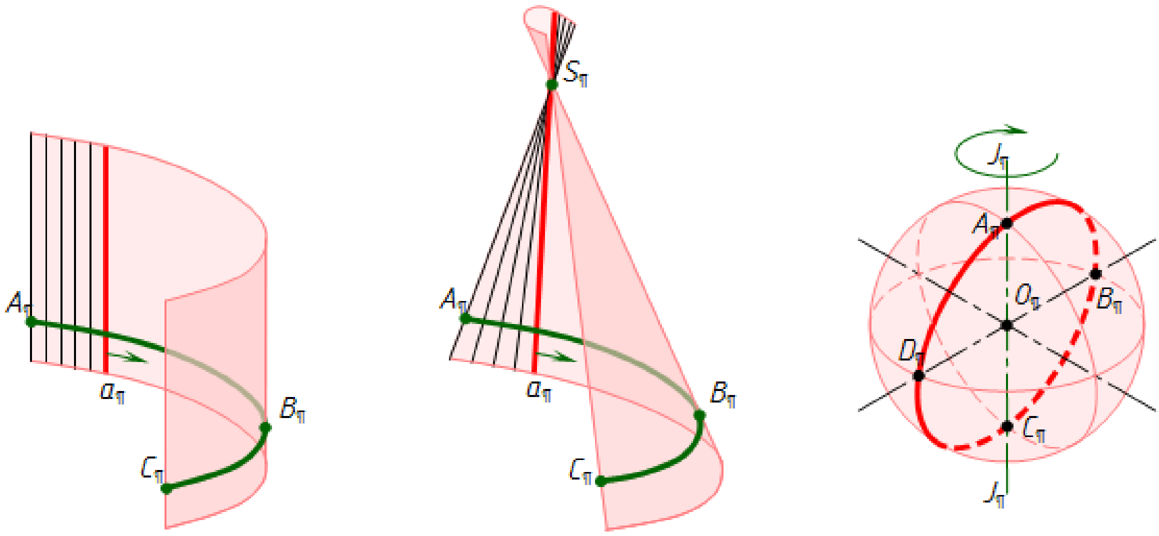
S.P. Burkova, G.F. Vinokurova, R.G. Dolotova

DESCRIPTIVE GEOMETRY



«NATIONAL RESEARCH TOMSK POLYTECHNIC UNIVERSITY»

DESCRIPTIVE GEOMETRY

Exercise-book of a theoretical course

TOMSK 2013

УДК 514.18(075.8)
ББК 22.151.3я73
Б914

Б914 Descriptive geometry: Exercise-book S.P. Burkova, G.F. Vinokurova, R.G. Dolotova; Tomsk: TPU Press. 2013. – 79 с.

The working book on descriptive geometry and the engineering drawing is developed for first-year students. The writing-book is used for work on lecture employment under the direction of the teacher.

This work book is intended for distance leaning Engineering Graphics for the Certificate of Higher Technical Education.

УДК 514.18(075.8)
ББК 22.151.3я73

Reviewed by: Prof. Dr. B.A. Ljukshin
Prof. A.L. Stukanov
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CONTENTS

PREFACE

This writing-book is intended for studying the course “Engineering Graphics” by students of technical specializations of TPU who go through the Bachelor Degree Program. The course is taught in the first semester.

The working writing-book contains drawings of tasks on the basic sections of a course; in it the place for the geometrical constructions which are carried out by students at lecture is provided. The following designations are accepted in the present writing-book:

1. Points of space are usually denoted by Latin capital letters (*A*,*B*,*C*) or figures (*1*,*2*,*3*);
2. Sequence of points (and other elements) - by interlinear indexes (*A1*,*A2*,*A3*,*B1*,*B2*,*B3*,);
3. Lines in space - by the points specifying the given line (*AB*, *CD*,);
4. Angles - by Greek small letters (α, β, γ)
5. Planes - by Latin capital letters (*P*, *R*, *Q*)
6. Surfaces - by Greek capital letters (Ψ, Φ, Ω,)
7. Projection centre – *S*
8. Projection planes: horizontal – *H*; frontal – *V*; profile – *W*
9. Coordinate axes system - *xyzO*, where:
   - abscissa axis – *x*; axis of ordinates – *y*; applicate axis – *z*;
   - origin of coordinates – *O* (capital letter);
   - new projection axes obtained at planes replacing – x_1,y_2;
10. Point projections – by the corresponding lower-case letters (*a*,*b*):
    - for horizontal projection plane – *a*;
    - for frontal projection plane – a';
    - for profile projection plane – a'';
11. Line projections - by projection of the points specifying the line – *ab*, $a'b'$, $a''b''$.
12. Coincidence, identity – ≡;
13. Coincidence, equality – =;
14. Parallelism – ||;
15. Perpendicularity – ⊥;
16. Representation – →;
17. Belonging of an element (a point) to a set (line, plane, etc.) – ∈;
18. Belonging of a subset (a line) to a set (plane, surface) – ⊂;
19. Intersection of sets – ∩.
20. Crossing – ∸.

Engineers create representation of a detail or a product on a sheet of paper as a drawing before it will be manufactured. Teaching a lot of subjects in high school is linked with studying different devices, machines and technological processes by their representations – drawings. So Engineering Graphics is included in number of subjects for training engineers.

Course objectives – ____

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CHAPTER 1. THE HISTORICAL INFORMATION

Graphic representations appeared at the early stages of the development of human society. Judging by those, which have been kept safe till nowadays, we can realise that most of them were connected with trade and handicrafts.

The first representations have been produced by the simplest tools, in the form of drawings outlining only the shape of things. But further development of man's manufacturing activities required more accurate representations of spatial objects.

Construction of fortresses and different fortifications demanded their preliminary imaging on the plane. The remnants of grand antique buildings prove that different plans and other representations of the erecting constructions have been used by the ancient experts.

Together with the development of graphic representations there evolved a science determining the rules and theory of the process. The first manuscripts in this field appeared in 3-5 ages B.C. They were the works by Hippokrates, Pithagoras, Archimedes and others. After them many outstanding scientists continued the development of the field. An Italian scientist, Leon Battista Alberti (1404 - 1472) presented the basis of the theoretical perspective. An ingenious Italian artist, Leonardo da Vinci (1471 - 1519) filled it up with the doctrine “About Decrease of Colours and Contour Precision”. A German artist and engraver Albrecht Durer (1471 - 1528) contributed the development of perspective. His method of perspective construction, given two orthogonal projections, is widely known. An Italian scientist Gvido Ulbani (1545 - 1607) can by right be considered a founder of the theoretical perspective, as his works contain the solutions of nearly all principal problems on it. A French architect and mathematician Desargues (1593 - 1662) was the first to apply the method of coordinates to construct the perspective, and became the founder of axonometric method in descriptive geometry.

At the end of XVIII century a French scientist Jasper Monge (1746 - 1818) summarised the knowledge on the theory and practice of imaging, and created a clear scientific discipline about rectangular projections. In 1798 he published his work “Descriptive Geometry” in which suggested to consider a plane drawing containing two projections to be a result of coincidence of two mutually perpendicular projection planes. This coincidence is obtained by rotation of the planes round their intersection line. Later the line was called “projection axis”.

In ancient Russia the graphics developed intensively but in its own original way. Some ancient drawings produced according particular rules are now available, such as: a plan of Pskov-town (1581), a drawing of the Moscow Kremlin (1600), “Siberian Book of Drawings” compiled by Semyon Remezov in 1701.

Evolution of technics, inventions and discoveries gave a new impulse to the development of representation means. In 1763 I.I.Polzunov produced a drawing of a factory steam machine invented by him. Some drawings of a self-taught mechanic I.P.Kulibin have also been kept. For example, drawings of a single span arch bridge over the Neva river (1773).

When in 1810 the Institute of Railway Engineering Corps was opened in Petersburg, among the other subjects there was taught a course of descriptive geometry. Carl Pottier, one of J.Monge’s pupils, was the first lecturer there. Since 1818 the lectures on descriptive geometry have been delivered by Professor Y.A.Sevostyanov (1796 - 1849). In 1821 he published an original course named “Foundation of Descriptive Geometry”. It happened to be the first textbook on descriptive geometry in Russia in the Russian language.

In Tomsk Polytechnic University the graphic disciplines have been taught since 1900. The first lecturer on descriptive geometry was V.Jhons.

Further development of descriptive geometry in Russia is closely connected with the names of M.I.Makarov (1824-1904), V.I.Kurdyumov (1853-1904), E.S.Fyodorov (1853-1919) and other scientists.

Professor V.O.Gordon (1892-1971), Academician N.F.Chetverukhin (1891-1974), Professor I.I.Kotov (1909-1976) and others greatly contributed to scientific researches on graphic representations, also to teaching descriptive geometry and drawing in the colleges and universities of our country.

Diversity of the drawings produced required unification of the rules and conventions of their production. In Russia it is regulated by National Standards of Russia and by international standards of ISO (International Standards Organisation).

Fulfilling the training drawings and other graphical papers students must follow the above standards which will be presented within the course study.

CHAPTER 2. PROJECTION METHOD

Images of three-dimensional space objects on a plane are made by the projection method.

The projector includes a projectable object, projecting beams and the plane on which the picture of the object appears.

2. 1 CENTRAL PROJECTION

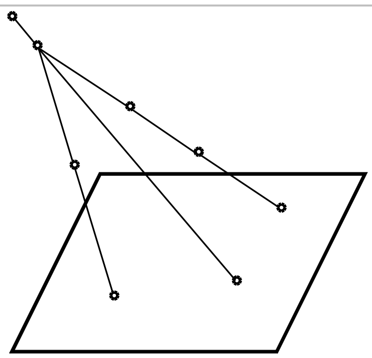


Fig. 1

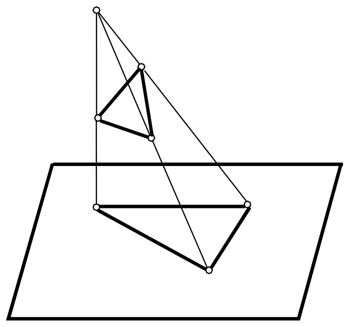


Fig. 2

Properties of central projection:

2.2 PARALLEL PROJECTION

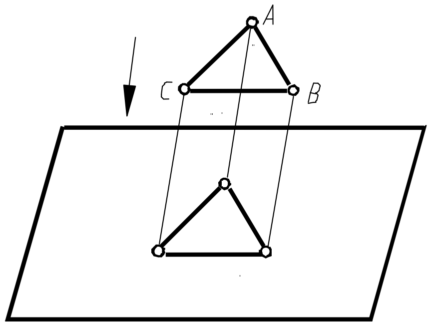


Fig. 3

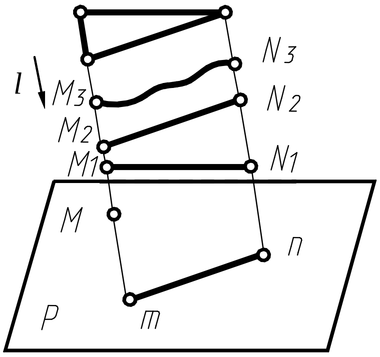


Fig. 4

2.3 METHODS OF PROJECTION DRAWINGS SUPPLEMENTATION

2.4 THE METHOD OF ORTHOGONAL PROJECTIONS

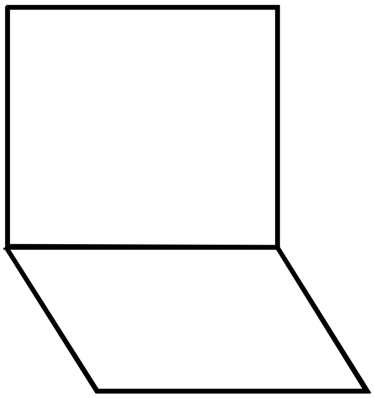


Fig. 5

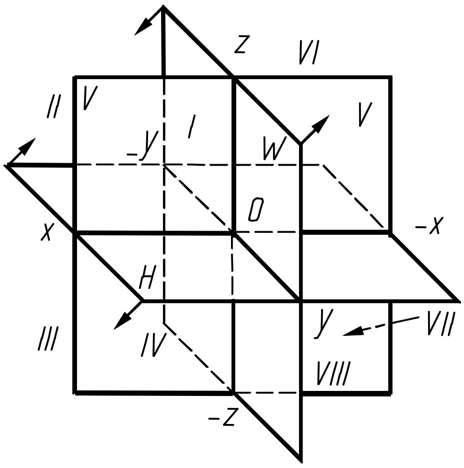


Fig. 6

CHAPTER 3. THE POINT AND THE STRAIGHT LINE

To obtain a clear understanding of the all external and internal forms of the components and their joints as well as to be capable of solving other problems, it is usually necessary to have three or more views of each detail. That is why there can be three or more projection planes.

3.1 DRAWING OF POINT

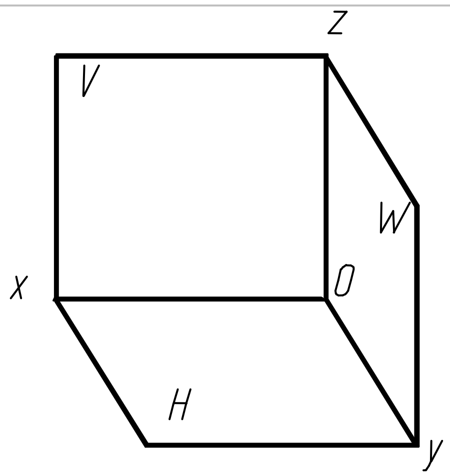


Fig. 7

H – ______

V – ______

W – ______

o – ______

ox, oy, oz – ______

ox – *oy* – *oz* –

A – ______

a – ______

a′ – ______

a″ – ______

oa_x – ______

oa_y – ______

oa_z – ______

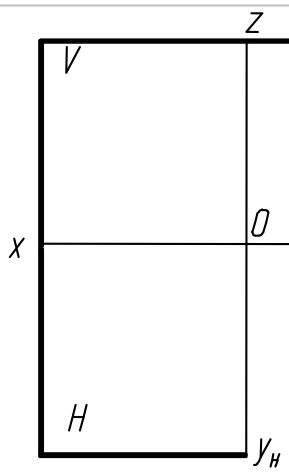


Fig. 8

Rules of orthogonal displaying of a point:

1.

2.

3.

4.

3.2 DRAWING OF A LINE-SEGMENT

Lines –

Straight Lines –

3.2.1 A line can have different positions relative to the projection planes

The line of general position – ______________________________

____

____

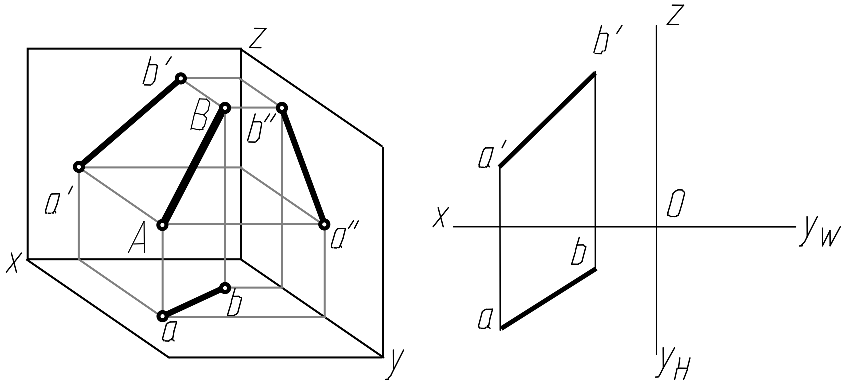


Fig. 9

____

____

The line of a particular position – ______________________________

____

____

LEVEL LINES

Horizontal line (AB // H) – ______________________________

____

____

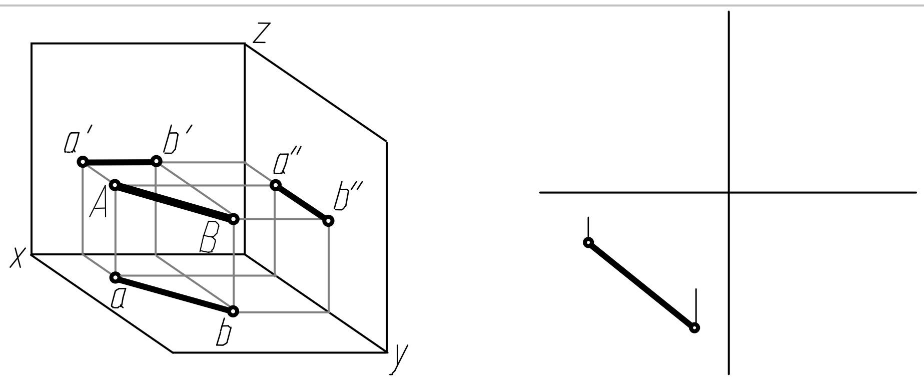
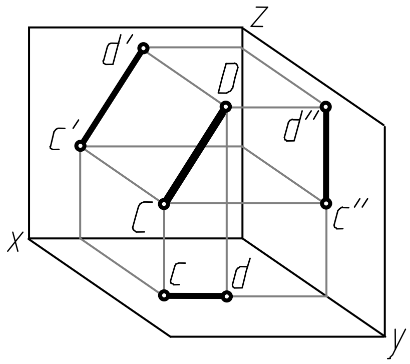


Fig. 10

Properties projection:
/ab/ = /AB/;
(a'b') // (Ox);
(a''b'') // (Oy_w);
($AB^{\wedge}V$) = ($ab^{\wedge}Ox$) = β;
($AB^{\wedge}W$) = ($ab^{\wedge}Oy_н$) = γ.

