



Introduction to Mechanical Engineering, Lecture 1

Introduction

Computer Aided Design (CAD)

Engineering Drawings



Lecturers/Instructors



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Course Goal

To understand engineers:
their problems and
their terminology
by doing their job
using their tools



Course purpose and objectives

The development of any class of robots and the use of robots in industry requires the engineer to have knowledge and skills in:

- the ability to read engineering drawings,
- the analysis and synthesis of mechanisms,
- the dynamic calculation of mechanisms and machines,
- the calculation stress and strain,
- understanding the technological production processes,
- modern CAD and CAE systems.



Course outline and organization

| | | |
|----|----|--|
| 1 | ср | 07.06.2023 Lecture 1 (Introduction; Engineering Drawings) |
| 2 | чт | 08.06.2023 CAD_DET1 (Intro to subject; History of CAD; Solid modeling) |
| 3 | сб | 10.06.2023 Lecture 2 (Intro to Theory of Mechanisms and Machines; Links, Joints (Kinematic pairs); Kinematic chains, Degrees of Freedom, Mobility) |
| 4 | сб | 10.06.2023 Lab 2 CAD_DET2 (Workflow, Work in groups; CAD file formats; Threads) |
| 5 | ср | 14.06.2023 Lecture 3 (Types of drives: kinematics, where to find other info; Drives: friction, belts, chains, gears, universal, geneva, ballscrew) |
| 6 | чт | 15.06.2023 Lecture 7 (Links, Joints, Connections; Shafts, Axles, Shaft couplings; Bearings) |
| 7 | сб | 17.06.2023 Lab 3 CAD_ASM1 (Bottom-Up approach; Basics) |
| 8 | сб | 17.06.2023 Lecture 11 (Basics of FDM Printing) |
| 9 | ср | 21.06.2023 Lecture 8 (Connections: Detachable (Threaded, Keyed, ...); Permanent (Riveting, Welding,)) |
| 10 | чт | 22.06.2023 Lab 4 CAD_ASM2 (Top - Down approach: WAVE; Assembly Load Options; GOST Naming convention; Common Parts Library; Sequence (Assembling animation)) |
| 11 | сб | 24.06.2023 Lab 8 CAD_RENDER (Render) |
| 12 | сб | 24.06.2023 Lecture 9 (Engineering Materials: Steel, Bronze, Aluminum, Titanium, Composites) |
| 13 | ср | 28.06.2023 Lab 5 CAE_DYN1 (Introduction to CAE; Animation Designer; Mechatronics Concept Designer; Motion; Measure; Interference; Density; Assign Materials) |
| 14 | чт | 29.06.2023 Lecture 5 (Motor sizing (selection)) |
| 15 | сб | 01.07.2023 Lab 6-7 CAE_DYN2 (Motion Analysis, Part 2) |
| 16 | сб | 01.07.2023 Lab 6-7 CAE_DYN2 (Motion Analysis, Part 2) |
| 17 | ср | 05.07.2023 Lecture 10 (Design Thinking and Manufacturing) |
| 18 | чт | 06.07.2023 Lab 9 MAN1 (How to create such parts?) |
| 19 | сб | 08.07.2023 Lecture 12 (Overview of Strength of Materials) |
| 20 | сб | 08.07.2023 Lab 10-11 CAE_STR1 (Stress Analysis) |
| 21 | ср | 12.07.2023 EXAM |
| 22 | чт | 13.07.2023 COMPETITION |



Grading criteria

Qz: Quizzes: 10%

CP: Competition: 20%

FE: Final Exam: 30%

HWs: Homework assignments: 40%

Extra: Slide fixes in Github: 5%

Late policy: -50% of max grade for a task

Scale:

A: 85 – 100%

B: 70 – 84.99%

C: 50 – 69.99%

D: 0 – 49.99% or less than 50% by any criterion.



Quizzes

Purpose: You have self-study theoretical classes. Quizzes encourage you to watch videos more seriously.



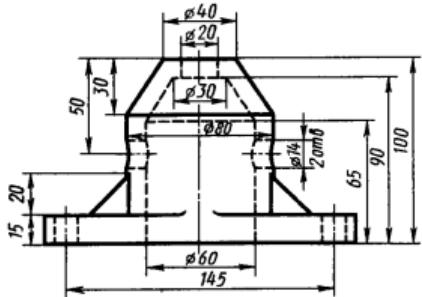
Competition

To be Announced later



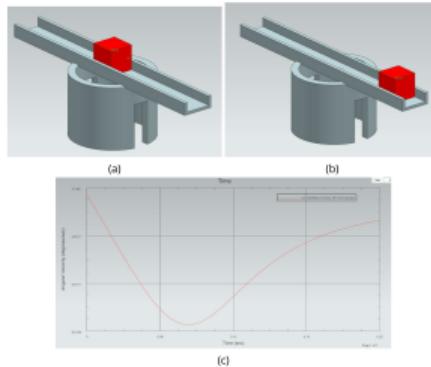
Final Exam (Previous Year)

1. (10 score) Make a CAD model of the blueprint, which provided below.
2. (2 extra score) Make the same blueprints (without dimensions), based on your CAD model.
3. (3 extra score) Perform the stress analysis of the detail. All forces and fix supports are on the picture. Material — Steel. You have to show the stress and strain diagrams and explain what happens to the parts after such a load.



CAD part

The task is to determine the maximum angular velocity of the structure that will be reached and the point in time when this maximum will occur.



CAE part

«Mechanics And Machines»

Final Exam

Theory part

Variant: 4

1. What the key aspects should we consider during the motor choosing? The general guideline of the motor selection.
2. Screw types. Multisided screws, prof and cons. Type of drills. Type of holes. How to distinguish them on a blueprints?

