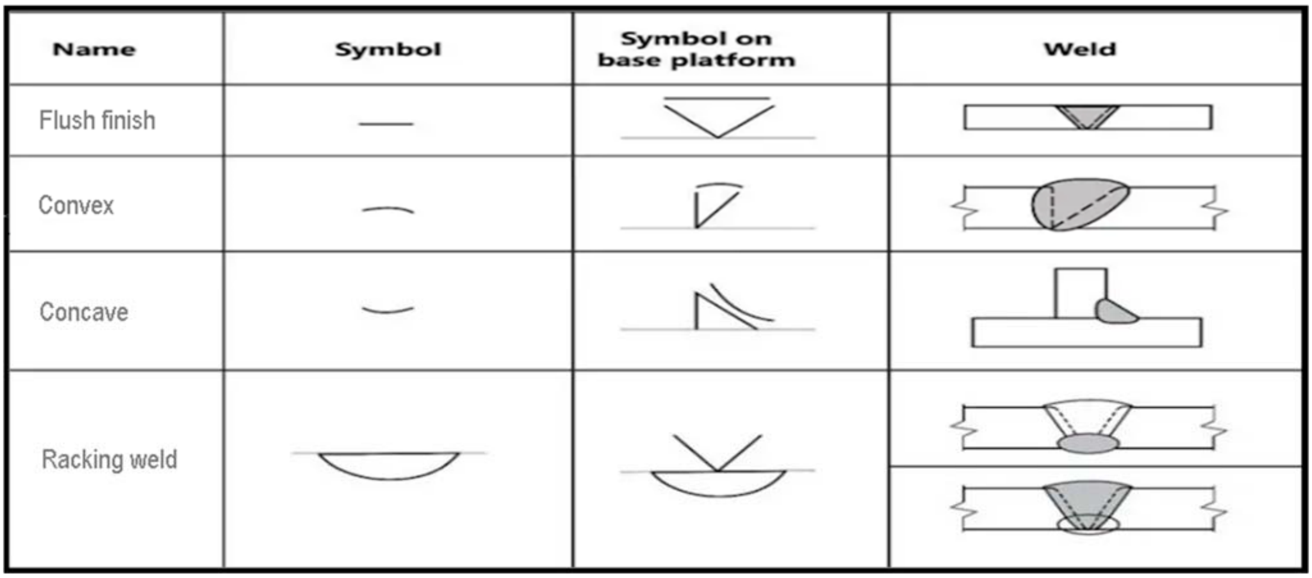
- The arrow line: directs attention to the weld's general location.
- The reference line: acts as the space where the details about the weld's type and exact location are presented.
- The weld position indicator line: The weld position indicator line in the base platform specifies the position in which the weld is to be performed.
- The tail: provides space for additional information unrelated to the primary specifics, such as welding standards, the type of materials, and the necessary welding procedure.



64. Figure The symbols of the weld joints

5.4.3 SUPPLEMENTARY WELDING SYMBOLS

These markers(*Figure 65*) complement the basic symbols to specify the required weld type. They encompass the weld's attributes, instructions on where and how to execute it, and the necessary finishing details.