Frontal line – ____



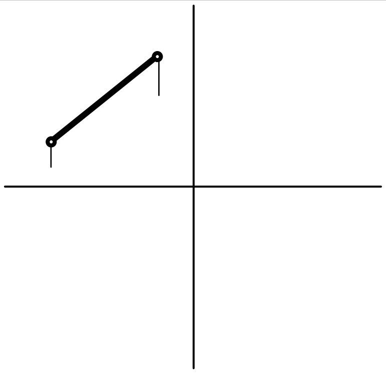
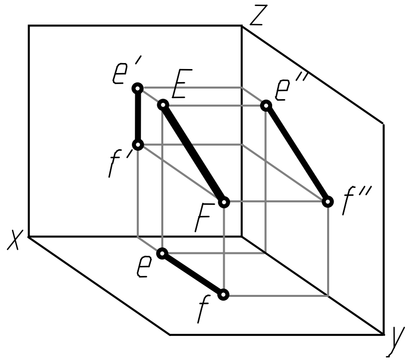


Fig. 11

Properties projection:

Profile line – ____



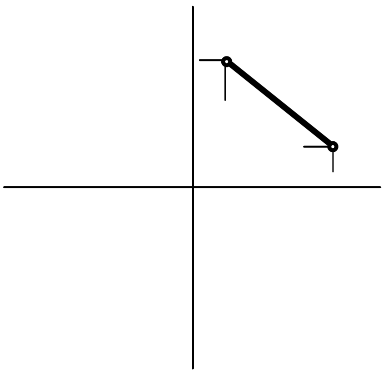


Fig. 12

Properties projection:

PROJECTING LINES

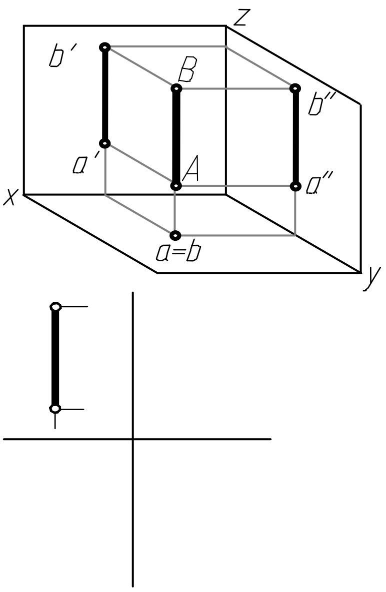


Fig. 13

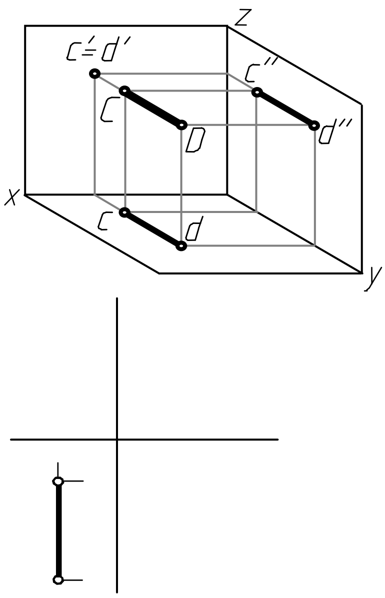


Fig. 14

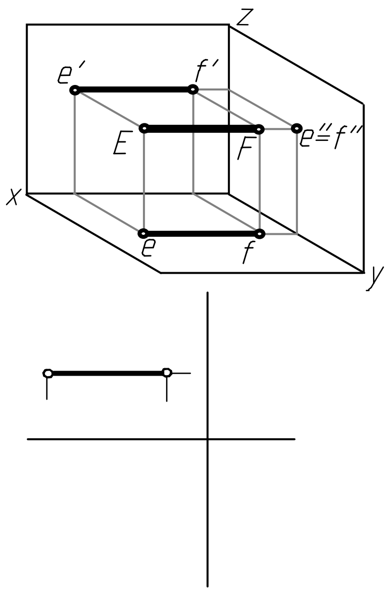


Fig. 15

Properties projection (Fig. 13)

Properties projection(Fig. 14)

Properties projection (Fig. 15)

3.3 MUTUAL POSITIONS OF A POINT AND A LINE

A point and a line in space may have different positions relative to each other and to a projection plane. If a point in space belongs to a line, its projections belong to the corresponding projections of the line.

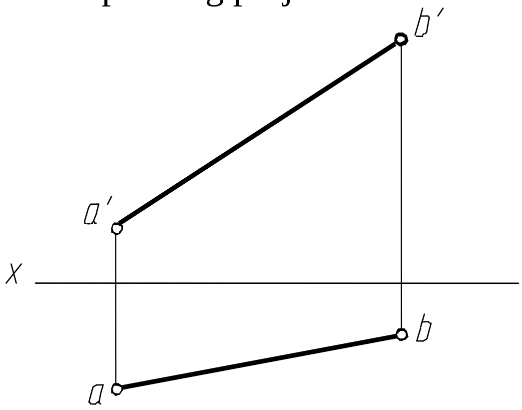


Fig. 16

3.4 TRACE OF A LINE

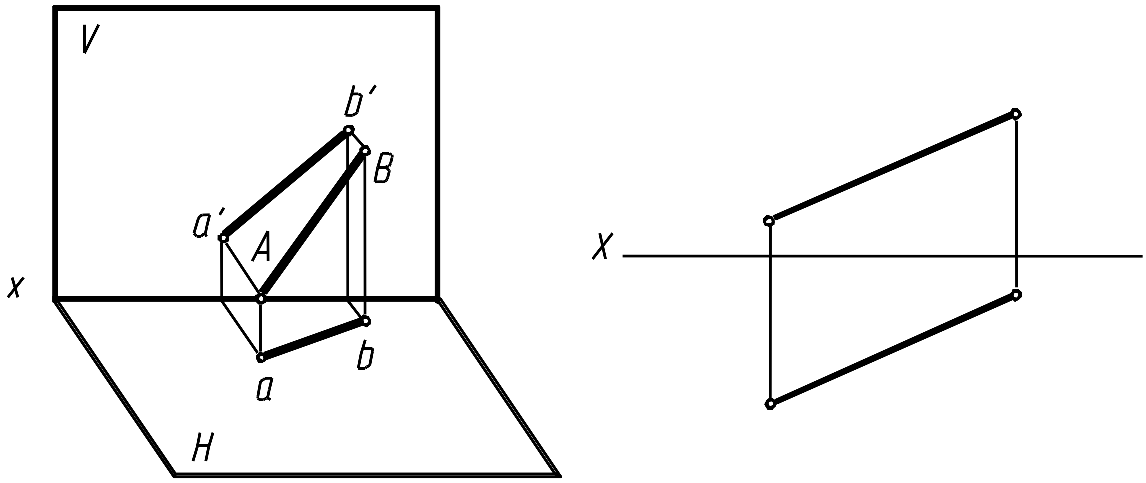


Fig. 17

3.5 THE RELATIVE POSITIONS OF TWO STRAIGHT LINES

Straight lines in space may have different relative positions:

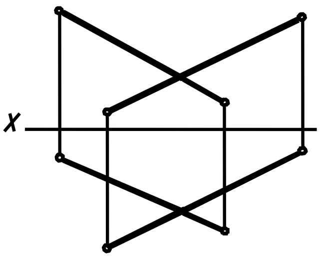


Fig. 18

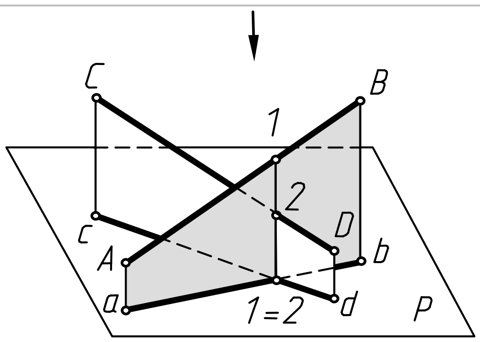


Fig. 19

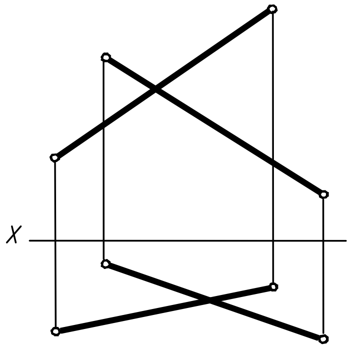
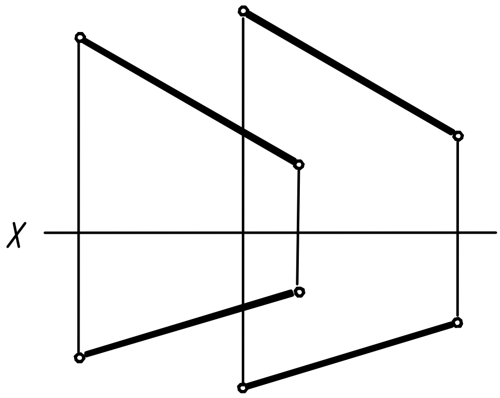
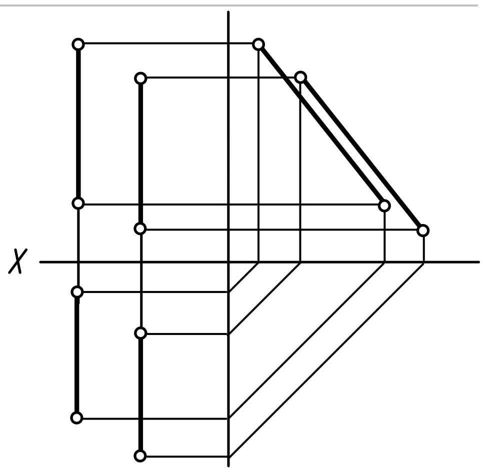


Fig. 20



a



б

Fig. 21

3.6 PROJECTING OF PLANE ANGLES

Any linear angle is formed by two intersecting lines. It is usually projected onto the projection planes in distortion. However, if both arms of the angle are parallel to one of the projection planes, the angle is projected on this plane without changing it, i.e. in true size.

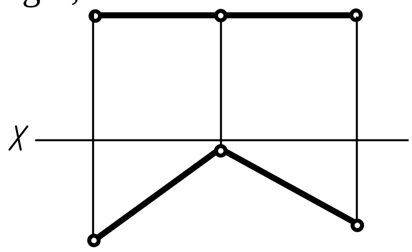


Fig. 22

Theorem. A right angle is projected as a right angle, when one of its arms is parallel to a projection plane and the second arm is not perpendicular to it.

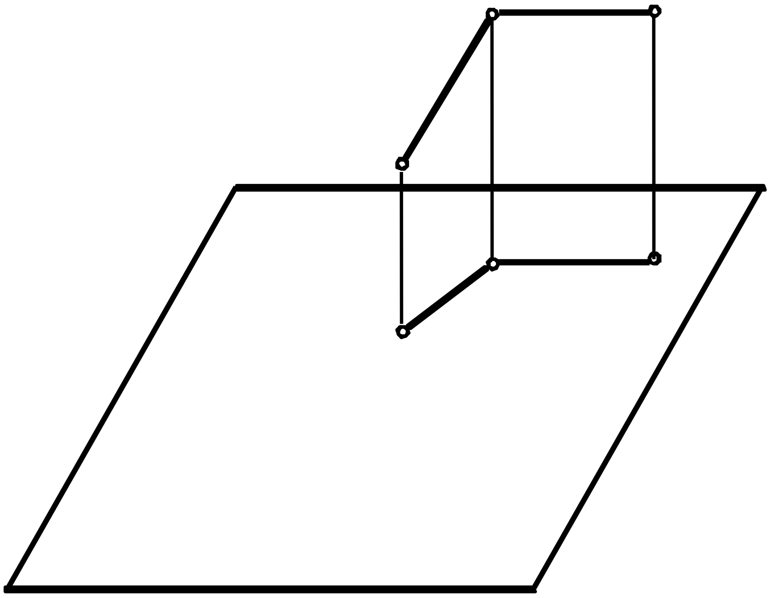


Fig. 23

CHAPTER 4. REPRESENTATION OF A PLANE IN A DRAWING

4.1 WAYS OF SPECIFYING A PLANE

The position of a plane on a drawing may be specified in one of the following ways:

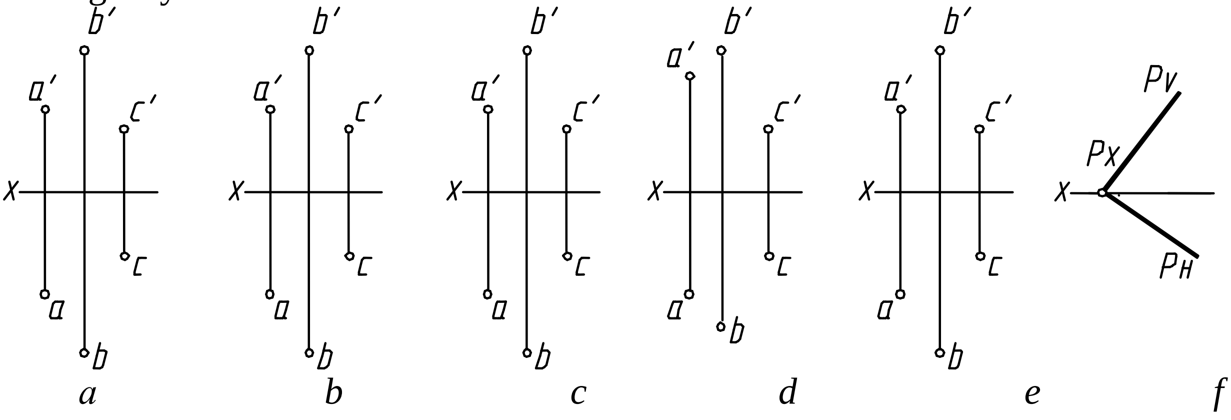


Fig. 24

а – ______________________________

б – ______________________________

в – ______________________________

г – ______________________________

д – ______________________________

е – ______________________________

4.2 ERACES OF THE PLANE

____

____

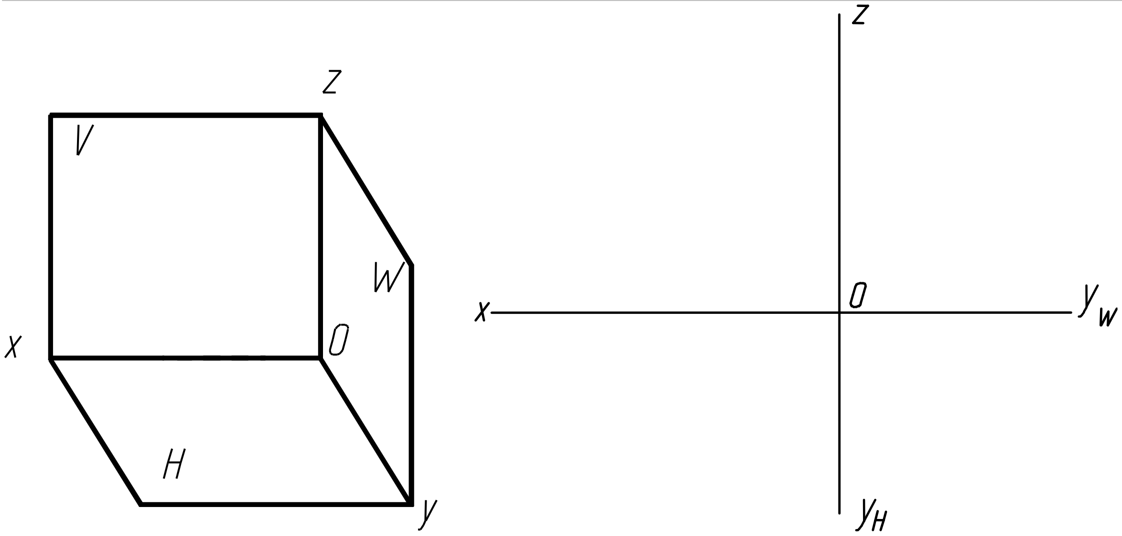


Fig. 25

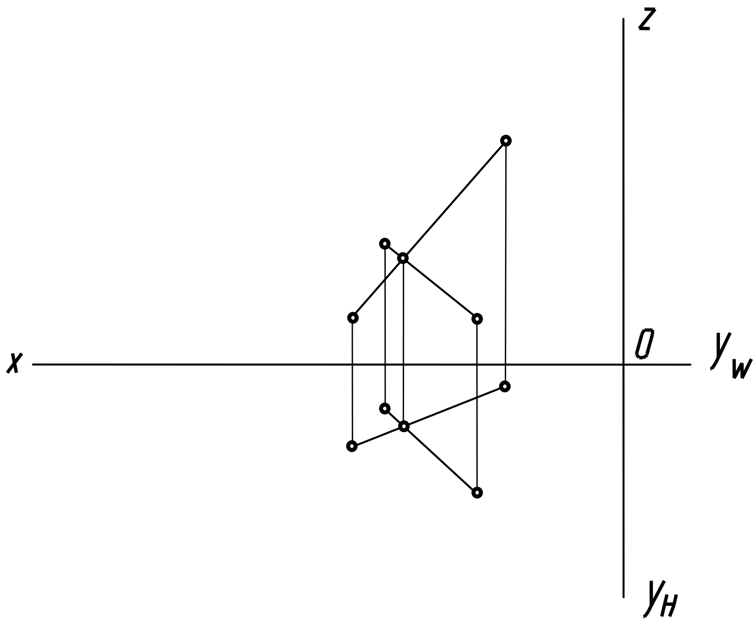


Fig. 26

4.3 THE POINT AND THE LINE IN THE PLANE

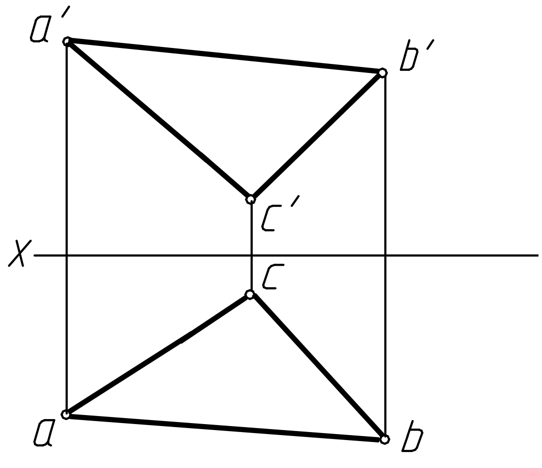


Fig. 27

4.4. THE POSITION OF A PLANE RELATIVE TO THE PROJECTION PLANES

The Planes of Particular Position

Projecting plane –

The horizontal projecting plane

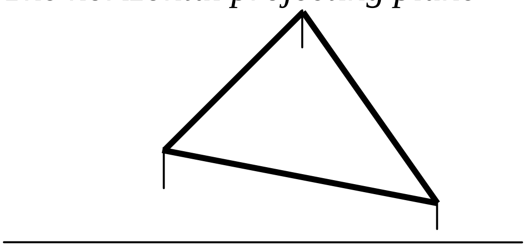


Fig. 28

The vertical projecting plane

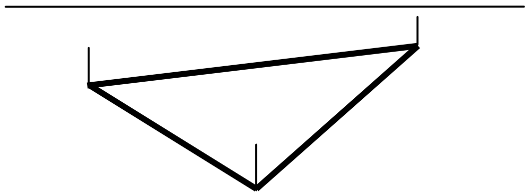


Fig. 29

The level planes – ______________________________

The horizontal plane

The vertical plane

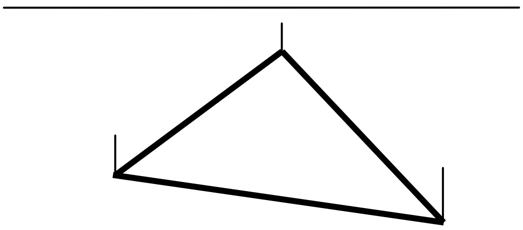


Fig. 30

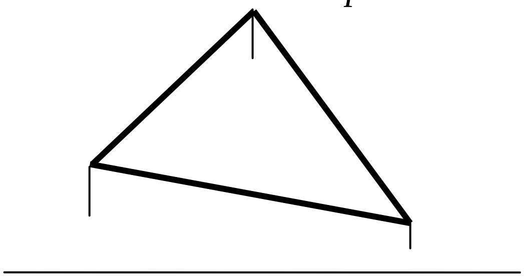


Fig. 31

The Principal Lines of the Plane

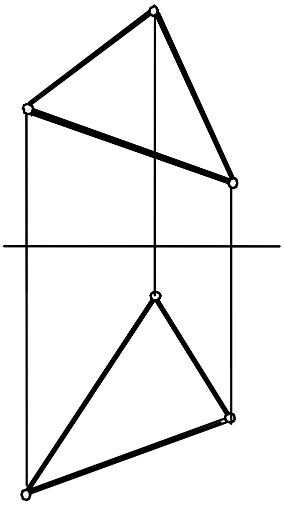


Fig. 32

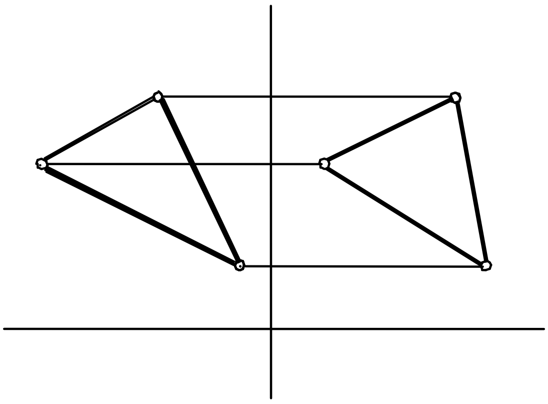


Fig. 33

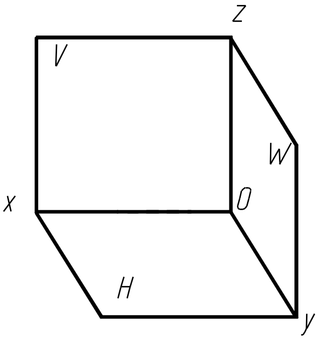


Fig. 34

4.5 THE RELATIVE POSITIONS OF A LINE AND A PLANE

The relative positions of a line and a plane are determined by the quantity of points belonging both to the plane and to the line.