Theory part



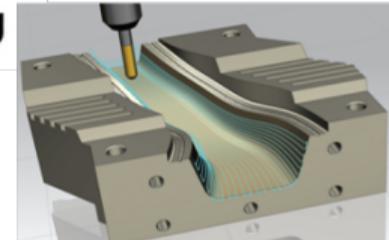
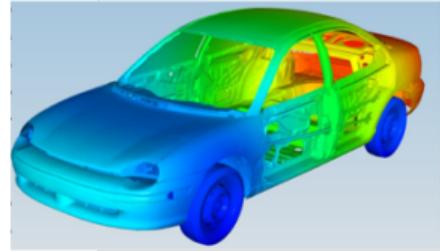
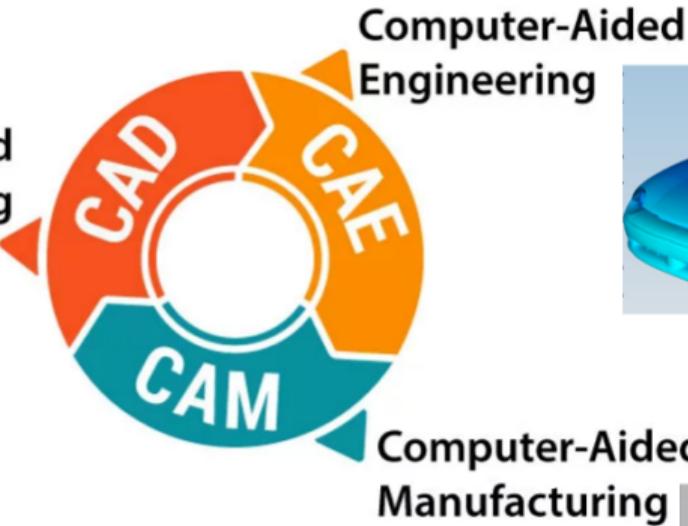
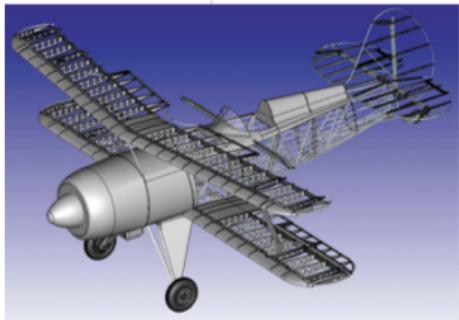
Lab Goals

To obtain the needed tools for solving the design part of
the competition



Computer Aided Design

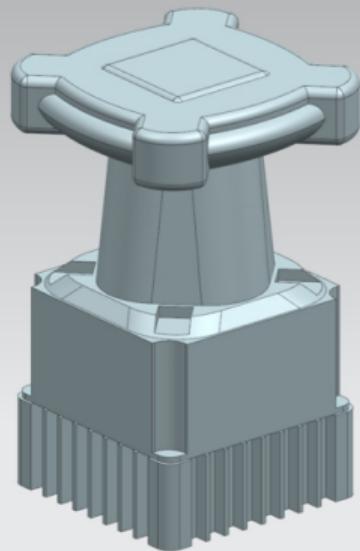
Computer-Aided
Drafting





Computer Aided Design

Types of modeling



Solid Modeling



Surface Modeling



History of CAD

- 60th** — Theoretical studies of the possibility of solving design problems on the computer were carried out.
- 70th** — Methods, algorithms and programs for solving individual tasks for different design stages were developed.
- 80th** — CAD is being developed and improved. 3D modeling became more popular.
- 90th** — Developers had finished formation of base concepts of CAD and unified data transfer between systems.



CAD benefits

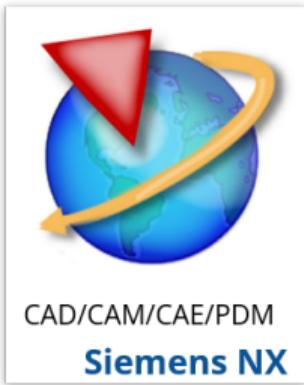
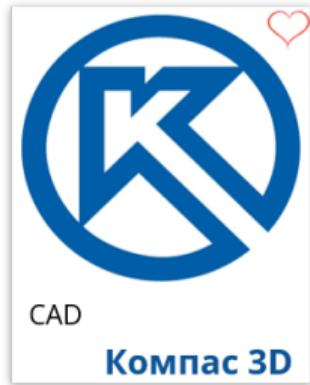
Cheaper

Safer

Faster



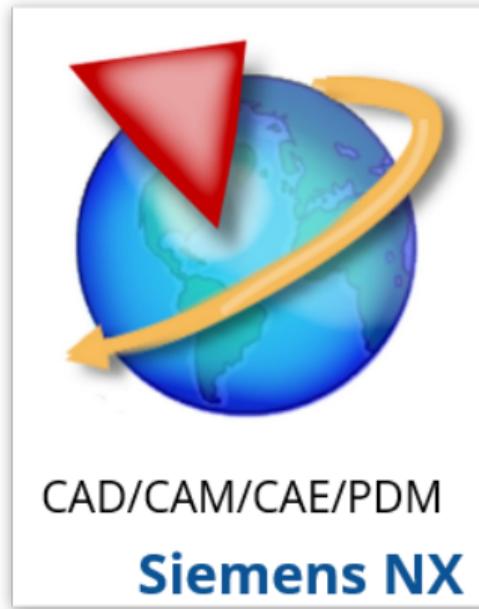
Popular CAD systems in Russia



Siemens NX

Prof

- All in one system
(CAD,CAM,CAE,PDM)
- Free for students
- Can create a real aircraft
in it



Cons

- Complex system
- Not popular in small
companies



Common usage of other systems for our tasks

- If you need a good drawings. Make CAD anywhere, afterwards import to Kompas-3D.
- If you need Standard Component Library (SCL), use either Kompas, or Solid Edge, or [mcmaster](#). Insert needed stuff in NX.



Common Labs Workflow

Lab 1

1. Oleg explains some new concepts.
2. Oleg provides HW, which should be done after the lab.
3. You start to watch prerecorded videos and make class tasks. You can do it at home.

Between lab 1 and lab 2

1. You should finish lab tasks and solve HW.
2. Submit only HW in Moodle.

Lab 2

1. Oleg explains some new concepts.
2. Oleg provides new HW, which should be done after the lab.
3. If you had self-study lectures — Oleg conducts quiz.
4. You defend previous lab task solutions and HW results.
5. You start to watch prerecorded videos and make class tasks. You can do it at home.



