«NATIONAL RESEARCH TOMSK POLYTECHNIC UNIVERSITY»

ENGINEERING GRAPHICS

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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.

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PREFACE

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.

Engineering Graphics contains as elements of Descriptive Geometry (theory of geometric objects drawing construction) as Technical Drawing (compose and reading of products drawings). In the process of study students know with main rules and requirements on a process of creation, designing and use of engineering documents. Moreover solving of geometrical problems develops spatial imagination and logical thinking, Without these skills any technical creation is impossible.

After studying the course "Engineering Graphics" students will:

- learn theoretical principles of drawing the points, lines, planes and some kinds of spatial lines and surfaces on a plane;
- familiarize with particular cases of problems solution on mutual belonging and intersection of geometric figures, as well as determining the true size of plane figures;
- master methods of drawing and corresponding conventions of simple objects;
- be able to determine geometric form of simple details by their image, and construct such images;
- acquaint with representation of some joints and connections, be able to read the drawings of technical devices, also construct such drawings following the standards requirements.

This textbook 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 textbook is accompanied by an workbook and systematic instructions and tasks.

Workbook includes tasks to be performed by the students to consolidate theoretical material. The content of the workbook is in the same sequence as that in the textbook.

Systematic instructions will help the students complete the offered tasks.

The authors will be thankful to you for your suggestions on perfecting the next edition of this textbook.

The following designations are accepted in the present book:

1. Points of space are usually denoted by Latin capital letters ($A,B,C,\ldots..$) or figures ($1,2,3,\ldots.$)
2. Sequence of points (and other elements) - by interlinear indexes ($A_1,A_2,A_3,\ldots B_1,B_2,B_3,\ldots$)
3. Lines in space - by the points specifying the given line (AB, $CD,\ldots$)
4. Angles - by Greek small letters ($\alpha, \beta, \gamma,\ldots$)
5. Planes - by Latin capital letters (P, R, $Q,\ldots$)
6. Surfaces - by Greek capital letters (Ψ, Φ, $\Omega,\ldots$)
7. Projection planes:
   horizontal - H;
   frontal - V;
   profile - W
   Projection centre - S
8. 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 – $x_1,y_2,..$
9. 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'';
10. Line projections - by projection of the points specifying the line - ab, $a'b'$, $a''b''$.
11. Coincidence, identity - $\equiv$
12. Coincidence, equality - $=$
13. Parallelism - $\|$
14. Perpendicularity - $\perp$
15. Crossing - $\div$
16. Representation - $\rightarrow$
17. Belonging of an element (a point) to a set (line, plane, etc.) - $\in$
18. Belonging of a subset (a line) to a set (plane, surface) - $\subset$
19. Intersection of sets - $\cap$

CHAPTER 1. FROM THE HISTORY OF GRAPHIC REPRESENTATIONS

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.