A line is parallel to a plane

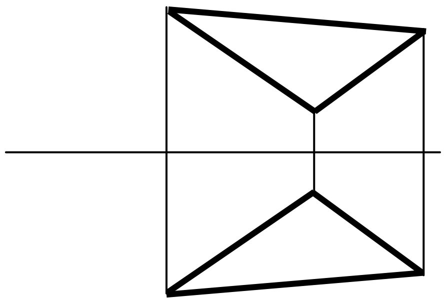


Fig. 35

Construction of the intersection point of a line and a plane.

To construct the point of intersection of a line and a plane means to find a point belonging to both, a given line and a plane. Graphically this is a point of intersection of the straight line and a line contained in the plane.

The plane has a projecting position

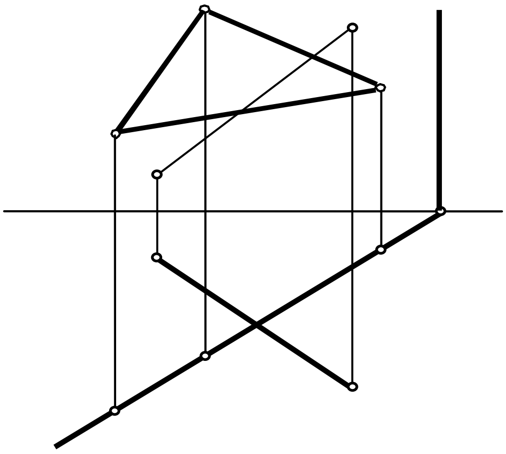


Fig. 36

The line has a projecting position

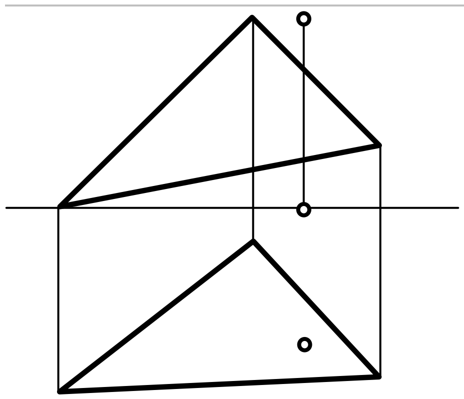


Fig. 37

The line and the plane have a general position

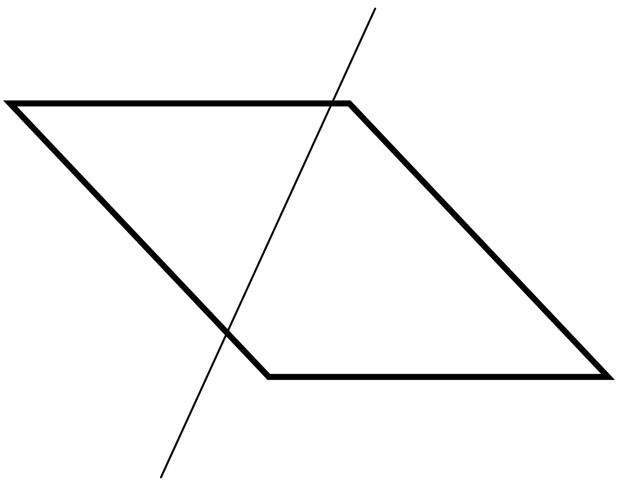


Fig. 38

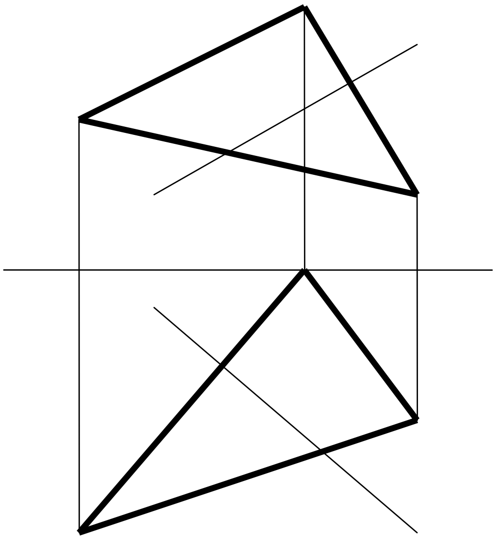


Fig. 39

4.6 MUTUAL POSITIONS OF THE PLANES

A general case of the mutual positions of planes is their intersection. In the particular case when the intersection line is at infinity, the planes become parallel. The parallel planes coincide when the distance between them is shortened to zero.

4.6.1 The parallel planes

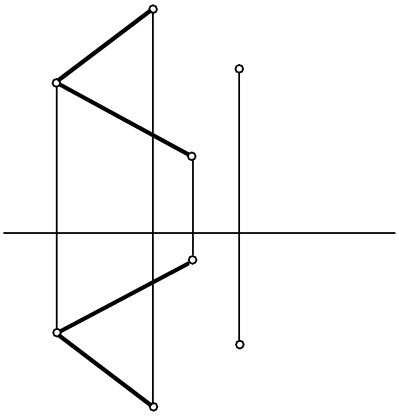


Fig. 40

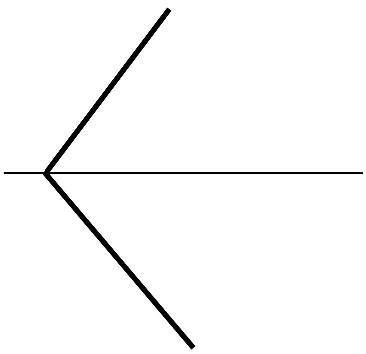


Fig. 41

4.6.2 Intersecting planes

Intersection of two projecting planes

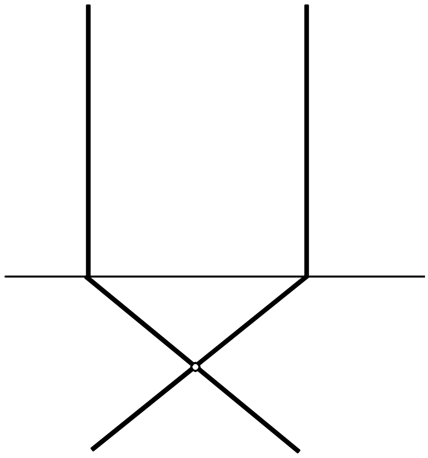


Fig. 42

Intersection of a projecting plane and an oblique plane

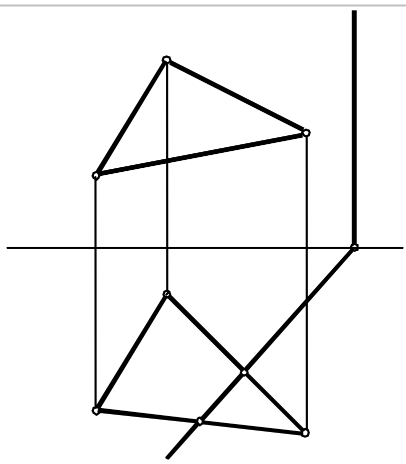


Fig. 43

Intersection of the oblique planes

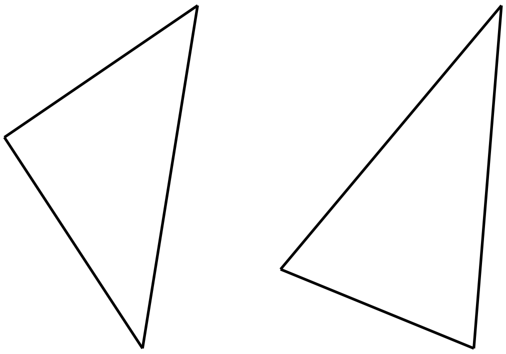


Fig. 44

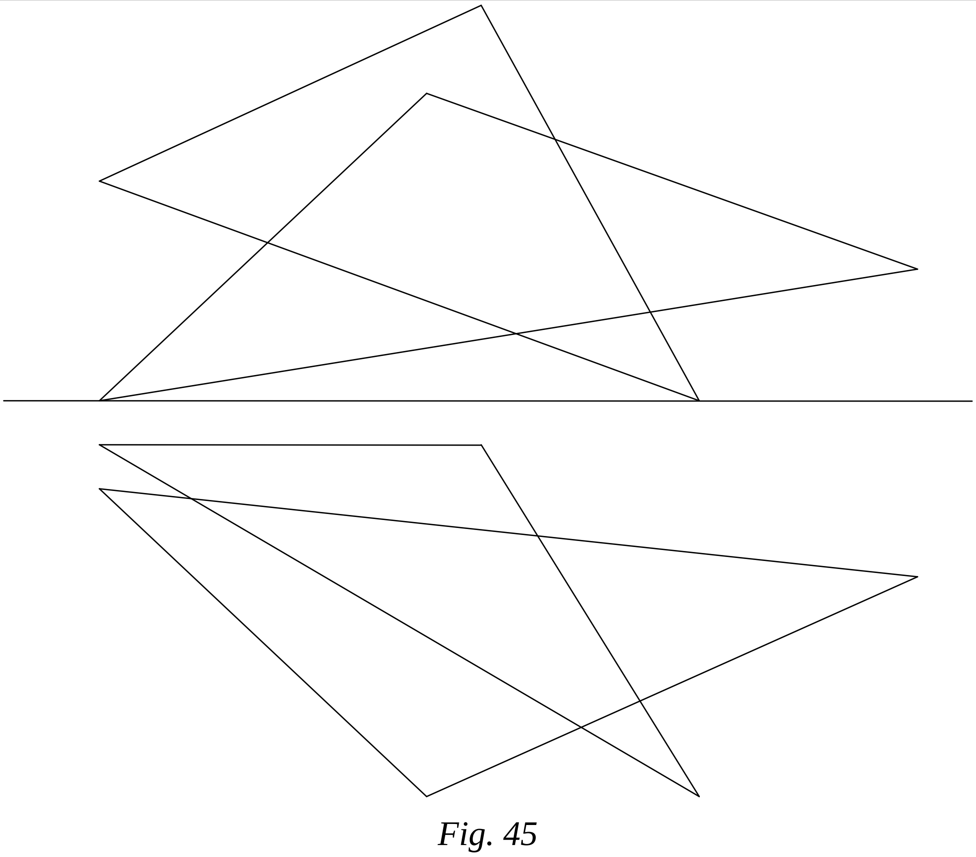


Fig. 45

4.7 METHOD OF REPLACING PLANES OF PROJECTION

Different methods of transformation of orthogonal projections are used to make the solution of metric and positional problems simpler. After such transformations the new projections help to solve the problem by minimal graphic means.

The method of replacing planes of projection consists in the substitution of a plane with a new one. The new plane should be perpendicular to the remaining one. The position in space of the geometric figure remains unchanged. The new plane should be positioned so that the geometric figure has a particular position to it, convenient for solving the problem.

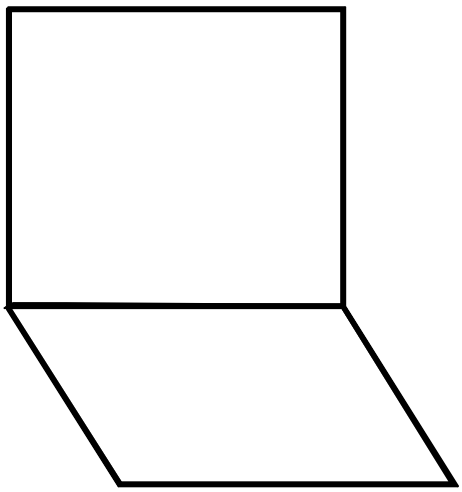


Fig. 46

4.1 Two primary goals of transformation of a straight line

Transform a line of general position:

1. Into a level lines;
2. Into a projecting line.

1. Transform a line of general position into a line parallel to one of the projection planes.

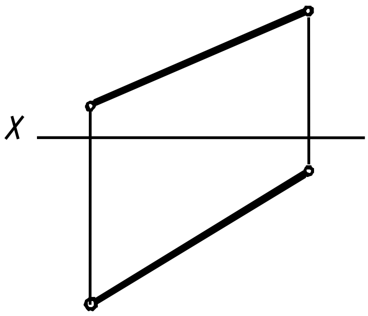


Fig. 47

2. Transform a line parallel to one of the projection planes into a projecting line

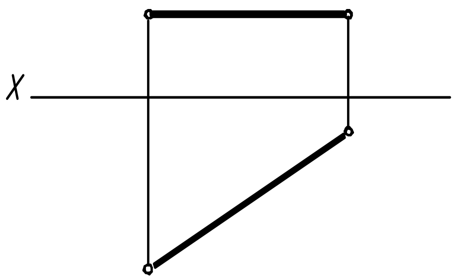


Fig. 48

3. Transform a line of general position into a projecting line

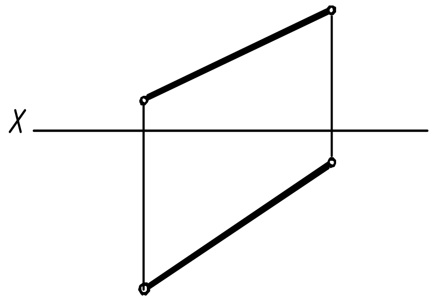


Fig. 49

4.2 Two primary goals of transformation of the drawing of a plane

Transform the general position plane:

1. Into a Projecting plane
2. Into a level planes

1. Transform the oblique plane into a projecting one, i.e. positioned perpendicular to one of the projection planes.

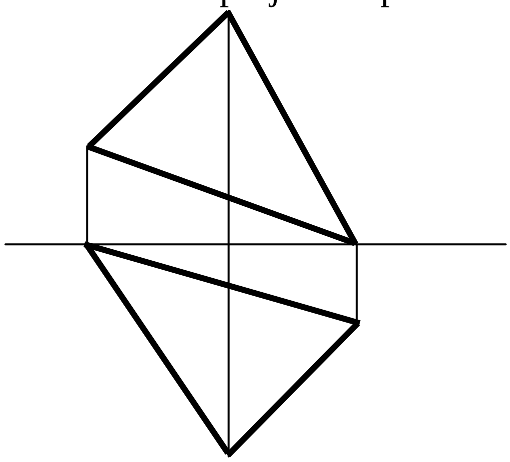


Fig. 50

2. Transform the plane from a projecting plane into a level plane

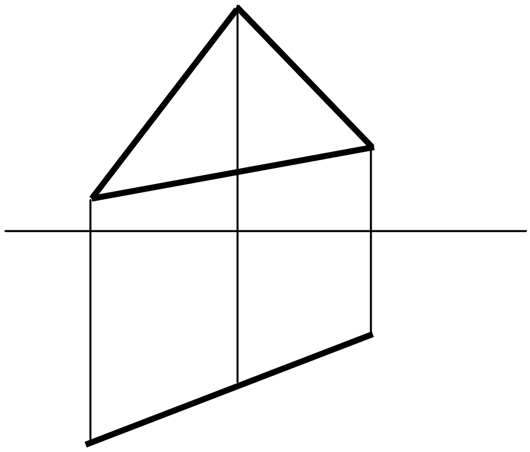


Fig. 51

3. Transform the plane general position a into a level plane

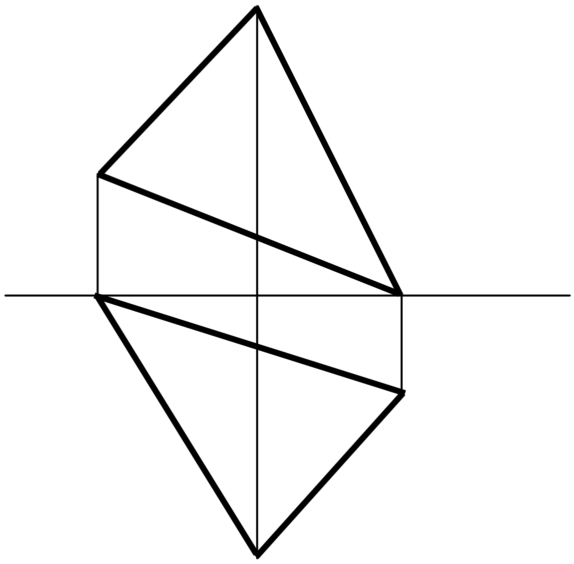


Fig. 52

CHAPTER 5. SURFACES

5.1 DETERMINING AND SPECIFYING SURFACES IN A DRAWING

In descriptive geometry surfaces are referred to as a set of consecutive locations of a moving line.