65. Figure Supplementary welding symbols

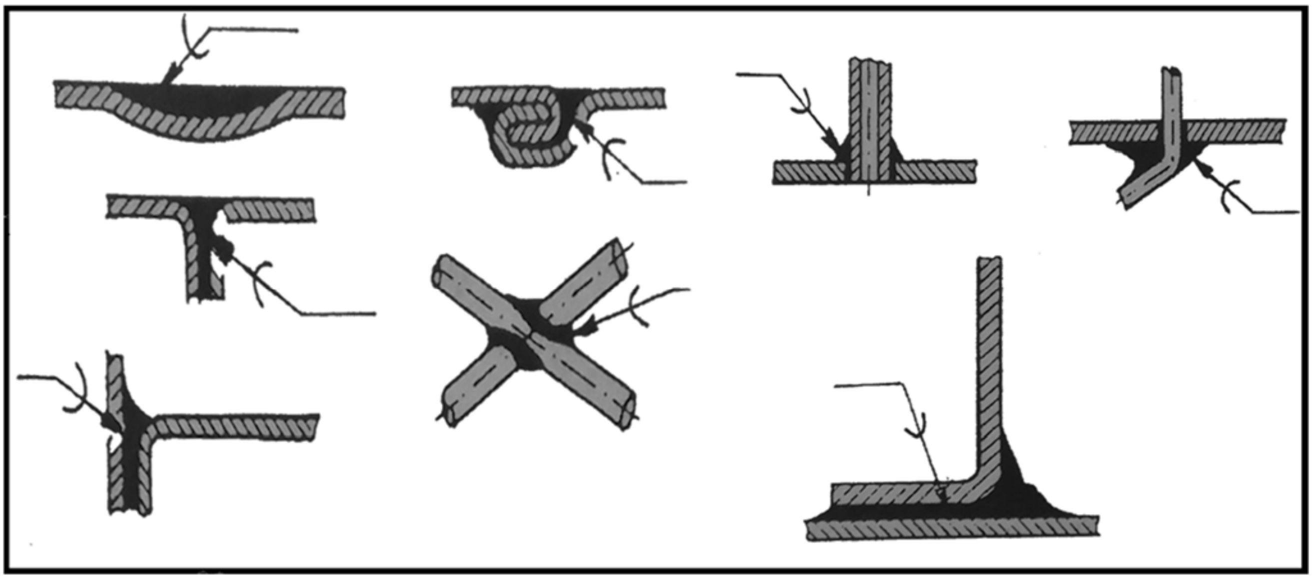
- Flush finish: This welding symbol indicates that the weld must be machined or ground to align flush with the surface of the remaining plate. The symbol is represented by a straight line, illustrating the appearance of the final surface.
- Convex: The convex finish of a weld bulges outward, resembling a balloon extending away from the weld, as depicted by its symbol.

- Concave: The concave symbol curves in a direction opposite to that of the convex, indicating that the weld should have an inward curvature, similar to the inner surface of a bowl. This finish is commonly associated with fillet welds.7
- Racking weld: This refers to the requirement for a preliminary weld at the base of a weld preparation, such as a V or U, before completing the entire weld. This initial weld provides a foundation for the complete weld, preventing it from burning through due to excessive heat when only a slim portion of the material is left. Its symbol, represented by a curved line, is positioned either below or above the primary welding symbol, based on which side of the reference line the main symbol is located.

5.5 SOLDERED AND BRAZED JOINTS

Soldering and brazing(*Figure 66*) are both techniques used to join metals without melting the base metals themselves. Soldering involves the use of fillers, known as solders, that melt at temperatures below 450°C (842°F). Due to its relatively low melting point, soldering is primarily used for delicate tasks like joining electrical components. In contrast, brazing uses filler metals, known as brazing rods, that melt at temperatures above 450°C but below the melting point of the base metals. Brazing provides a stronger bond than soldering and is often used in plumbing, metalwork, and in the construction of more robust structures. Both methods, when executed correctly, create a seamless bond that can be as strong as the metals being joined.

Before soldering or brazing, surfaces require thorough preparation to ensure a strong and effective bond. First, the areas to be joined must be cleaned to remove any oxidation, grease, dirt, or other contaminants. This can be done using solvents, wire brushes, or abrasives. Applying a flux before soldering or brazing is also crucial. Flux facilitates the flow of the filler material and helps prevent the formation of oxides during the heating process.



66. Figure Soldered joints

The strength of a soldered or brazed joint depends on various factors including the materials used, the quality of the preparation, and the techniques applied. Generally, a brazed joint offers a stronger bond compared to a soldered joint due to the higher temperatures involved, which allow for better penetration and flow of the filler material. However, both soldered and brazed joints, when executed correctly, can provide connections that are robust and reliable for their intended applications.

5.6 GLUED JOINTS

In the field of mechanical engineering, adhesive bonding has become an integral method for joining components. This technique offers several advantages over traditional joining methods such as welding, bolting, or riveting. Adhesive bonded joints distribute stress more evenly across the bonding surface, reducing localized stress concentrations. This can lead to lighter, more streamlined designs as there's no need for additional fasteners or overlapping material. Additionally, adhesive bonding can join dissimilar materials, including metals, plastics, and composites, which might be incompatible with other methods. The process also provides excellent resistance to fatigue, vibration, and environmental factors. However, surface preparation and the choice of the right adhesive are critical to achieving a strong and durable bond.