Engineering Drawings



Projections

Video

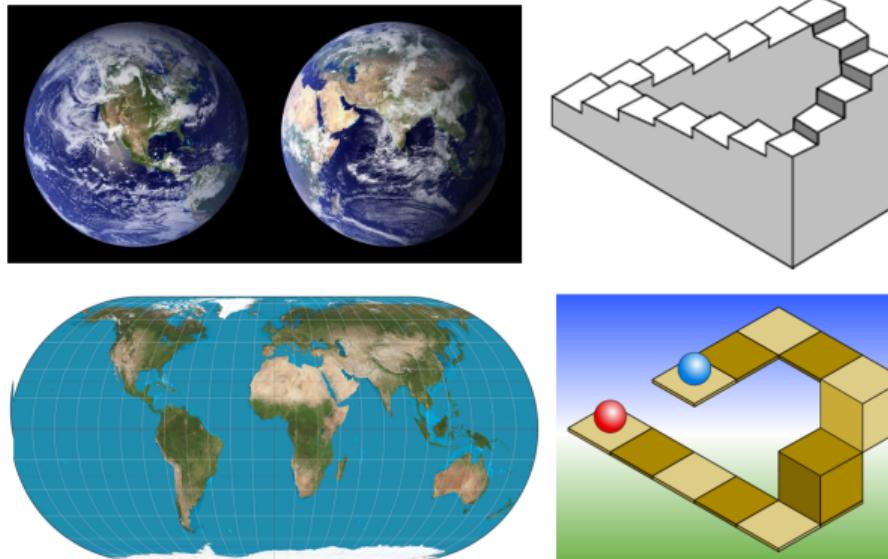
We work with 3D-objects which must be shown in a flat drawing. This is a problem.



Projections

On the one hand, we cannot accurately show curved surfaces.

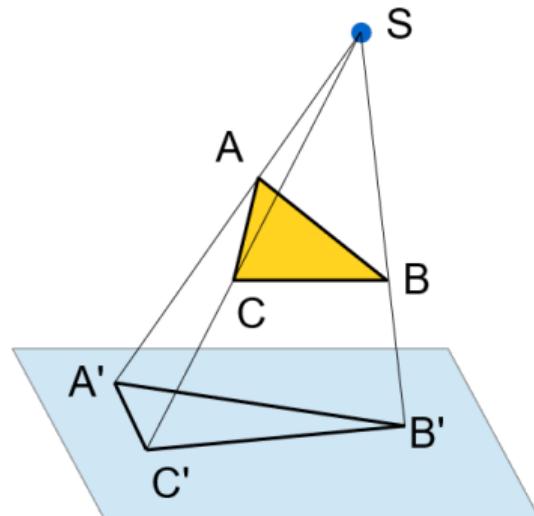
On the other hand, we can draw something absolutely impossible or something possible but unclear.