Classification

5.2 DETERMINING AND SPECIFYING SURFACES IN A DRAWING

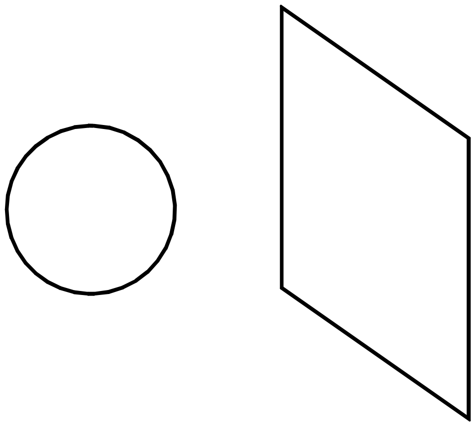


Fig. 54

5.3 RULED SURFACES

Polyhedral Surfaces

A pyramidal surface

A prismatic surface

5.4 A POINT ON THE SURFACE

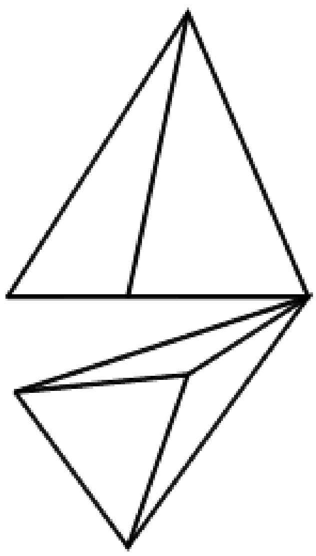


Fig. 55

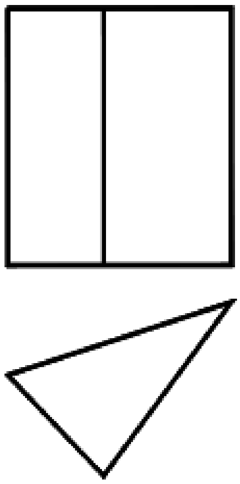


Fig. 56

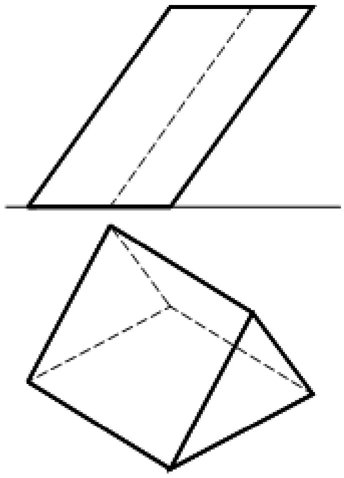


Fig. 57

5.5 A POLYHEDRON CUT BY A PLANE

When polyhedral surfaces are cut by planes we obtain polygons in the section, whose vertices are determined as the points of intersection of the polyhedron edges with a cutting plane.

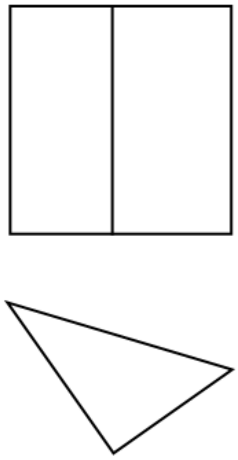


Fig. 58

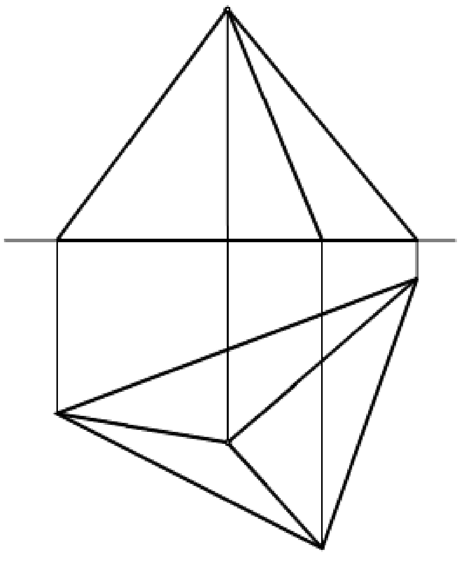


Fig. 59

5.6 CONICAL AND CYLINDRICAL SURFACES. TORSES

Conical Surfaces Cylindrical Surfaces

Torses –

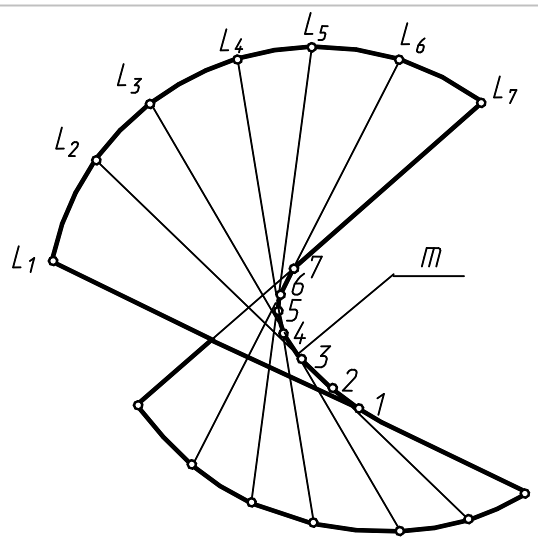


Fig. 60

5.7 ROTATION SURFACES. ROTATION SURFACE CUT BY A PLANE

Rotation surface is a surface described by a curve (or a straight line), rotating on its axis.

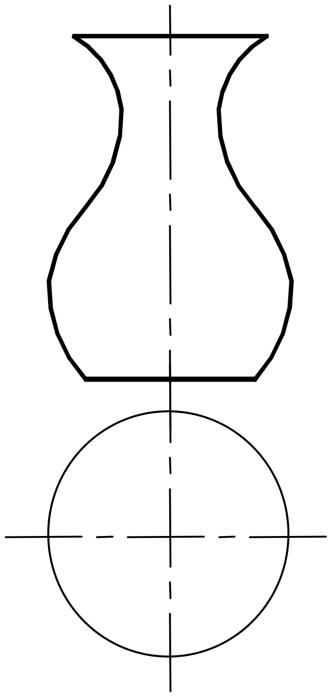


Fig. 61

Cylinder of rotation

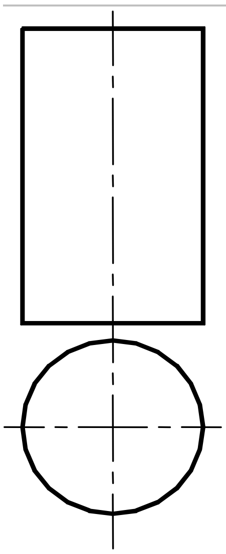


Fig. 62

Drawing a Projection of an Intersection Line of a Cylinder Cut by a Plane

When a cylinder of rotation is cut by a plane parallel to the rotation axis, a pair of straight lines appears in the section. If a section plane is perpendicular to the axis of rotation, the cutting results in a circle. Generally, when a cutting plane is inclined to the rotation axis of a cylinder, an ellipse is obtained by cutting.

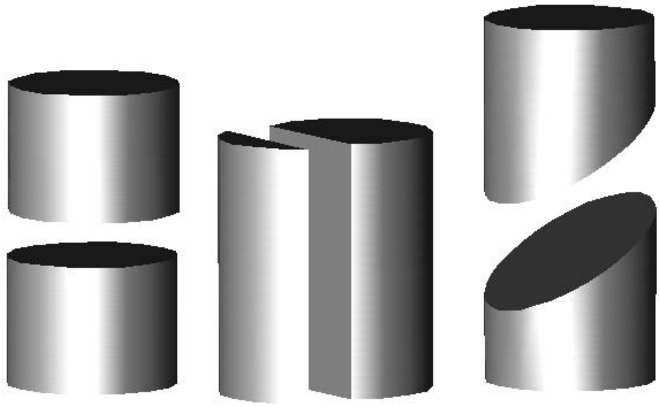


Fig. 63

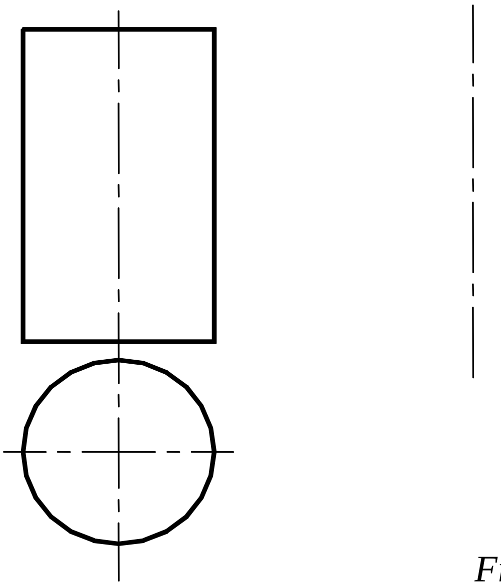


Fig. 64

Cone of rotation

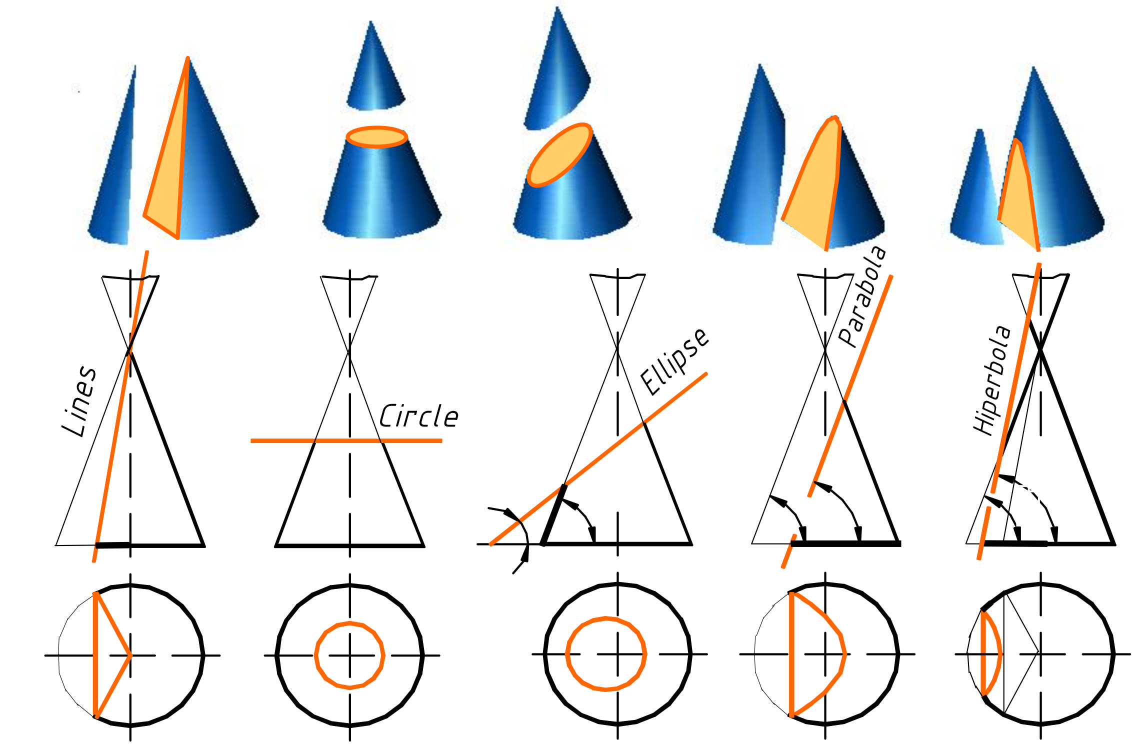


Fig. 65

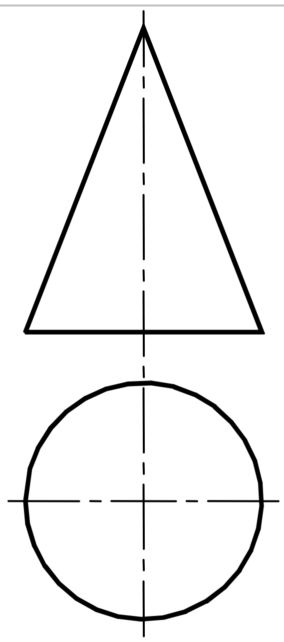


Fig. 66

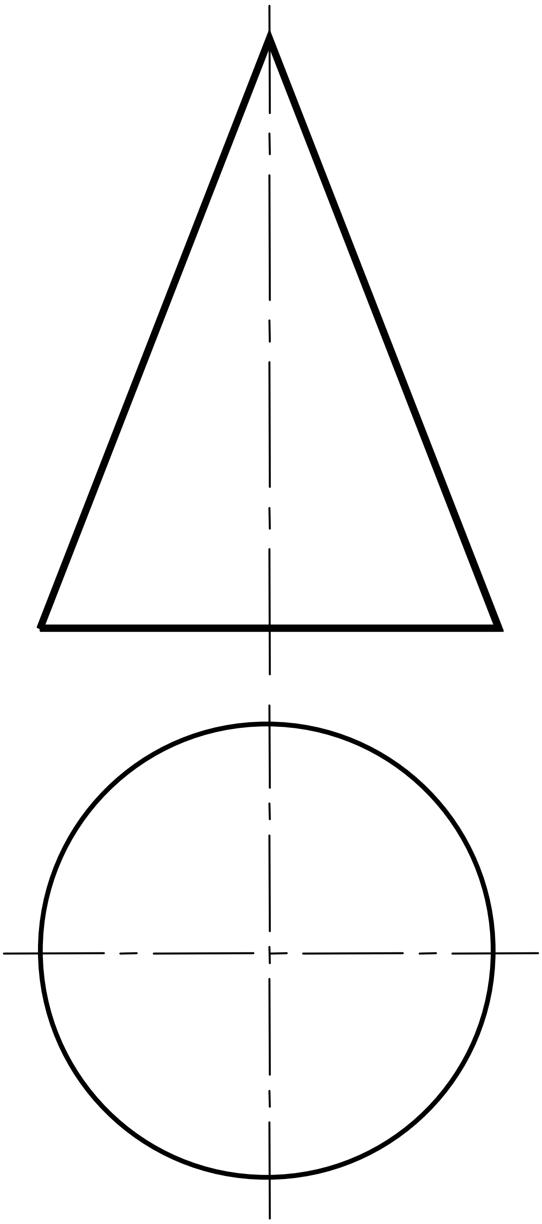


Fig. 67

Ball Surface (a Sphere) – ____________________________________

Ball surface is a surface obtained by rotation of a circle round an axis of its diameter. A plane intersects a sphere always in a circle. This circle may be projected as:

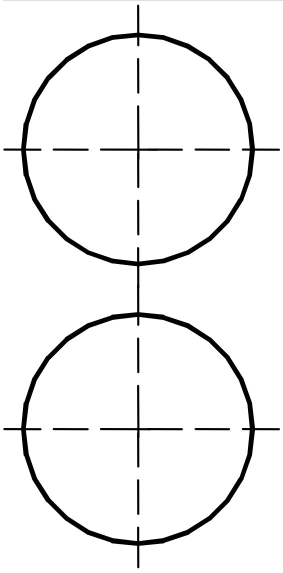


Fig. 68

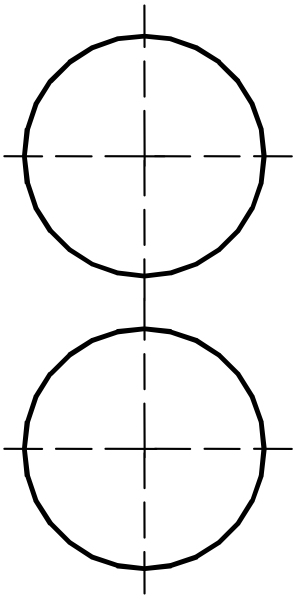


Fig. 69

Cutting a Sphere by a Plane

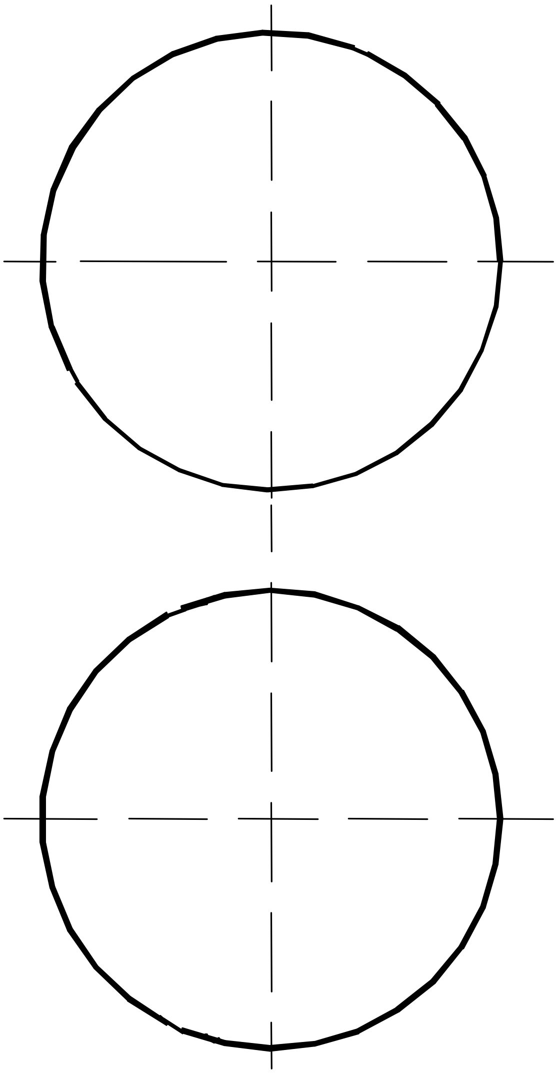


Fig. 70

Torus –

Open torus or a ring-torus Closed torus Self-intersecting torus

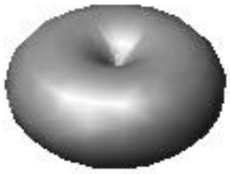


Fig. 71

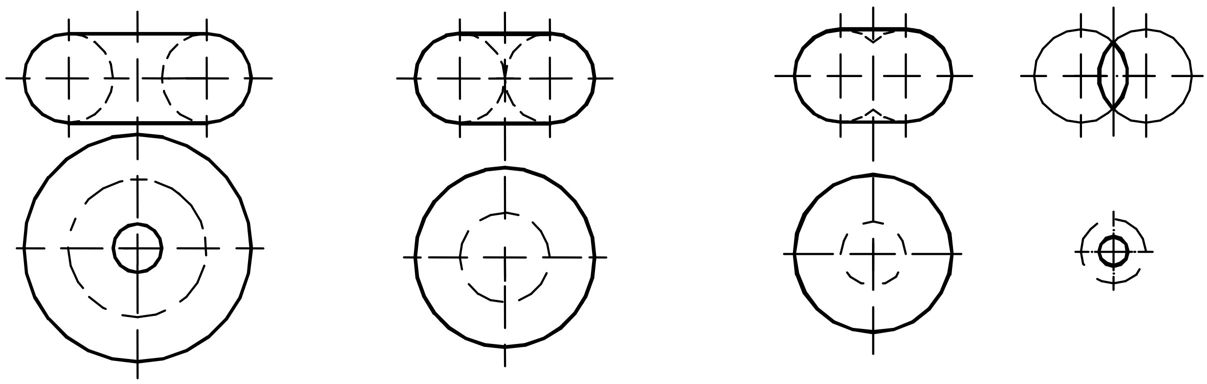


Fig. 72

Hyperboloid of rotation, ellipsoid of rotation, paraboloid of rotation

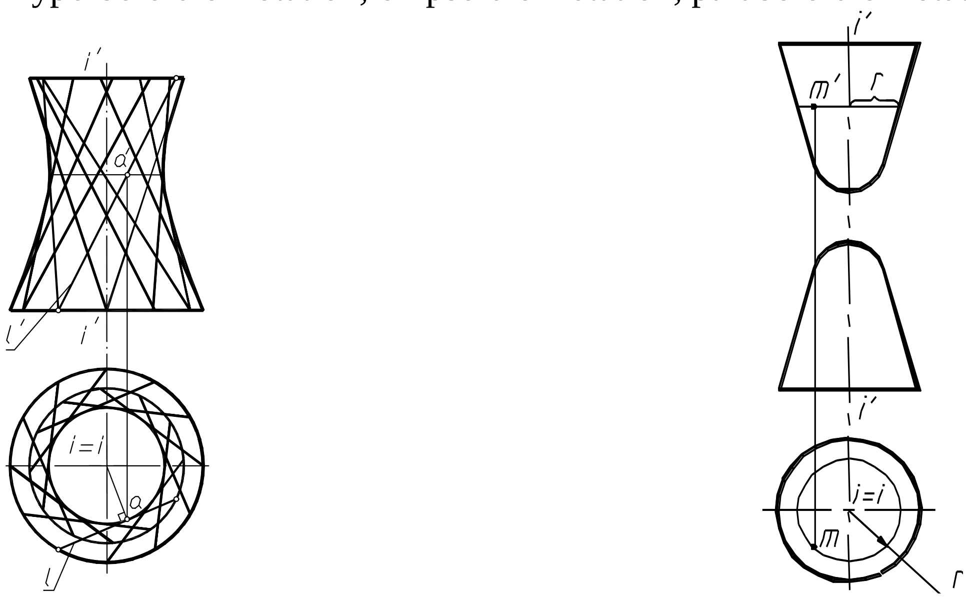


Fig. 73

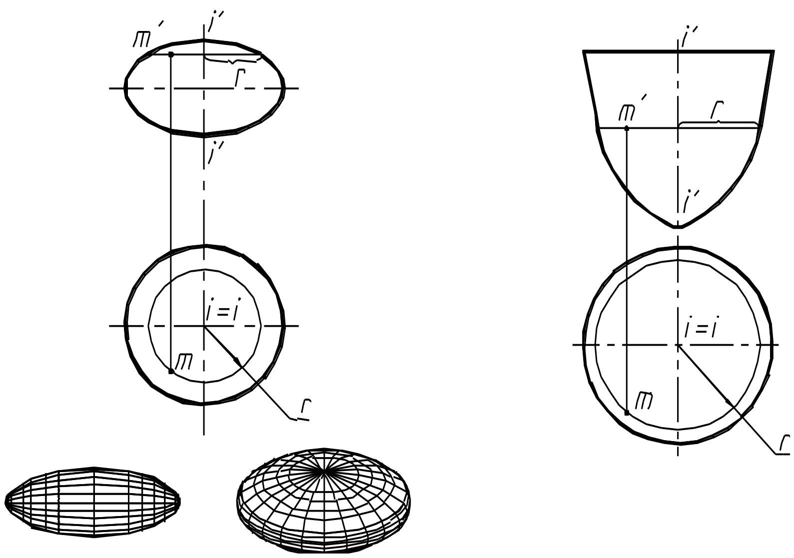


Fig. 74

5.8 SCREW SURFACES.

A screw surface is a surface described by a generatrix at its helical motion. If a generatrix of a screw surface is a straight line the surface is referred to as *a ruled screw surface or a helicoid* (*helice (Fr.)*-a spiral, a spiral staircase). A helicoid may be right or oblique depending on the generating line being perpendicular or inclined to the helicoid axis.