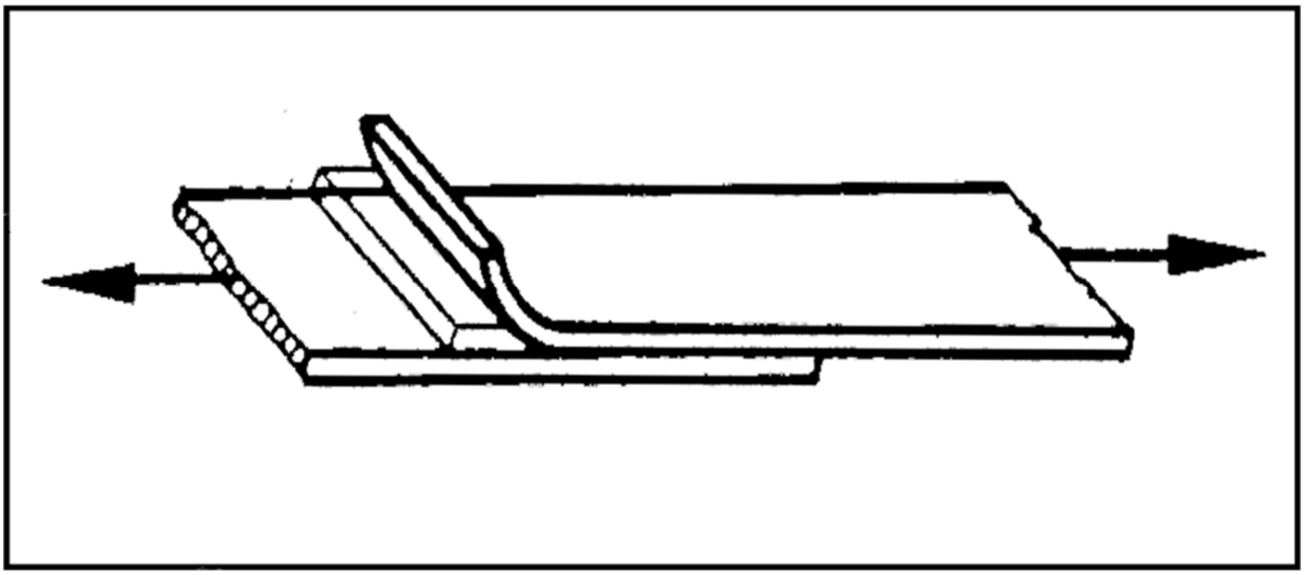
Before adhesive bonding, it's essential to thoroughly prepare the surfaces to ensure optimal adhesion and the long-term durability of the bond.

Steps for surface preparation:

- Cleaning: Start by removing any loose particles, dust, or dirt from the surface. This can be done using a soft brush or compressed air.
- Degreasing: Remove any oils, greases, or contaminants from the surface using appropriate solvents or degreasing agents. After applying the solvent, wipe the surface with a clean, lint-free cloth or rinse with clean water, depending on the solvent's instructions.
- Abrading: For some materials, lightly abrading the surface can enhance adhesive bonding. Sanding with fine-grit sandpaper or using abrasive pads can create micro-roughness, increasing the surface area for the adhesive to grip.
- Chemical Treatments: Certain materials, especially metals and some plastics, may benefit from chemical treatments like etching or priming, which can increase surface energy and improve adhesive wettability.
- Rinsing: After chemical treatments, it's crucial to rinse the surface with distilled or deionized water to remove any residues.
- Drying: Ensure the surface is completely dry before applying the adhesive. This can be done using clean compressed air, heat guns, or simply letting it air dry, depending on the material and the specific application.