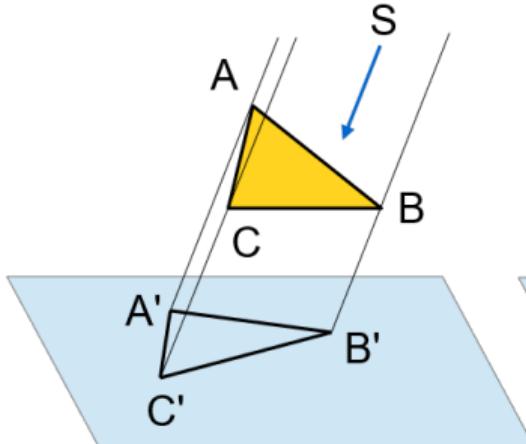
Parallel and perspective projections

Central (perspective) projection

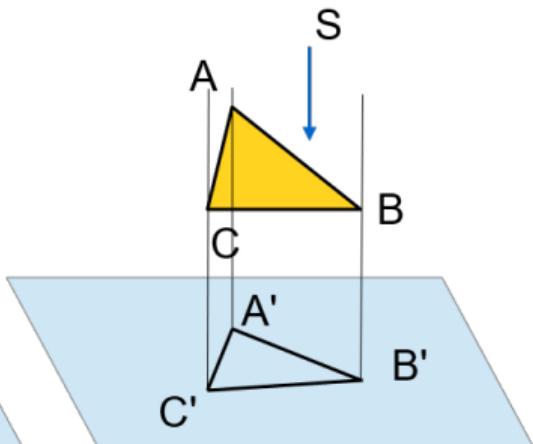


Parallel projections

General (oblique) case



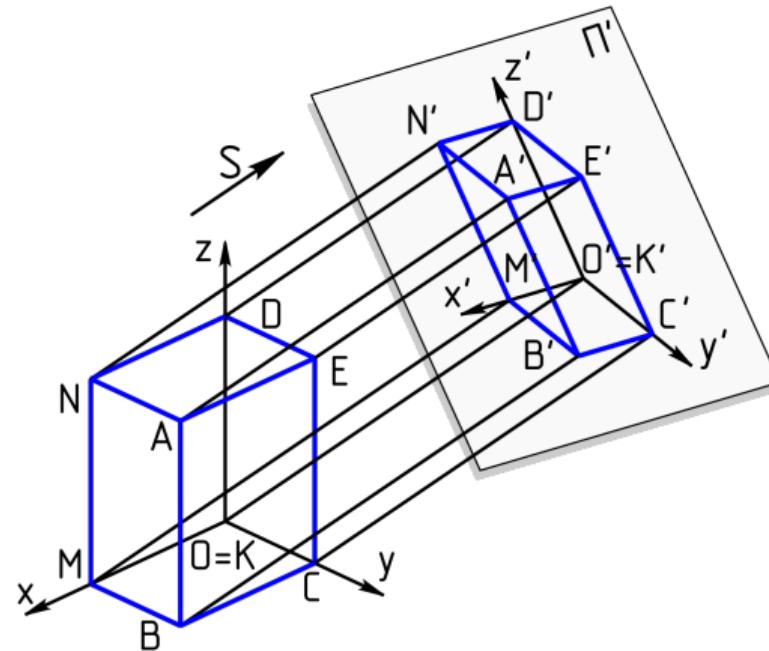
Orthographic projection





Axonometric projections

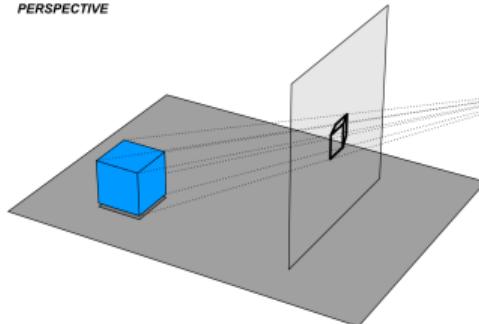
General



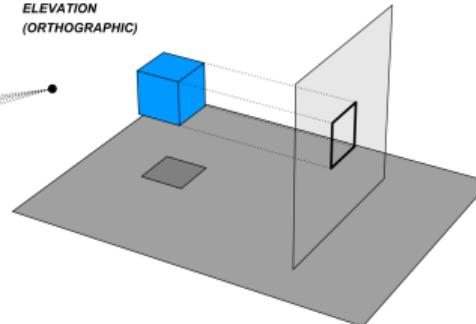


Axonometric projections

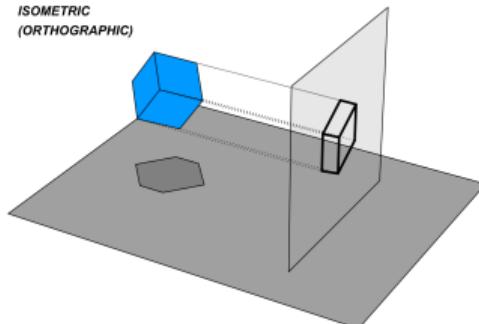
PERSPECTIVE



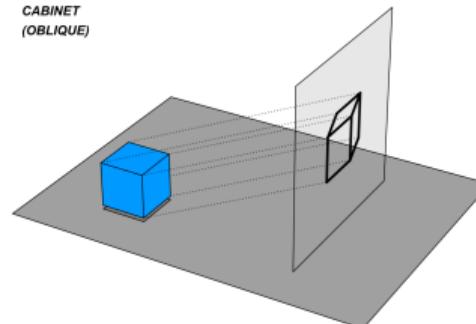
ELEVATION
(ORTHOGRAPHIC)



ISOMETRIC
(ORTHOGRAPHIC)

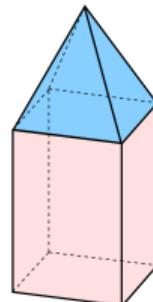
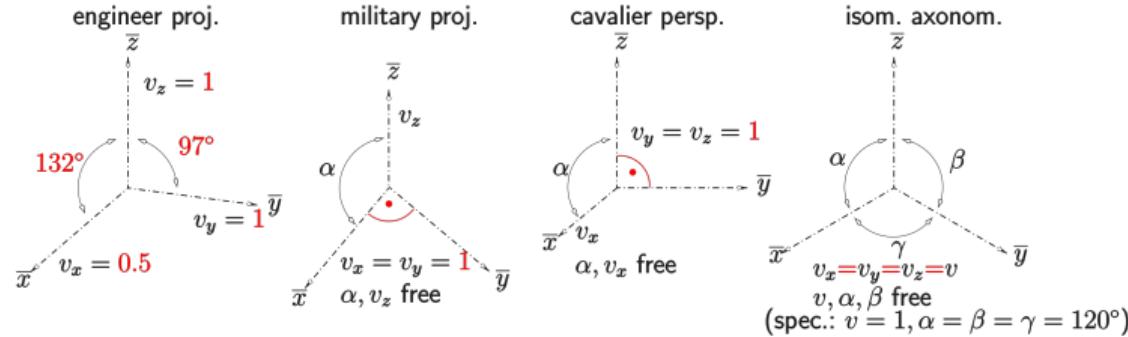


CABINET
(OBlique)

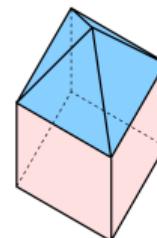




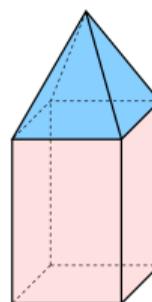
Axonometric projections



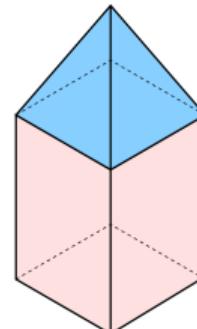
engin. proj.



milit. proj.



caval. persp.



isom. axon.