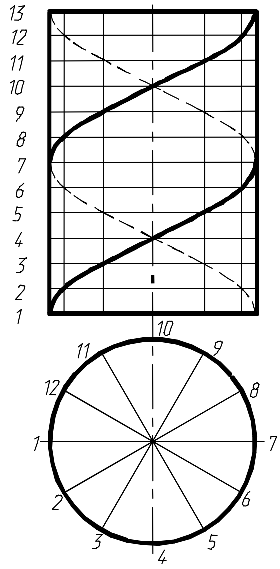


Fig. 75

A few kinds of a ruled screw surface.

A right helicoid is produced by the motion of the linear generatrix *l* along two directrices, one of which is the cylindrical screw line *m*, the other is its axis *i*.Note that in all its positions the line l is parallel to the plane perpendicular to the axis *I* (called a plane of parallelism). Usually one of the projection planes is taken for the plane of parallelism. The generatrix *l* of the right helicoid intersects the screw axis *I* at a right angle. The right helicoid may be referred to as one of the conoids and called a *screw conoid*.

An oblique helicoid is distinguished from a right one by its generatrix *l* intersecting the helicoid axis at a constant angle α different from the right angle. In other words, the generatrix *l* of an oblique helicoid slides along two directrices, one of which is the cylindrical screw line *m*, the other - its axis *I*. Note that in all its positions the line *l* is parallel to the generating lines of a certain cone of rotation.

The angle of this cone included between the generating line and the axis parallel to the helicoid axis, is equal to φ. It is called a director cone of an oblique helicoid.

5.9 MUTUAL INTERSECTION OF SURFACES

The line of intersection of two surfaces

As the surfaces-mediators very often planes or ball surfaces (spheres) are used.

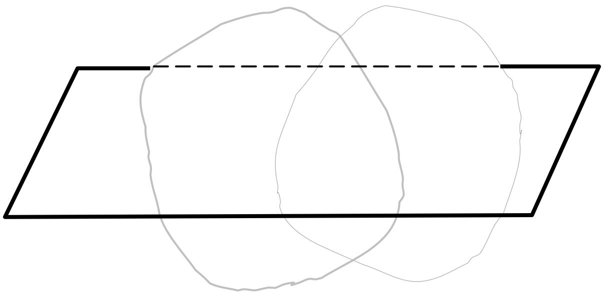


Fig. 76

Method of Auxiliary Cutting Planes

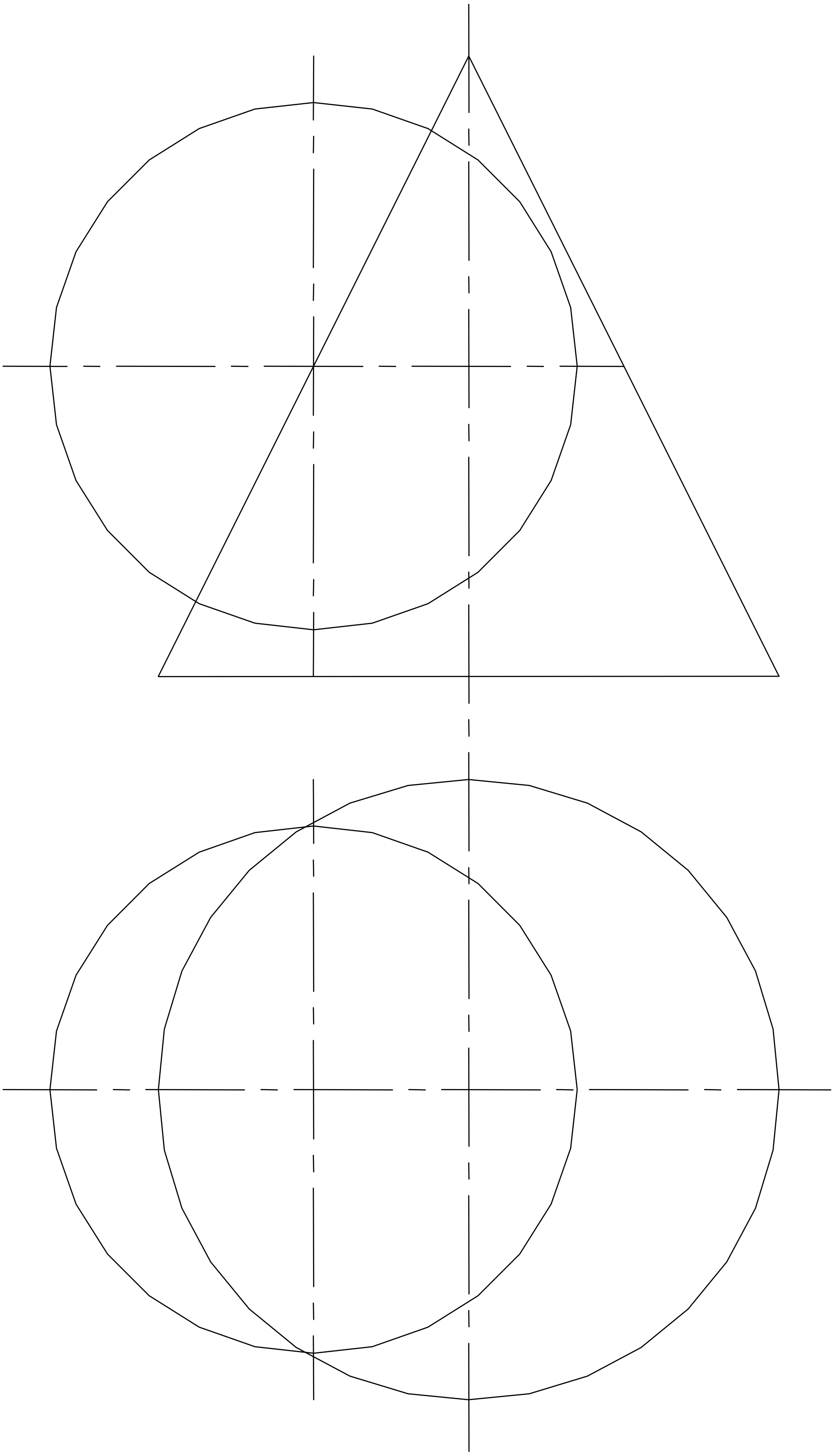


Fig. 77

Coaxial surfaces

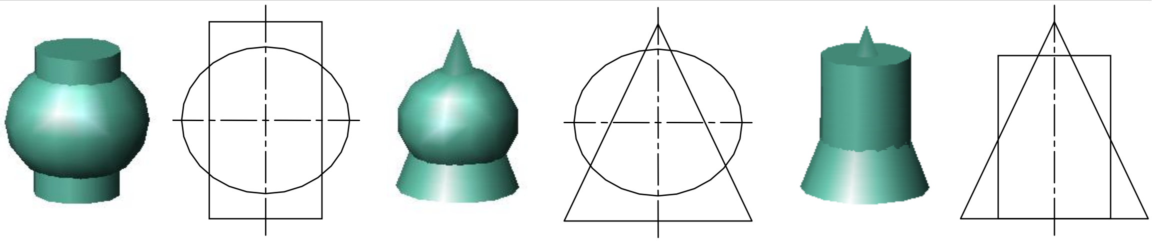


Fig. 78

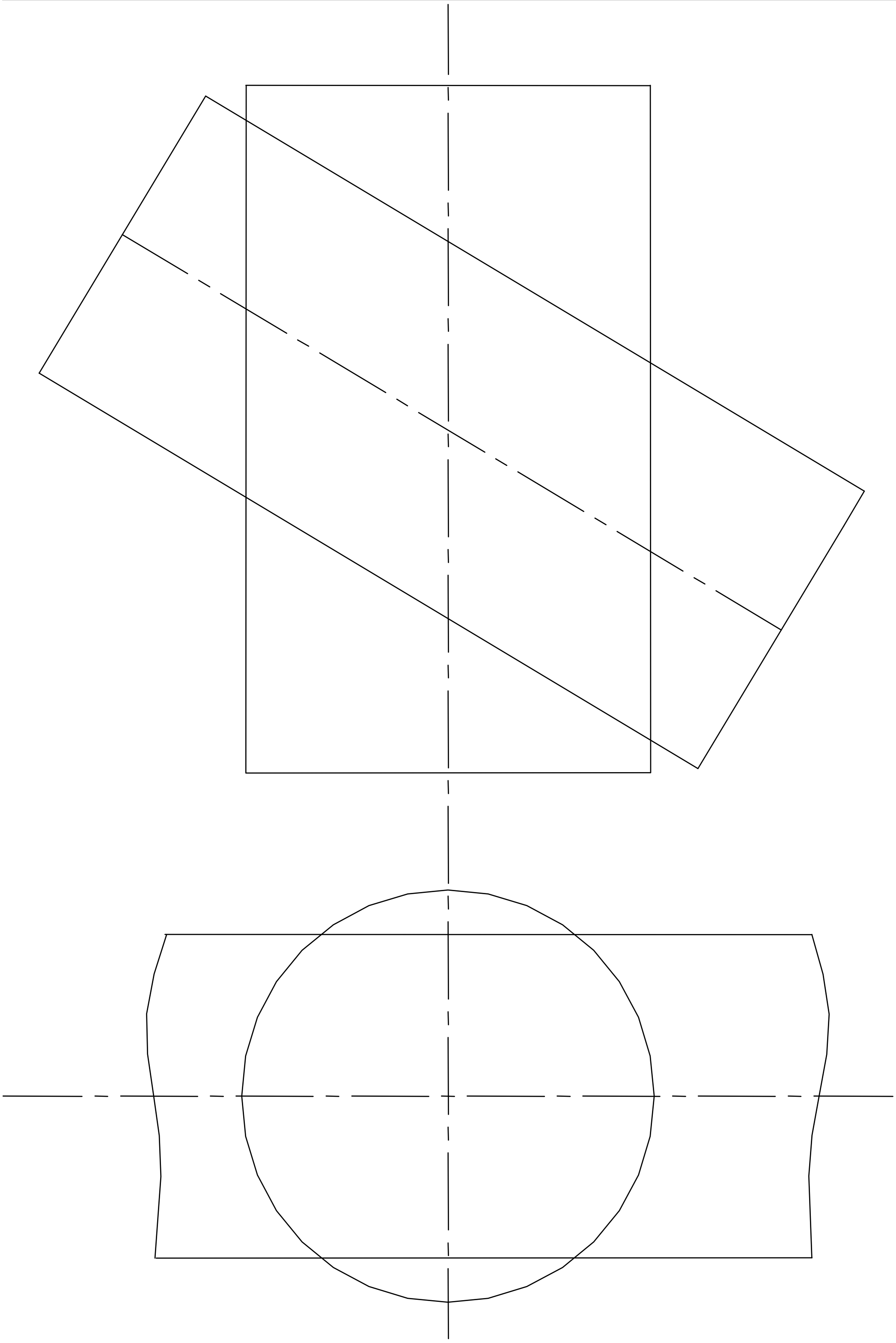


Fig. 79

Possible Cases of Intersection of Curved Surfaces

There are four variants of two surfaces meeting.

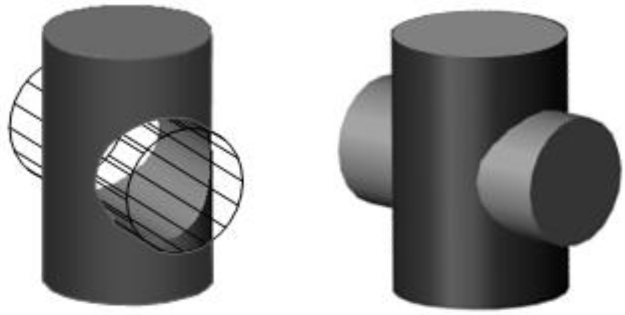


Fig. 80

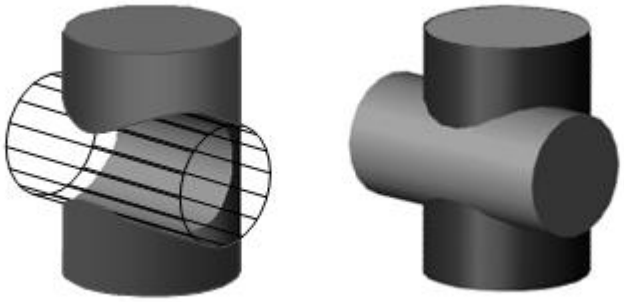


Fig. 81

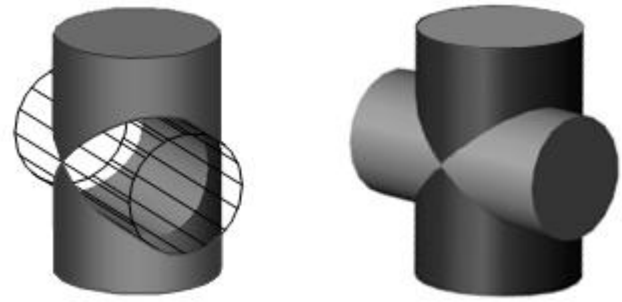


Fig. 82

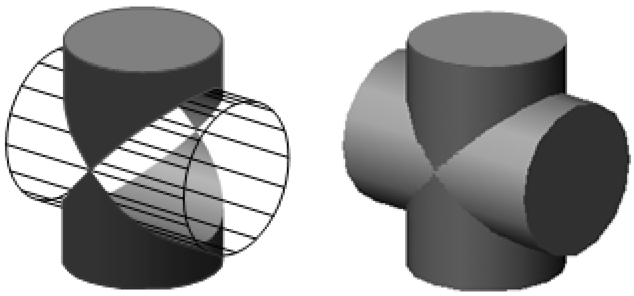


Fig. 83

Intersection of the Surfaces of the Second Order

Monge theorem

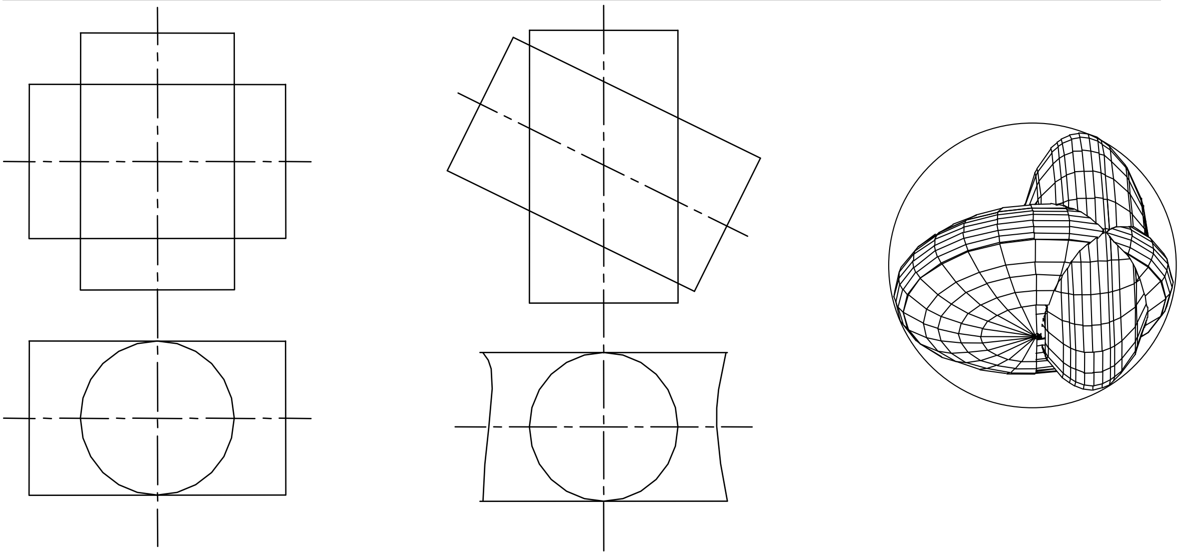


Fig. 84

T*heorem two surfaces of the second*

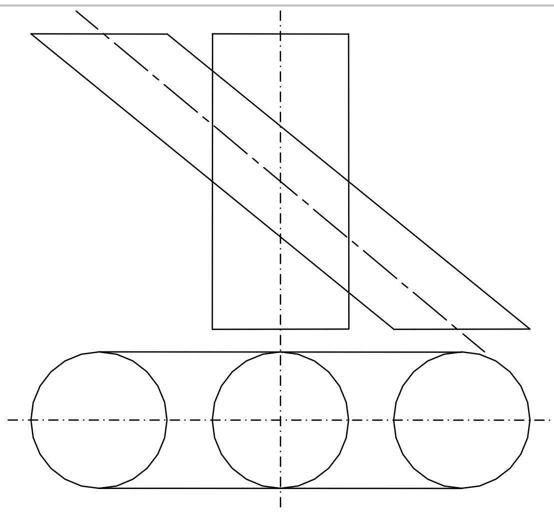


Fig. 85

CHAPTER 6. AXONOMETRIC PROJECTIONS

A complex drawing is rather simple and easily measured, although it is hard sometimes to imagine an object in space by means of it. It is often necessary to have in addition to it a drawing of pictorial view, which may be obtained by projecting an object and its co-ordinate axes onto one plane. Then one projection will provide a visual and metrically distinguished image of the object. Such kinds of an object representation are called the axonometric projections.