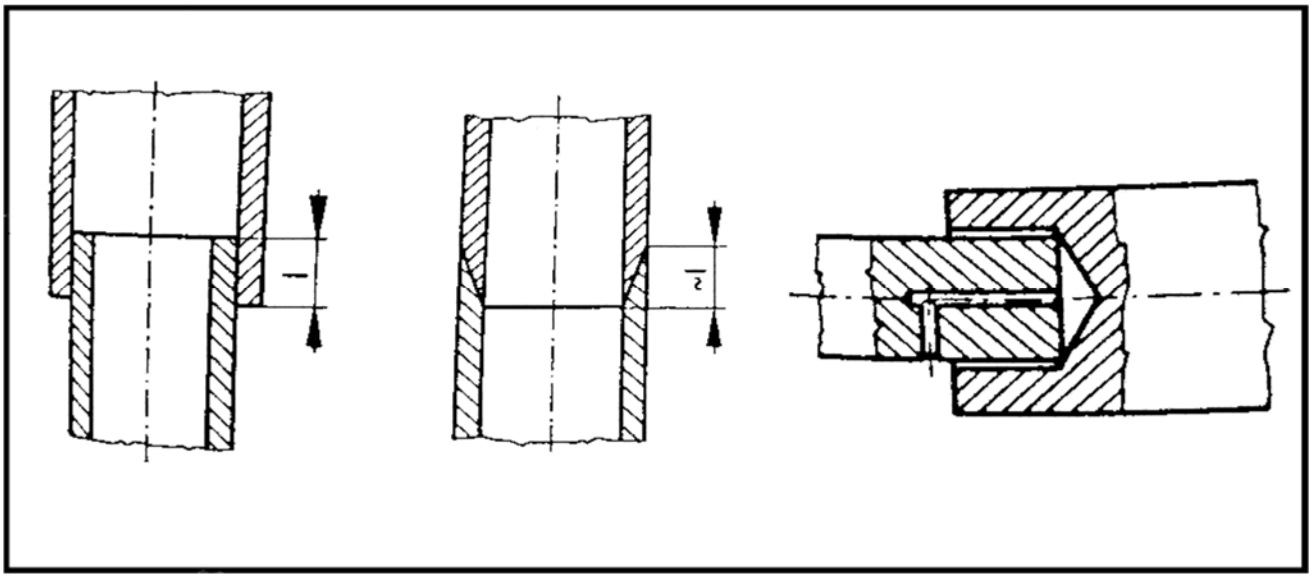
- Immediate Bonding: After preparation, it's advisable to proceed with the bonding process as soon as possible to prevent the surface from becoming re-contaminated or oxidizing.

In the context of adhesive bonding, "delamination" refers to the separation or splitting of layers within bonded assemblies(*Figure 67*). When subjected to bending stresses, ancillary tensile stresses can arise, especially near the edges of the bonded material. These stresses can exceed the adhesive's capacity to maintain cohesion, leading to a peeling or separation at the edges. Essentially, the bonded layers start to peel away from each other, compromising the integrity of the bond. Delamination can be a significant concern, as it weakens the overall structure and can lead to complete bond failure if not addressed. Ensuring proper surface preparation, using the appropriate adhesive, and considering the mechanical loads and environmental conditions the bond will be subjected to are crucial to mitigate the risk of delamination.



67. Figure Delamination of glued bonding

In adhesive bonding, it's crucial to maximize the contact area between the surfaces being joined. As depicted in *Figure 68*, various pipe joints can achieve this through methods such as creating a tapered design for the pipe ends or sliding pipes of different diameters into one another. The illustration also highlights that when a component is bonded into a hole, a vent hole is necessary. This ensures that any trapped air within the hole does not exert pressure on the component being bonded, which could compromise the adhesive joint's integrity.



68. Figure Construction aspects of glued joints

6. CHECKING QUESTIONS

- What ways of representation of parts did you learn?
- What is axonometric projection?
- Which types of axonometric projections do you know?
- What is the Monge plane system?
- How can you draw a 3D object to a 2D system?
- How many ways do you know to drawing parts to 2D system?
- What is the European projection system?
- What can we show with sections?
- How many types of section drawing method do you know?
- What is the scale? Why are used in drawings?
- Describe the rules of giving dimensions.
- Describe the elements of size specification.
- Describe what the fasteners are.
- Describe what the pitch is.
- Describe the difference between metric screws and UNT screws.
- Which types of threads do you know?
- Which types of key connections do you know?
- Which types of welding seams do you know?
- Describe what the welding is.
- Describe what the soldering is.
- Describe what gluing technology means.

7. COLLECTING WORKS AND PRACTICES

- Make projection drawings of different parts.
- Make sectional drawings.
- Draw some simple machine parts and make a scale grid for them.
- Collect different machine drawings and study them.
- Collect fasteners and put labels on them.
- Collect key and put labels on the.
- Buy C45 steel in 5x5 mm cross-section and make some keys.
- Glue a couple of plate and try to destroy the bond.
- Look for welding seams wherever you go and take photos of them. At home, make drawings of the welded structures based on the photos.

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