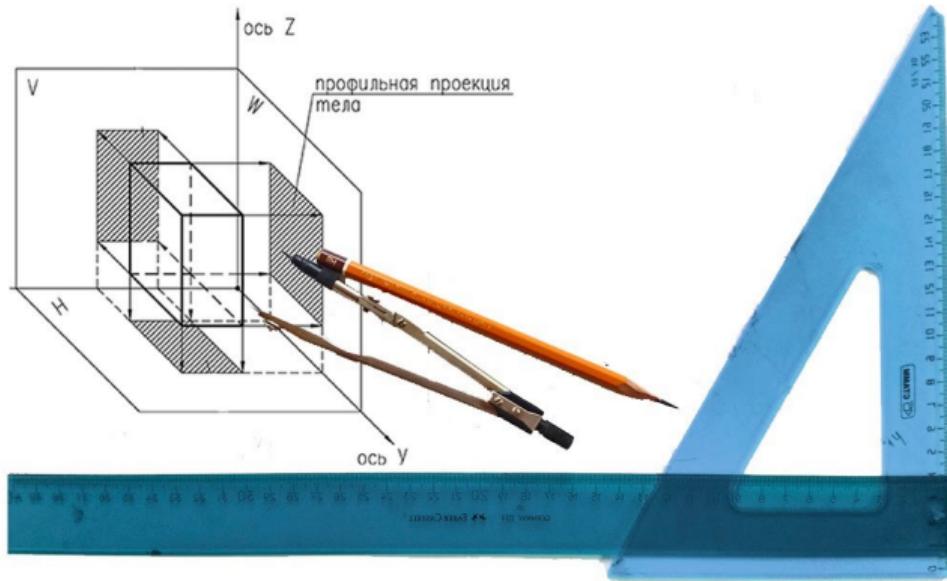


Make a line projection

Video

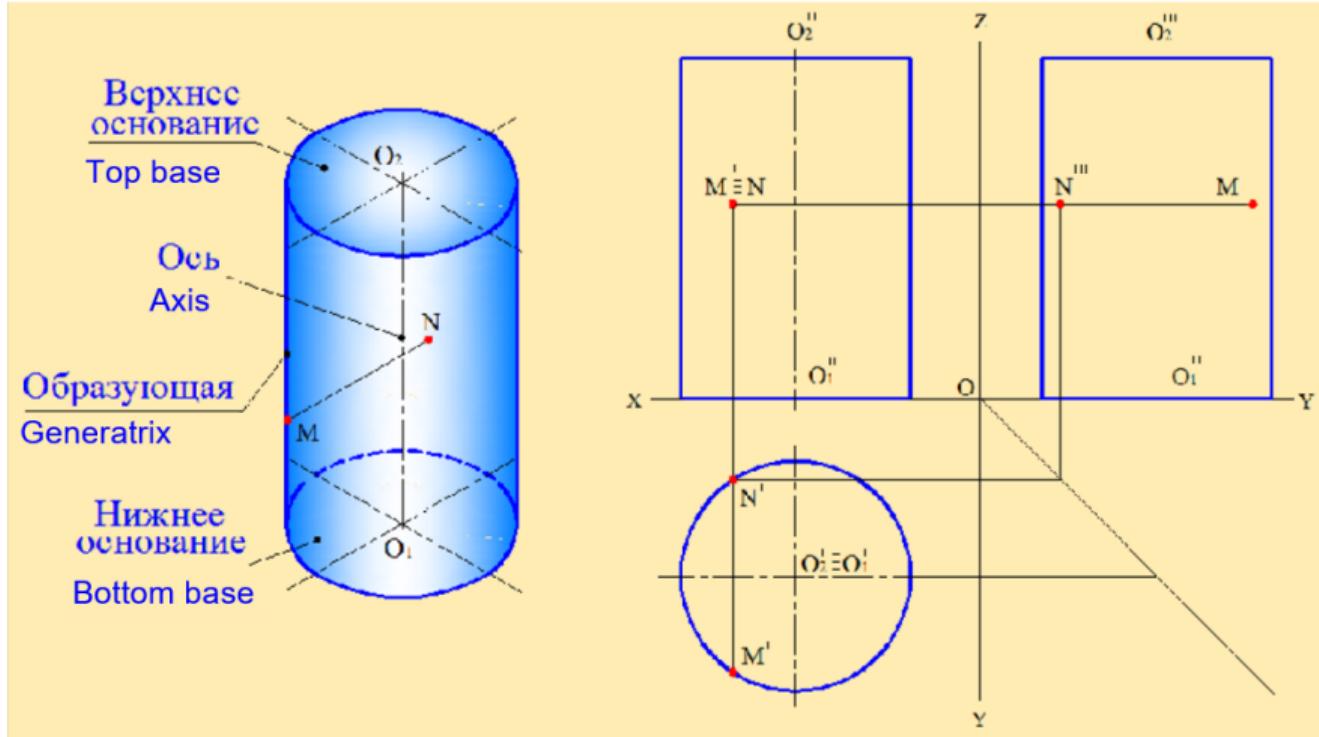
Черчение школа архитектурный ВУЗ

Часть2. ПРОЕКЦИОННОЕ ЧЕРЧЕНИЕ. Введение
Построение проекции точки, отрезка, плоскости в системе ортогонального проецирования.