The method of axonometric projection consists ____________________

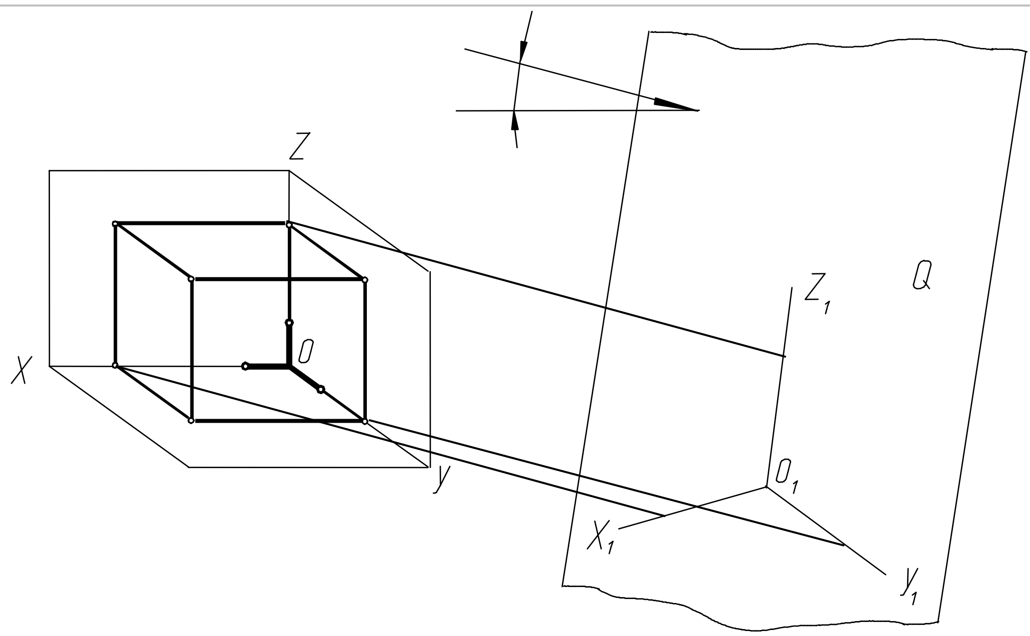


Fig. 86

The principal theorem of axonometric was declared by the German mathematician K.Pohlke in 1853:

Isometry

Dimetry

The cross-hatching lines in axonometric projections are drawn parallel to one of the diagonals of the squares lying in the corresponding co-ordinate planes, the sides of which are parallel to the axonometric axes.

а) isometry *б)* dimetry

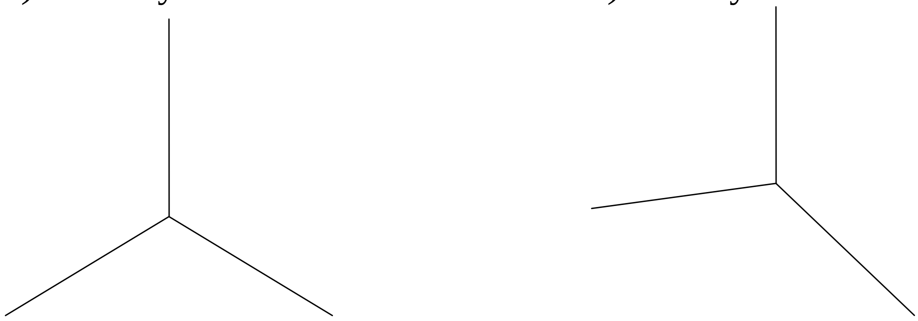


Fig. 87

Representation of a Circle and a Sphere in Axonometry

а) isometry

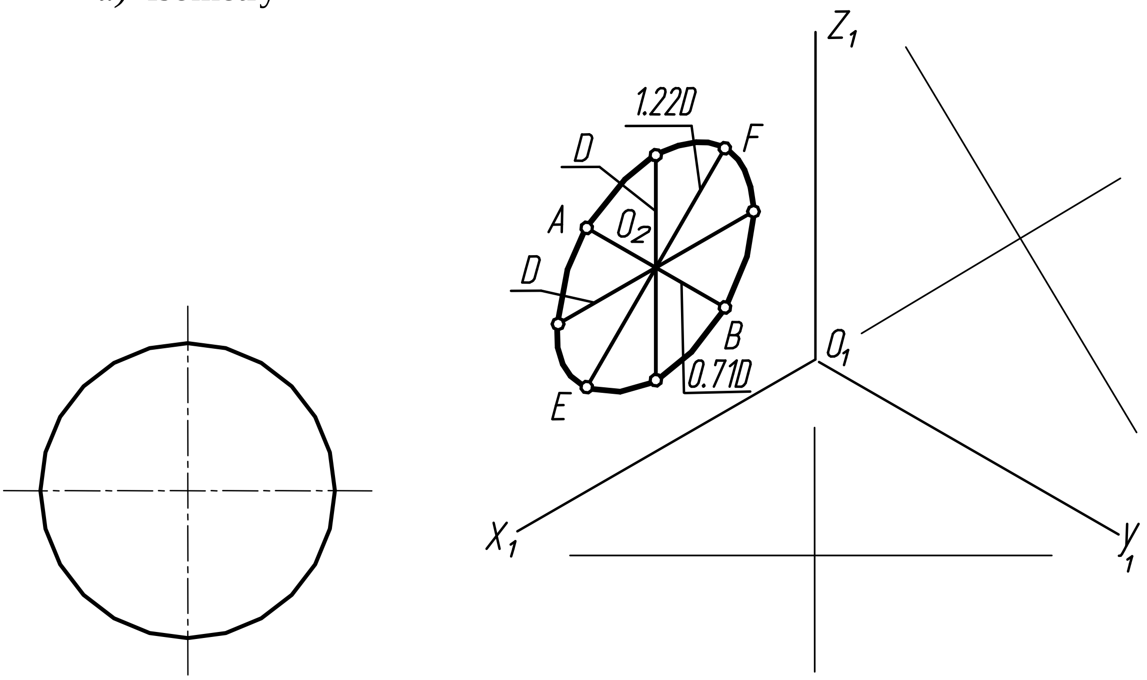


Fig. 88

б) dimetry

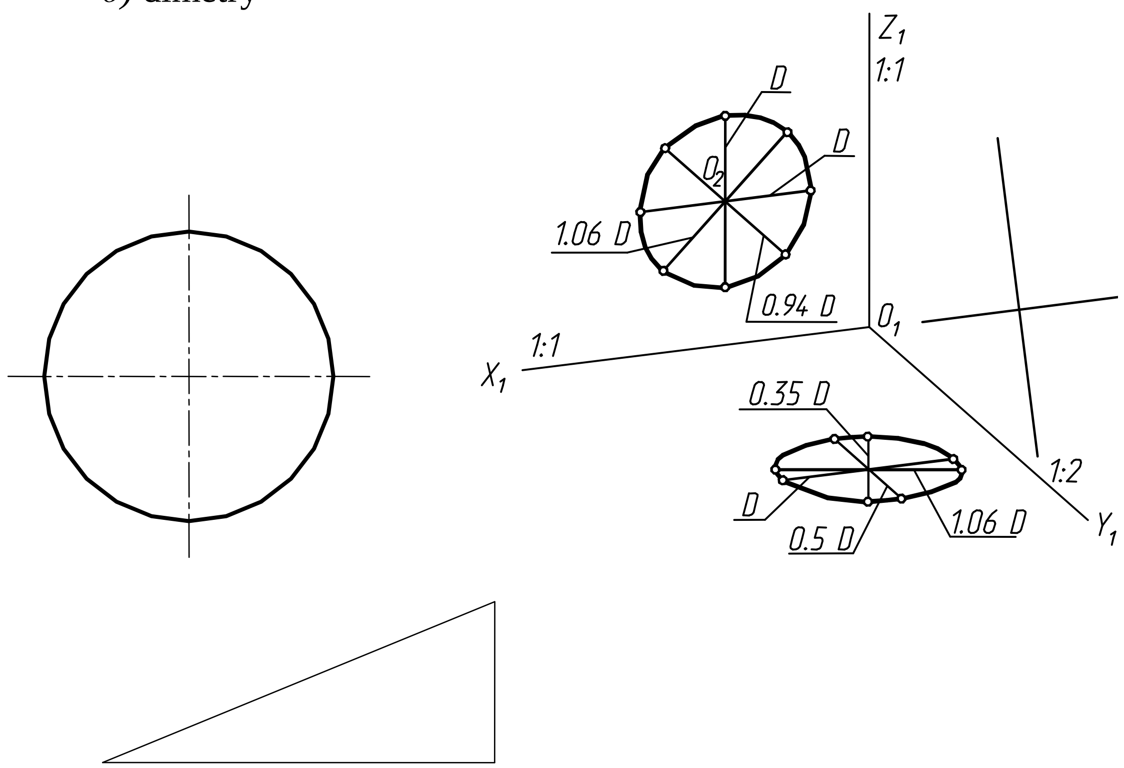


Fig. 89

Representation of a Sphere and of a torus in Axonometry

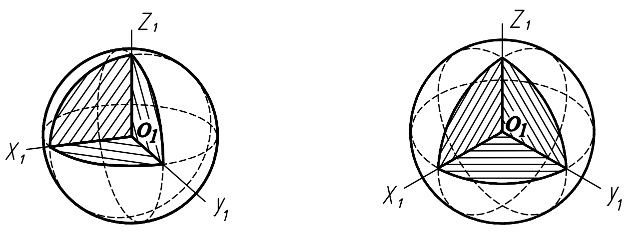


Fig. 90

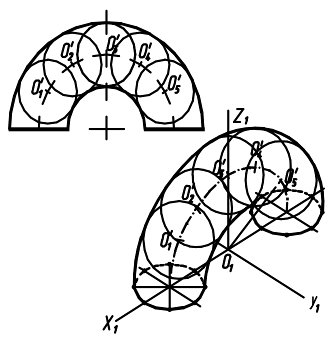


Fig. 91

When a sphere is constructed by the true values of distortion, its axonometric projection is a circle of the diameter equal to the diameter of the sphere. When a sphere is constructed by reduction, the diameter of the circle enlarges in conformity with the reduction coefficient: in isometry it is 1.22; in dimetry - 1.06. Fig. 89-91 shows an isometric projection of a torus produced by means of the auxiliary spheres inscribed in it

Oblique Axonometry. The Frontal Dimetric Projection

A detail in the frontal isometry should be positioned relative to the axes so that the complex plane figures, circles and arcs of the plane curves are located in the planes parallel to the frontal projection plane. In this case their representations are distortionless and the drawing work is simpler to do. The location of the axonometric axes is similar to that of the frontal isometric projection. It is admissible to apply the frontal dimetric projections with the angle of inclination of the axis y_1 of 30° and 60°. The distortion coefficient on the axis y_1 is *0.5*, on the axes x_1 and z_1 it is *1*. The circles lying in the planes parallel to the frontal projection plane *V* are projected on the axonometric plane as circles, those lying in the planes parallel to *H* and *W* planes - as ellipses. The major axis of ellipses *2* and *3* is *1.07*, the minor one - *0.33* of the circle diameter. The major axis A_1B_1 of ellipse *2* is inclined to the horizontal axis x_1 at the angle of $7°14'$, the major axis of ellipse *3* - at the same angle to the vertical axis z_1.

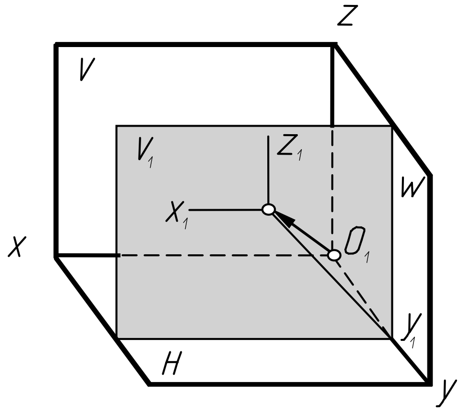


Fig. 92

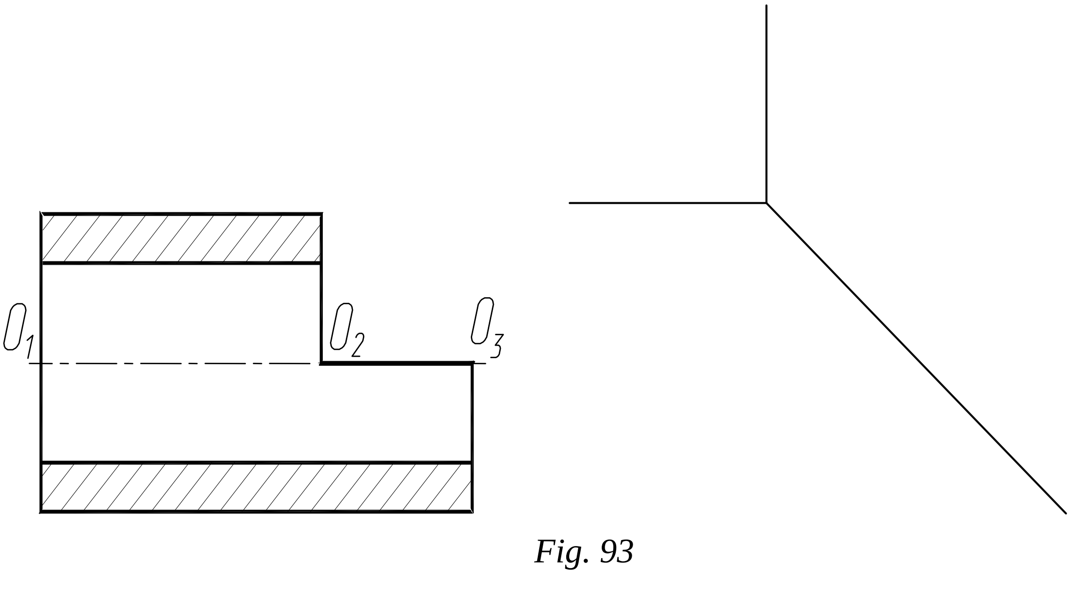


Fig. 93

CHAPTER 7. REPRESENTATIONS

7.1 THE VIEWS

View (elevation) - ____

____

____

View:

- ______________________________
- ______________________________
- ______________________________

____

____

____

Projecting in First Angle Projection (E-Method)

____

____

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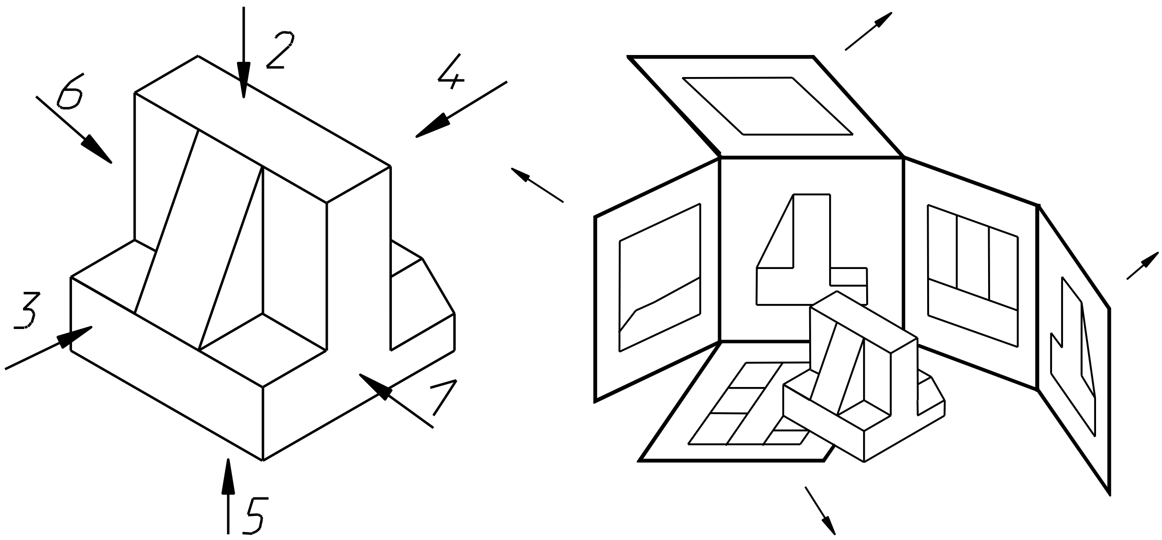

Fig. 94

The principal views – ____

____

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The principal representation view