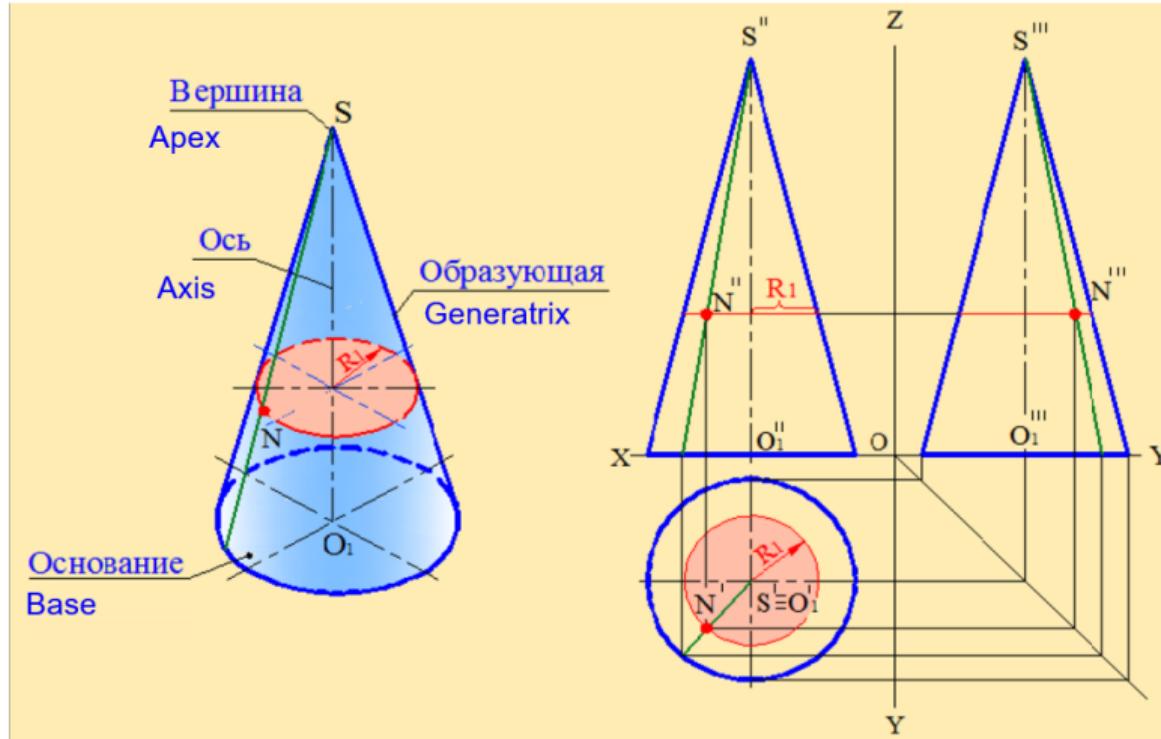


Orthographic Multiview projections



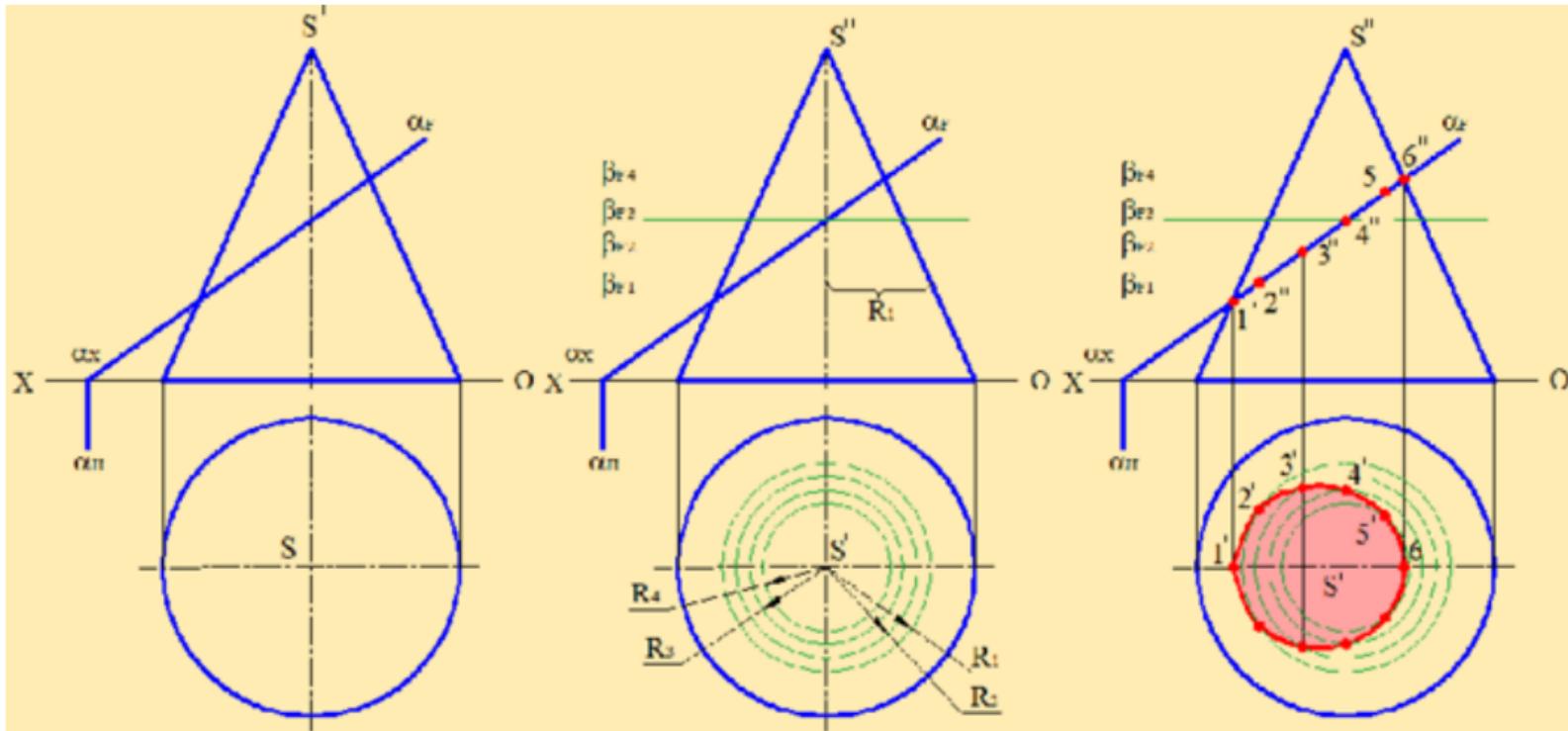


Orthographic Multiview projections



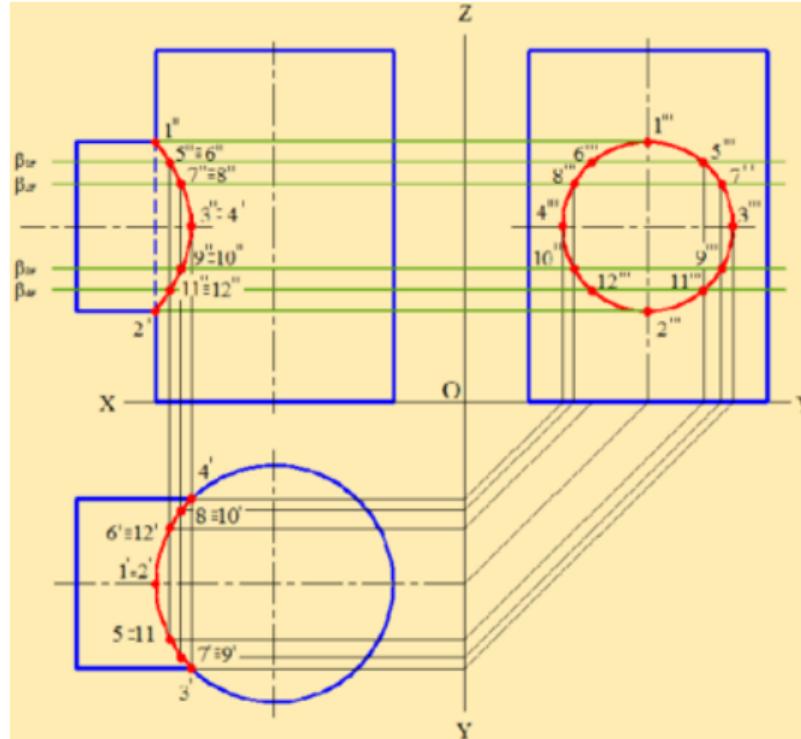


Orthographic Multiview projections





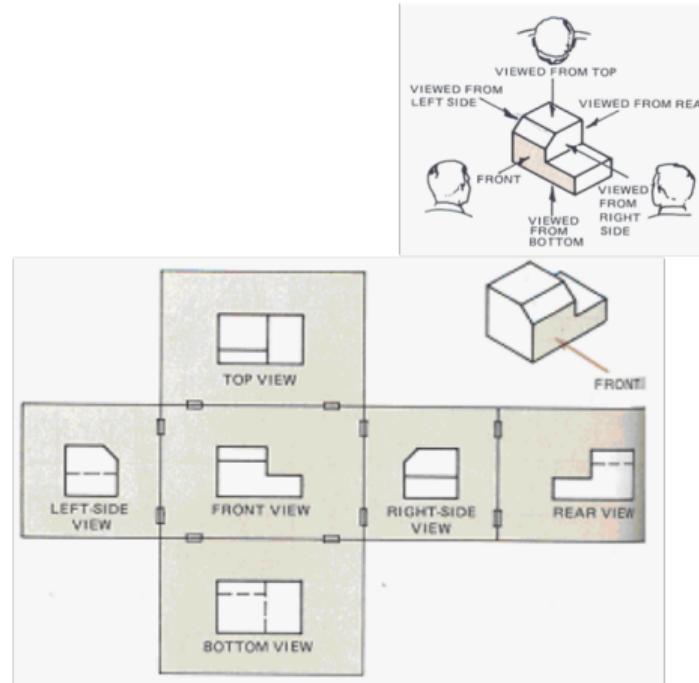
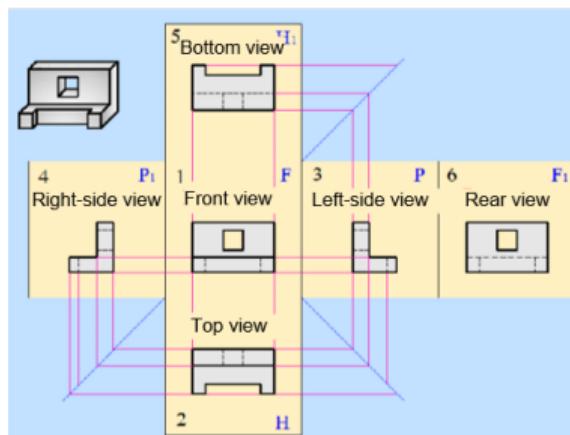
Orthographic Multiview projections





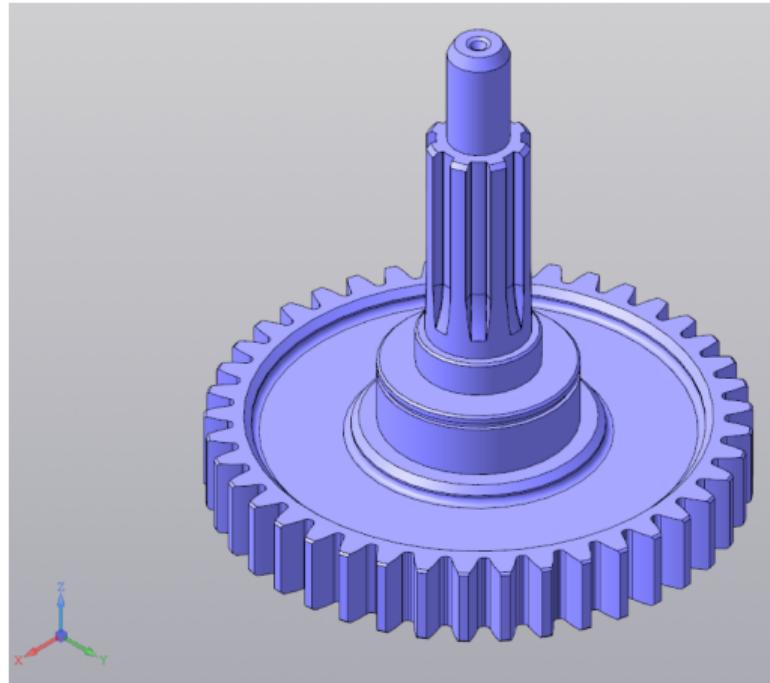
Orthographic Multiview projections

The difference between European and American standards

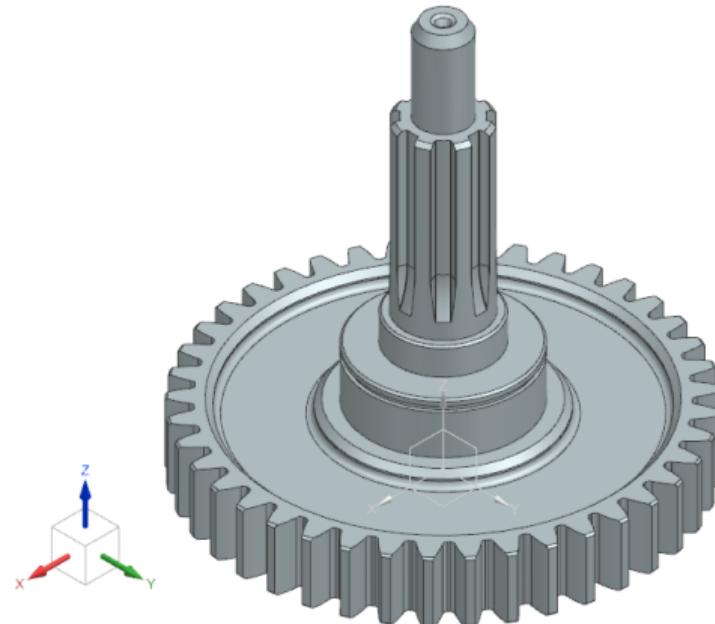




Orthographic Multiview projections



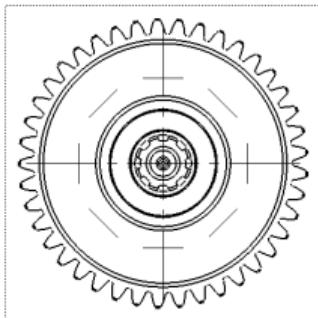
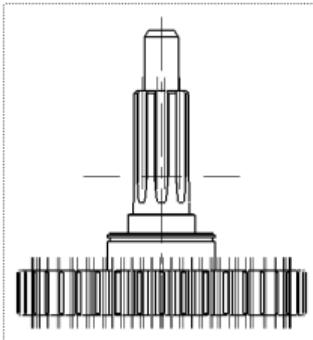
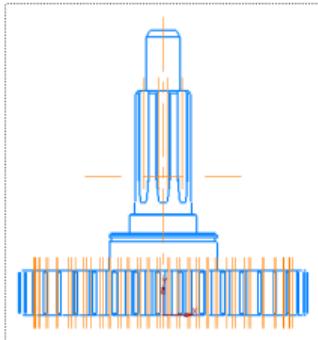
Kompas 3D



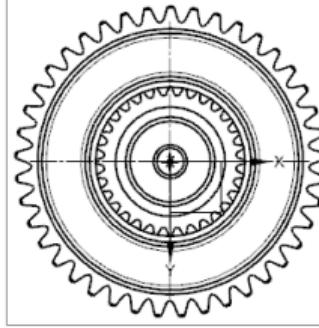
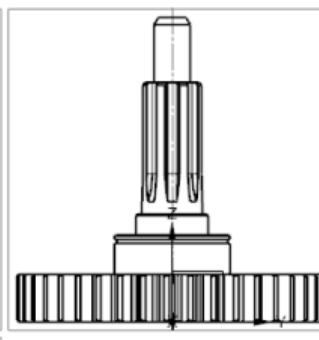
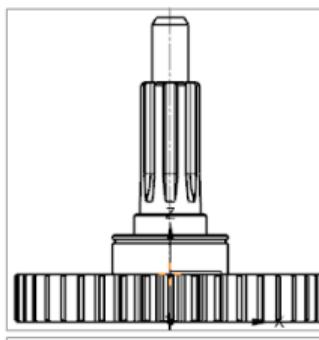
Siemens NX



Orthographic Multiview projections

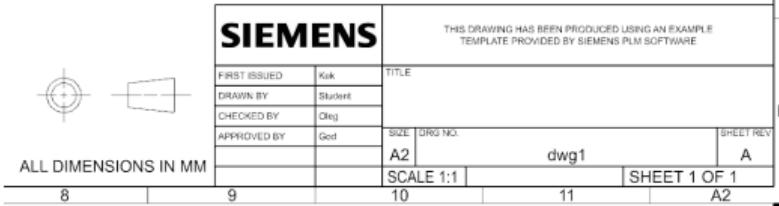


Kompas 3D (European system)



Siemens NX (American system)