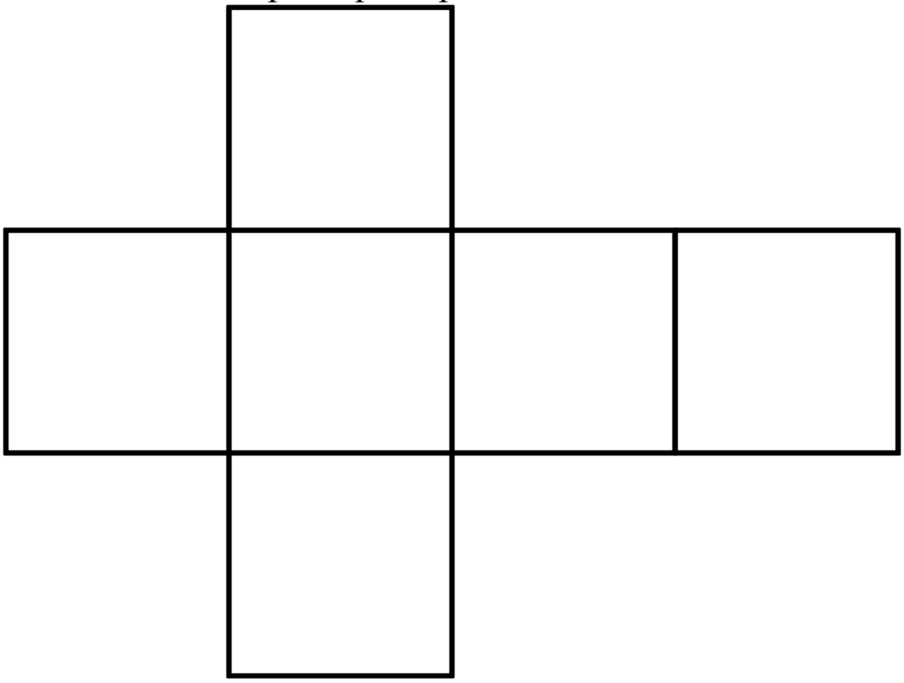

Fig. 95

The main kind ______________________________

Projective communication of kinds

The Designation of principal views in the absence of projective communication

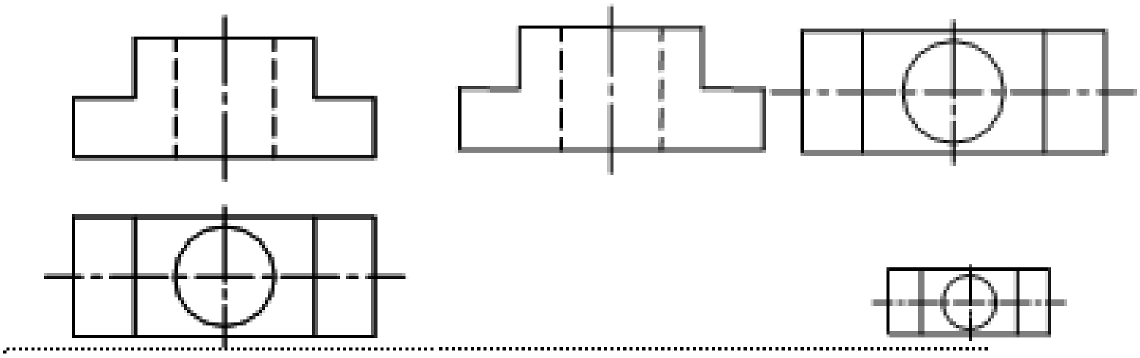

Fig. 96

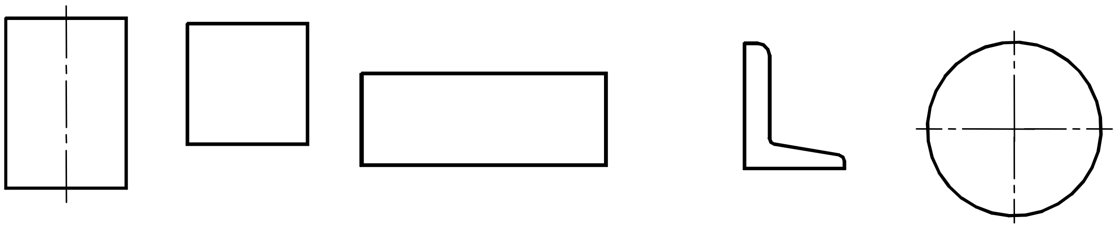

Fig. 97

Additional view

Additional view

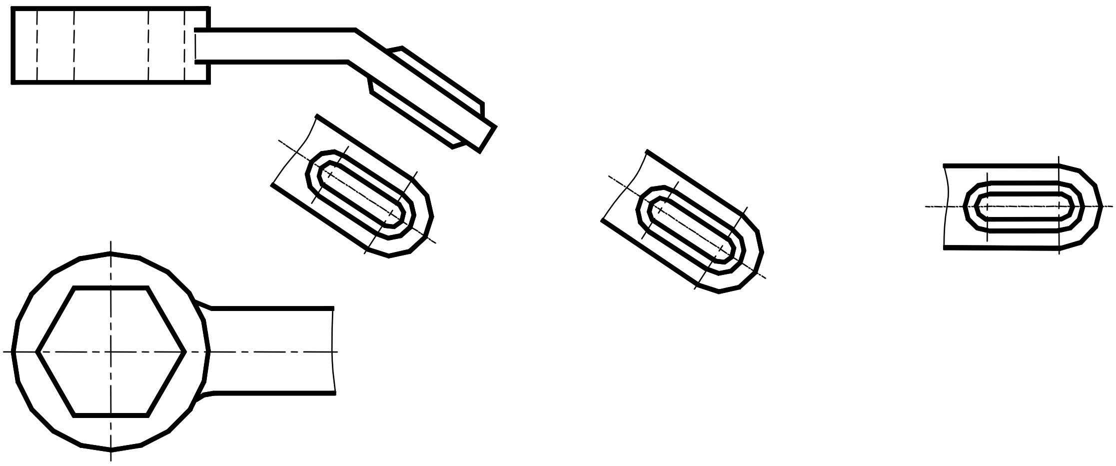

Fig. 98

Detail (partial) view

Detail (partial) view

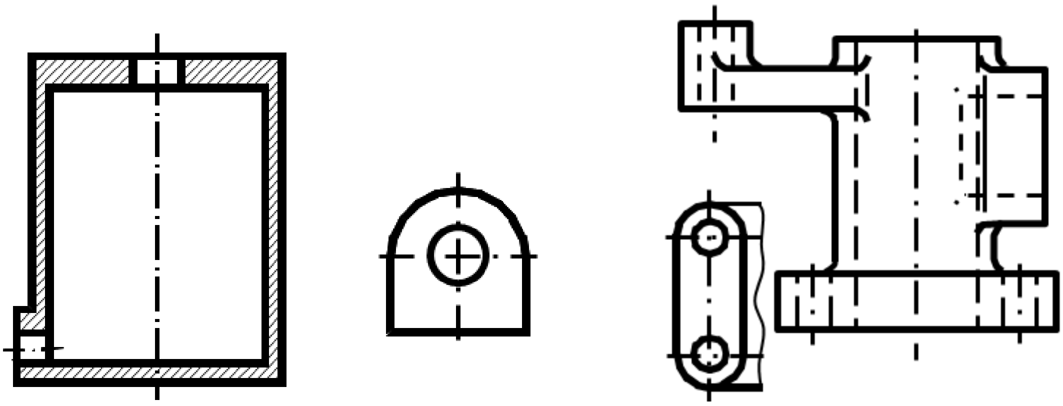

Fig. 99

7.2 SECTIONAL VIEW

Sectional View -

Sectional View:

Horizontal

Vertical

Frontal

Profile

Oblique

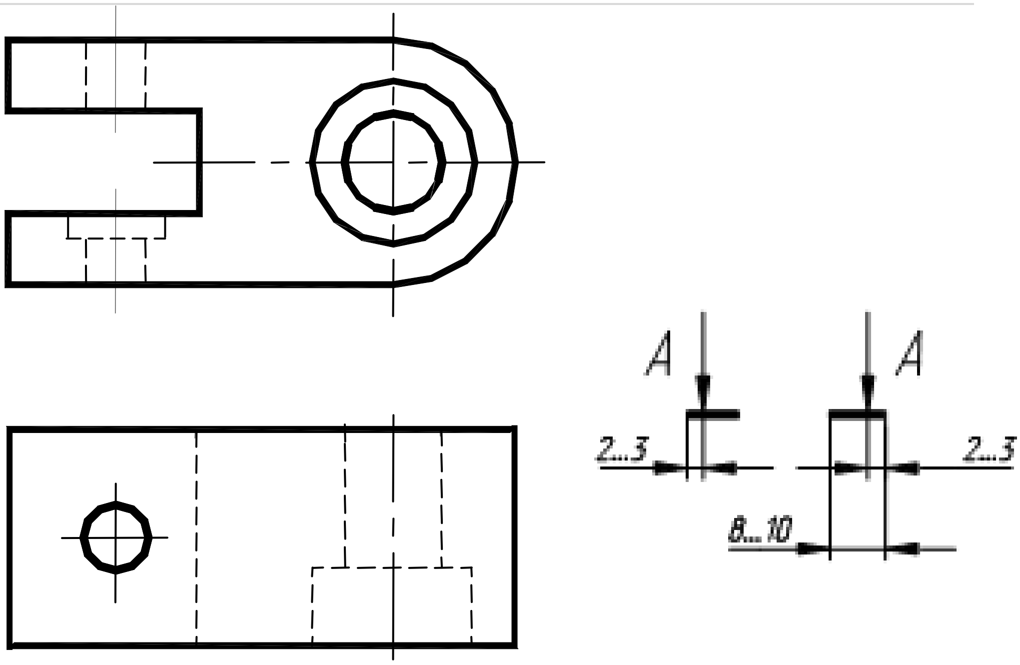

Fig. 100

Complex Sectional View

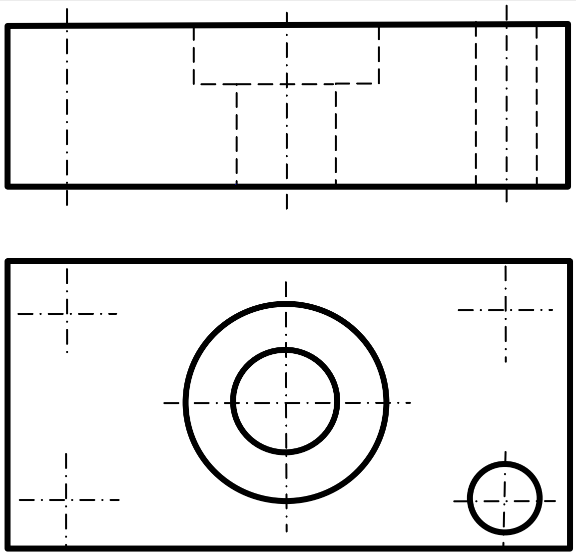

Fig. 101

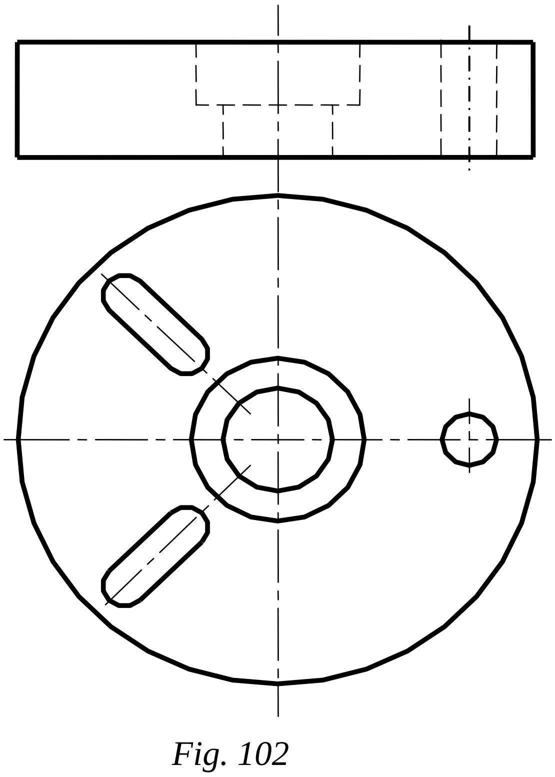

Fig. 102

7.3 SECTION

Section -

Removed section   Covering section

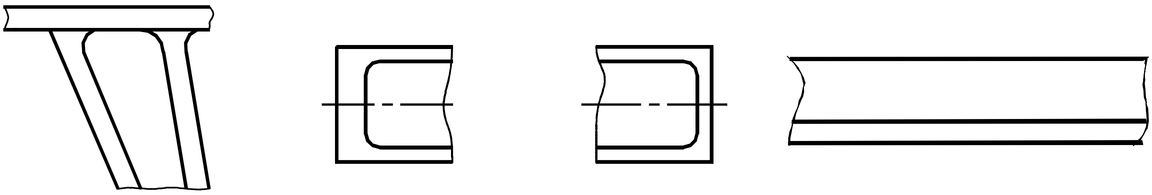

Fig. 103

7.4 REMOVED VIEW

Removed view

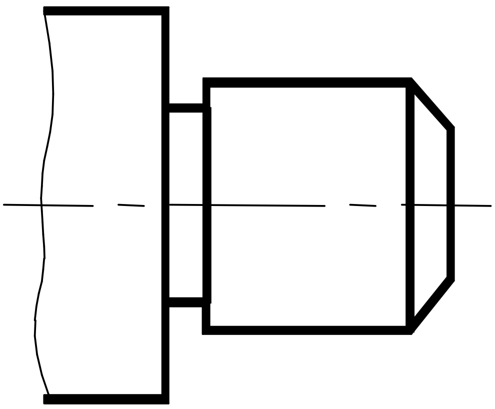

Fig. 104

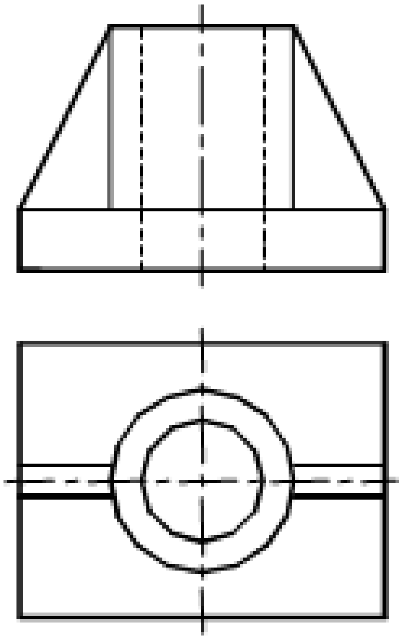

Fig. 105

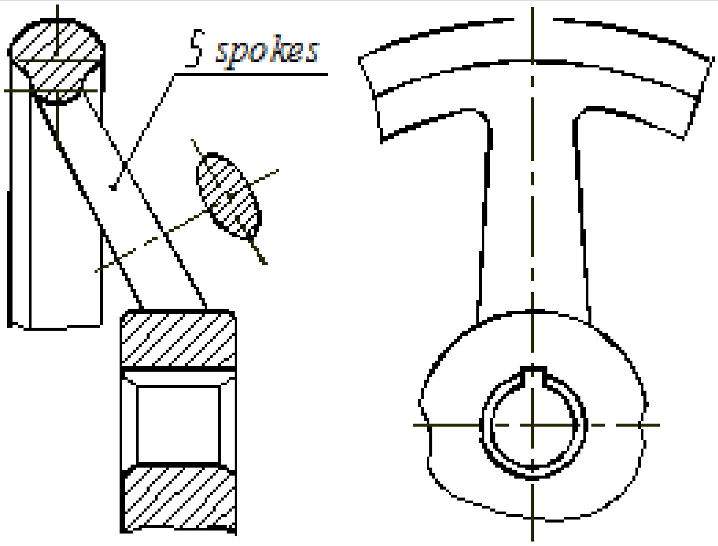

Fig. 106

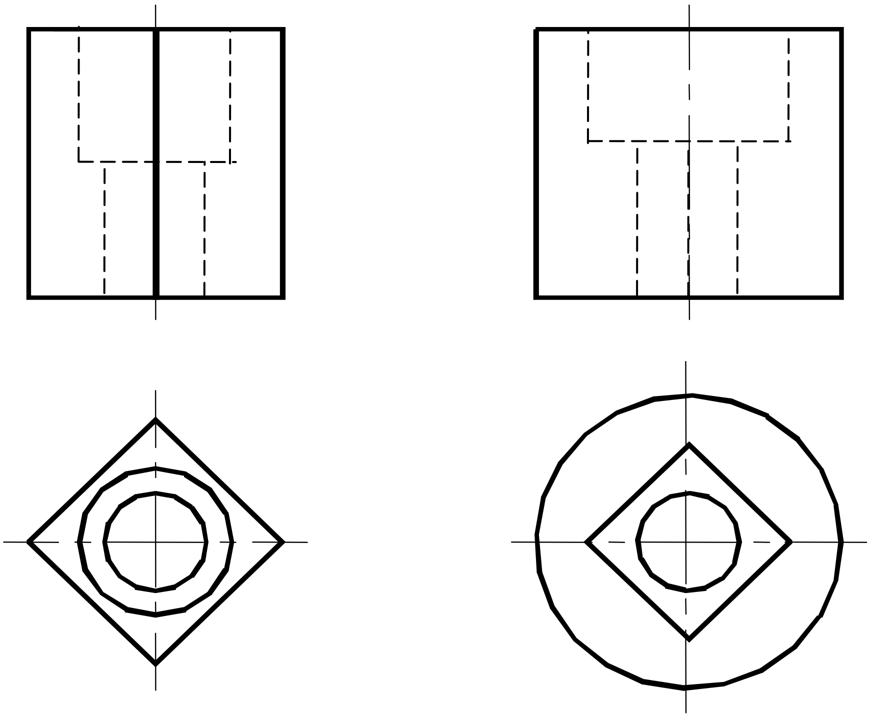

Fig. 107

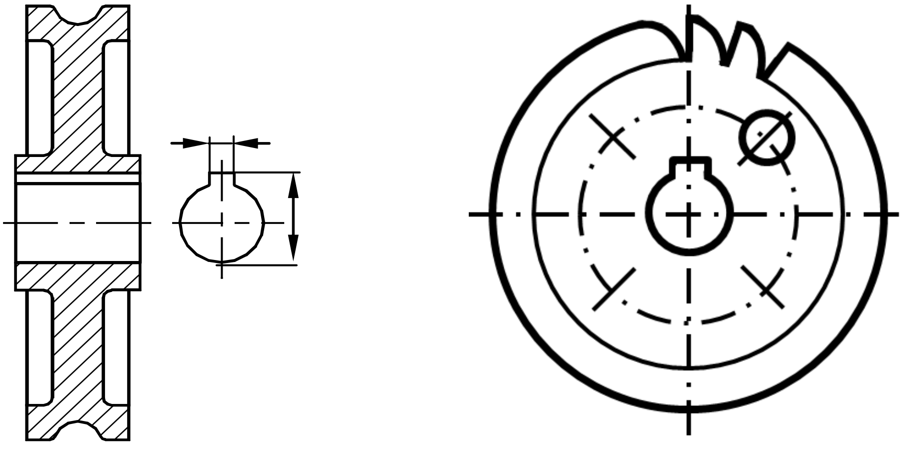

Fig. 108

CHAPTER 8. DIMENSIONING

When a drawing is made, dimensioning is of vital importance since one can determine the size of an object represented only by its dimensioning, whatever the scale is and however accurately the drawing is completed.

When dimensioning a drawing, it is very important to specify the dimensions correctly in accordance with an object's application and the conditions of its manufacture.

Dimensioning of a drawing is completed with:

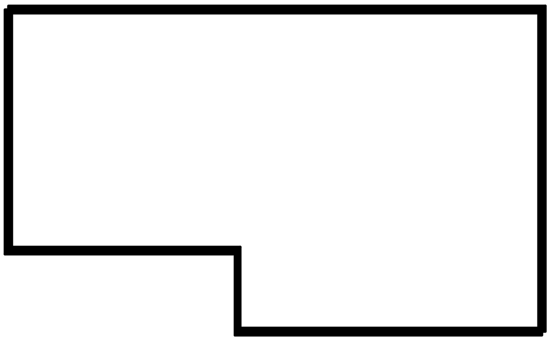

Fig. 109

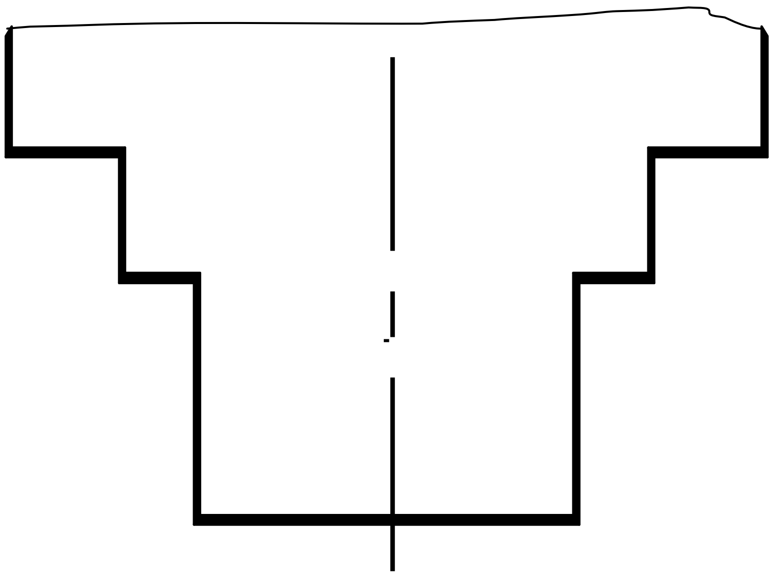

Fig. 110

Ways of dimensioning

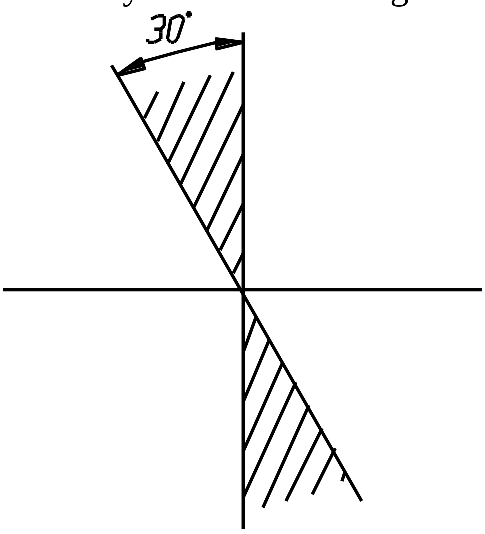

Fig. 111

When printing a group of adjacent small dimensions, replace the arrowheads by clearly **printed dots or hatching lines on the extension lines**

Fig. 112

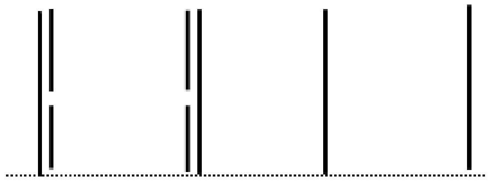

Fig. 113

Dimensioning angles

The angles are dimensioned in degrees, minutes and seconds, the units should be designated.

When dimensioning angles, draw the dimension lines with a compass; the point of the compass should be on the point of the angle.

In the area above the horizontal axis line dimension figures are placed on top of dimension **lines from the side of convexity**, in the area below the horizontal axis line dimension figures are placed **from the side of concavity**.

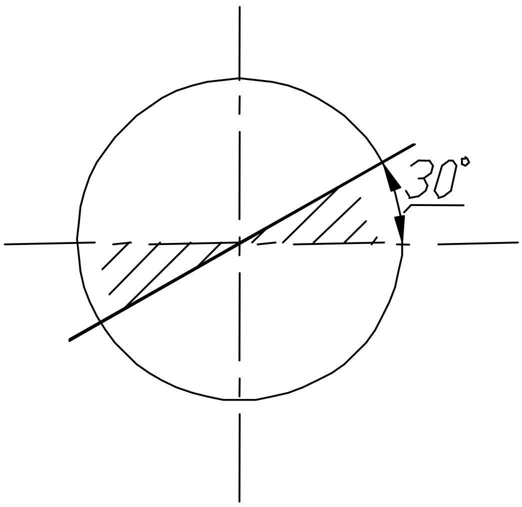

Fig. 114

Dimensioning of radiuses

Radius is denoted by the letter R placed in front of the dimension, e.g. R20. There are no other symbols or signs between the letter R and a dimension.

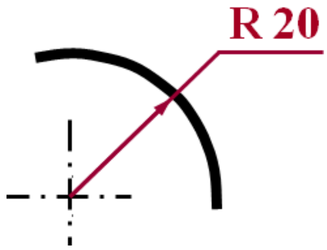

Fig. 115

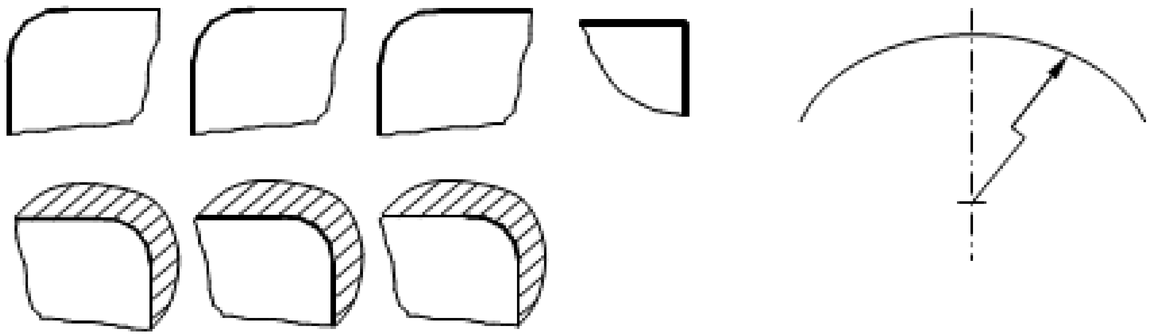

Fig. 116

Note: Radii specify the arcs which round-off the outline, and also most of the arcs are of 180° and less.

Full circles and arcs of more than 180° are specified only by diameters, even though they may have breaks.

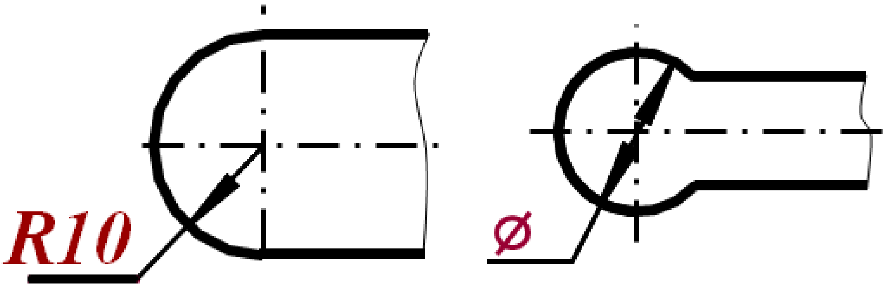

Fig. 117

Dimensioning of diameters

Diameter is denoted by the symbol ∅ placed in front of the dimension, e.g. ∅ 50.

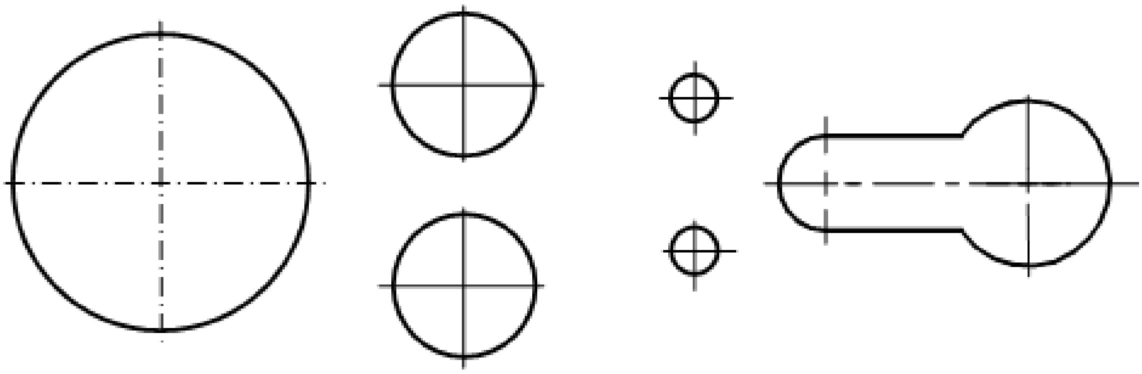

Fig. 118

Types of the sizes

Forming

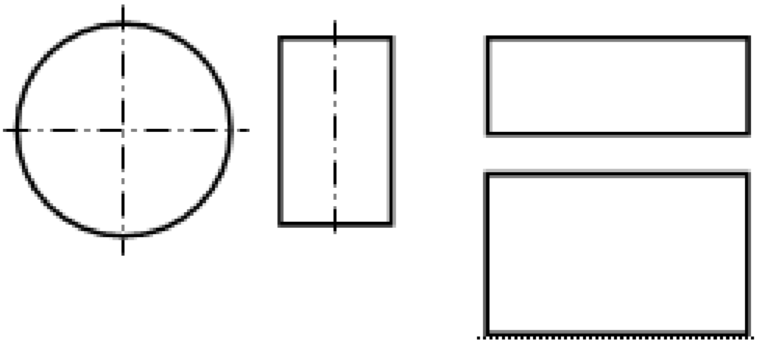

Fig. 119

Coordinating

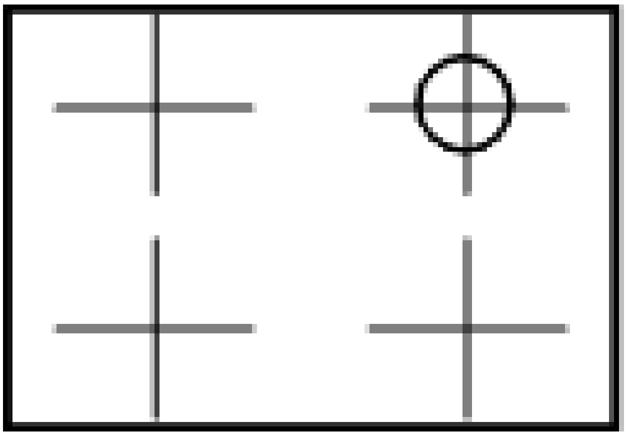

Fig. 120

Dimensional lines with breakage

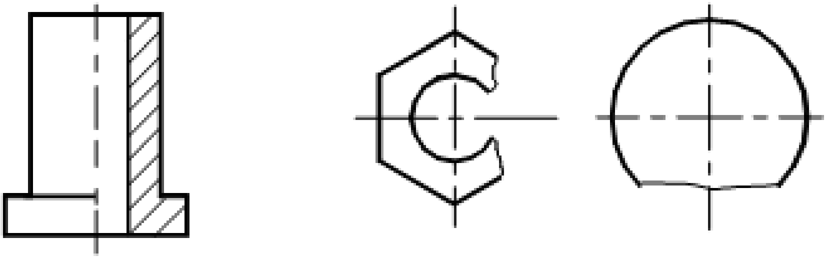

Fig. 121

Dimensioning According to The Base

There are four types of dimension base:

A Constructional base

A Technological base

A Measuring base

An Assembling base

An Assembling base

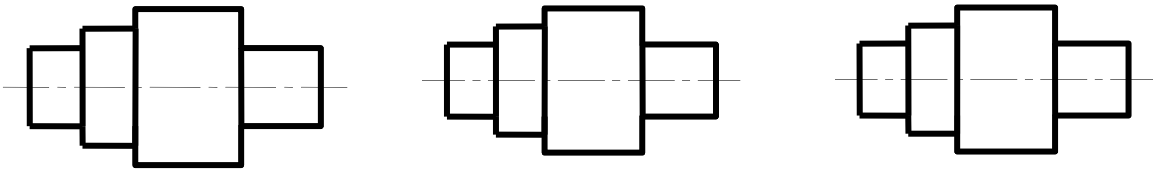

Fig. 122

Referential dimensions are the dimensions which cannot be completed on a given drawing. But they should be shown to make the drawing easier to use. They are usually denoted by the symbol * and the following note printed in the technical requirements: “*Referential Dimensions”.

Simplifications in Dimensioning

There are some simplifications allowing us to reduce the number of dimensions on a drawing.

For example, dimensions of two symmetrically positioned elements (except holes) are put on only once (no numbering shown), grouped in one place.

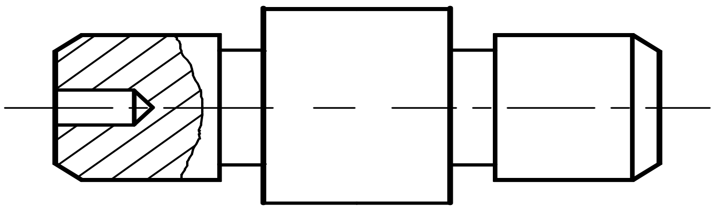

Fig. 123

When several elements, similar in the form and size, are dimensioned, the dimensions of only one of them is shown and the number of the elements.

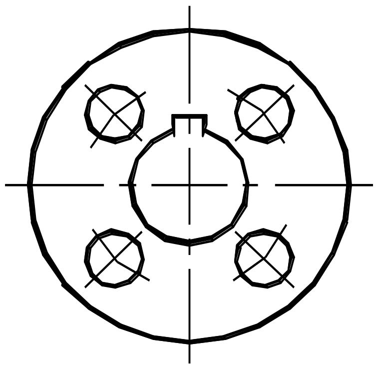

Fig. 124

Chamfers dimensioning

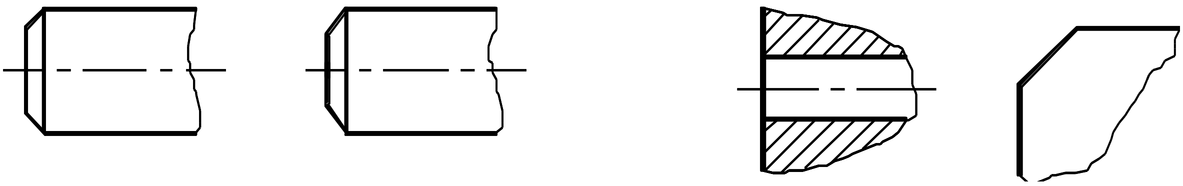

Fig. 125

QUESTIONS

QUESTIONS TO CHAPTER PROJECTION METHOD

1. What is the method of construction of the central projection of a point?
2. In what case is the central projection of a straight line represented by a point?
3. What is the essence of the parallel projection method?
4. How is the parallel projection of a line constructed?
5. Can the parallel projection of a line be represented by a point?
6. What are the positions of a point and a line projections if the point lies on the line?

QUESTIONS TO CHAPTER THE POINT AND THE STRAIGHT LINE

1. What location relative to the projection planes causes a line to be called "a line of general position"?
2. What is the locus of a line in the system of the planes *H*, *V*, *W* given all three projections of the line are equal in length?
3. How do we construct a profile projection of a line of general position given its frontal and horizontal projections?
4. What positions of a straight line in the system of *H*, *V*, *W* planes are considered to be the particular ones?
5. What is the position of a frontal projection of a line-segment given its horizontal projection is equal to the line-segment proper?
6. What is the position of a horizontal projection of a line-segment given its frontal projection is equal to the line-segment proper?
7. What is referred to as "the trace of a straight line on a projection plane"?
8. Which coordinate is equal to zero:
   a) for a frontal trace of a line;
   b) for a horizontal trace of a line?
9. What is the locus of a horizontal projection of a straight line frontal trace ?
10. What is the locus of a frontal projection of a straight line horizontal trace ?
11. How are two skew lines denoted in the system of *H*, *V* planes?
12. What can you say about the intersection point of the projections of two skew lines?
13. What property of parallel projection refers to the parallel lines?
14. Is it possible to determine parallelism of two profile lines by a drawing in the system of *H*, *V* planes?
15. In what case is a right angle projected as a right angle?

16. Can a projection of an acute or obtuse angle, one arm of which is parallel to a projection plane, be equal to the given angle in space?
17. How do we construct right triangles in a drawing in order to determine the length of a segment of a line of general position and its inclination angles to the projection planes *H* and *V*?

QUESTIONS TO CHAPTER REPRESENTATION OF A PLANE IN A DRAWING

1. Are the ways of specifying a plane figure?
2. What are “traces of the plane”?
3. What plane is called a projecting plane?
4. What is the level plane?
5. Under what conditions does a line belong to a plane?
6. Under what conditions does a point belong to a plane? What lines are referred to as the principal lines of the plane?
7. What are the terms of a line and a plane to be parallel?
8. How can you find the meeting point of a line and a plane?
9. What are the relative positions of the planes?
10. What determines mutual parallelism of two oblique planes in a drawing?
11. What is the way of drawing an intersection line of two planes?
12. What is the gist of the replacing planes of projection method?
13. What mutual relations must the old and new planes of projections have?
14. What actions are necessary to obtain the following transformations: of a general position line into a projecting one; of an oblique plane into a level plane?

QUESTIONS TO CHAPTER SURFACES

1. What is “surface”?
2. What is the meaning of the expression “To specify a surface in a drawing”?
3. What surfaces are called “ruled surfaces”?
4. What is the difference between the polyhedral surfaces and polyhedrons?
5. What is the condition of a point belonging to a surface?
6. How do we obtain the surfaces of rotation?
7. What lines on a surface of rotation are referred to as parallels and meridians?
8. How is a surface of helicoid formed?
9. What lines are produced by intersection of a rotation cylinder with the planes?

10. What lines are produced by intersection of a rotation cone with the planes?
11. How to pass a plane to obtain a circle in a torus section?
12. What is the general method of drawing the intersection line of surfaces?
13. In what cases do we use projection planes, spheres as mediators for the construction of intersection lines of surfaces?
14. What points of an intersection line are referred to as control ones?
15. Give the formulation of Monge theorem and introduce the example of its application in practice.

QUESTIONS TO CHAPTER AXONOMETRIC PROJECTIONS

1. What is the essence of the method of axonometric projection?
2. Formulate the principal theorem of axonometry.
3. What is the coefficient of distortion?
4. How are the coefficients of distortion related to each other?
5. How are the axonometric projections classified according to the direction of projecting and the comparable value of the coefficients of distortion?
6. What is the way of determining the direction of the major and minor axes of an ellipse, if ellipse is the isometric and dimetric projection of a circle?
7. What line is called the outline of the axonometric projection of a sphere?
8. What is the value of the coefficients of distortion in an oblique frontal isometry?
9. Name the coefficients of distortion in an oblique frontal isometry?
10. What is the way of constructing the axes in an oblique axonometry?

QUESTIONS TO CHAPTER REPRESENTATIONS

1. What are the principal views? How are they positioned on a drawing?
2. What are the rules of designating a view having no projecting link with the principal view?
3. What representation is called an auxiliary view, a detail view? In what cases are they applied and how are they denoted?
4. When is it permitted to apply a break of a representation?
5. What representation is called a sectional view? How are the sectional views classified depending on a cutting plane position relative to the horizontal projection plane or relative to the object; depending on a number of the cutting planes?
6. What sectional view is referred to as a scrap one?

7. In what cases are the sectional views not designated?
8. What letters denote the sectional views?
9. How are the complex sections classified?
10. What are the peculiarities of drawing a complex step-type sectional view?
11. When is it permitted to join a half view and a half sectional view?
12. What line separates a scrap section from the view and how is it drawn?
13. What elements of an object are not hatched on a section?
14. What simplifications are used when the projections of the intersection lines of surfaces are drawn?
15. Are the small angles of taper and slopes shown in all drawings?
16. How is knurling drawn?
17. What is a covering projection and what are the rules of its construction?
18. What is an extension element?
19. How are the extension elements denoted on drawings?

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DESCRIPTIVE GEOMETRY

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