Drawing standards



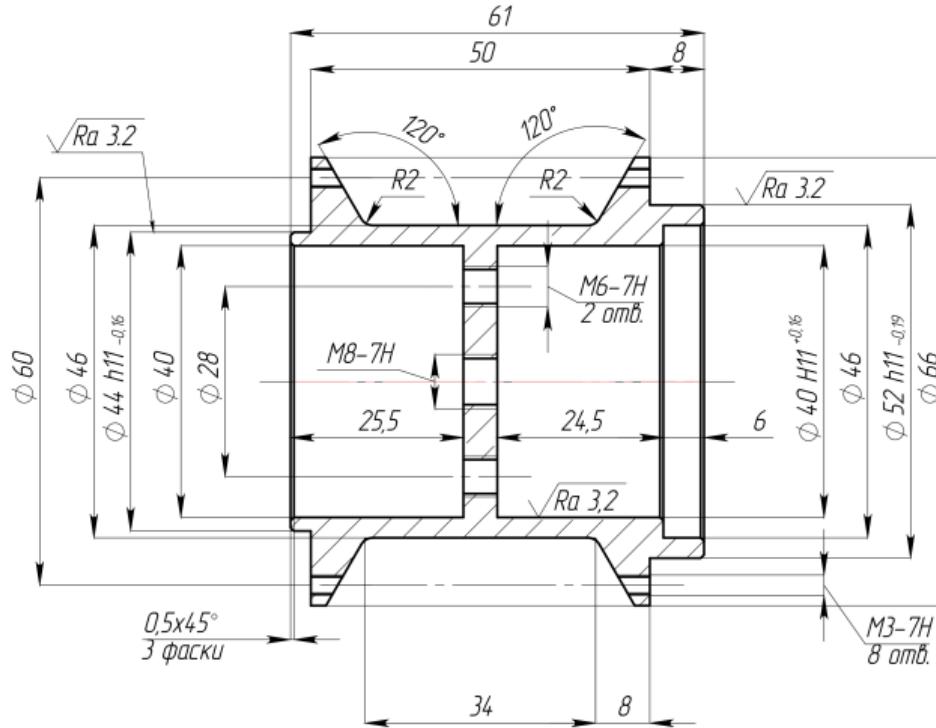
ANSI standard Title Block

| | | | | | |
|---------------------------|--------------|----------|-------------|-------------|-----------------------------------|
| | | | | | |
| Изм. | Лист | № докум. | Подп. | Дата | |
| Разраб. | Буянов ВВ | | | | |
| Проб. | Кузьминов РР | | | | |
| Т. контр. | | | | | |
| Н. контр. | | | | | |
| Чтврт. | | | | | |
| <i>АНЦП.014.00.00.003</i> | | | | | |
| <i>Корпус для вала</i> | | | | | |
| | | Лист | Масса | Масштаб | |
| | | | <i>0,13</i> | <i>1:51</i> | |
| | | Лист | 1 | Листов | 1 |
| <i>Д16Т ГОСТ 4784-97</i> | | | | | AНО ВО “Университет Иннополис” |
| Копирофайл | | | | | Формат |
| | | | | | A2 |

GOST standard Title Block

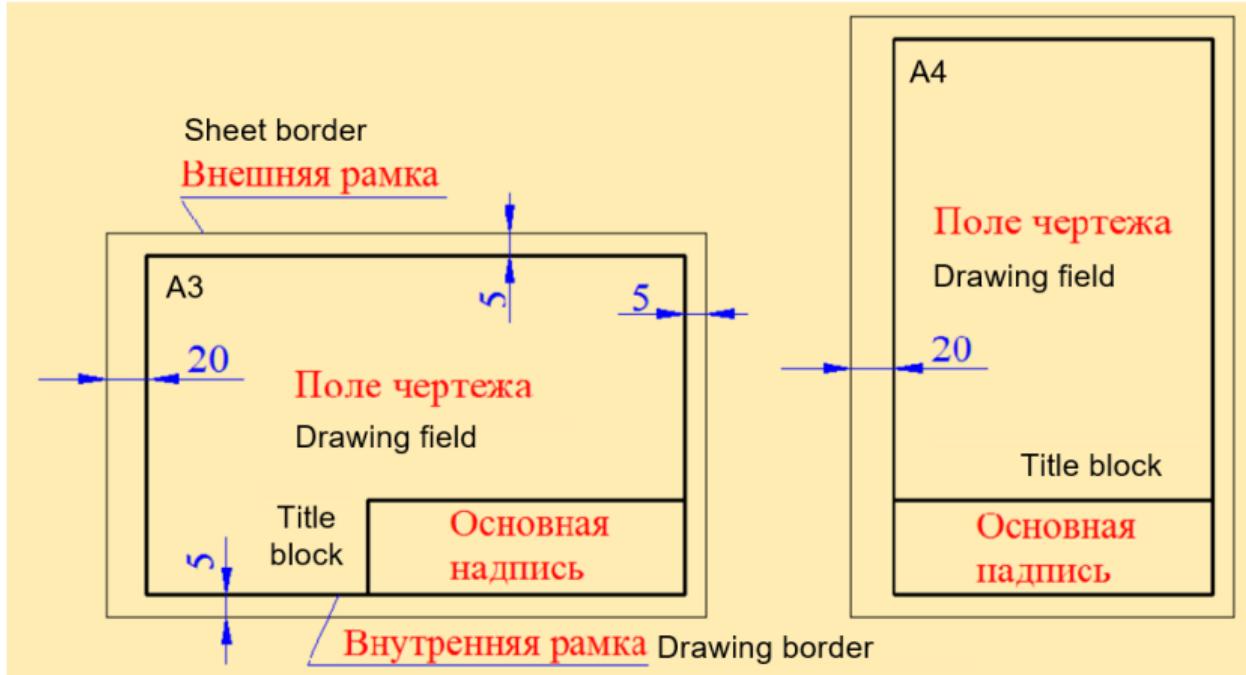


GOST Drawing Example





GOST Drawings





GOST Drawing Title Block





Scale

Scale

Drawings may be made actual size, or they may be made smaller or larger than the actual size of the object. A drawing that is twice the actual size of the part would show a scale of $2 = 1$ or $2:1$. A drawing made half the actual size of a part would be in a scale of $1/2 = 1$ or simply $1:2$.

| Type of Scales | Scale Values |
|--------------------------|--|
| Enlargement Scale | $50:1$ $25:1$ $10:1$ $5:1$ $2:1$ |
| Full Scale | $1:1$ |
| Reduction Scale | $1:2$ $1:3$ $1:5$ $1:10$ $1:100$ |

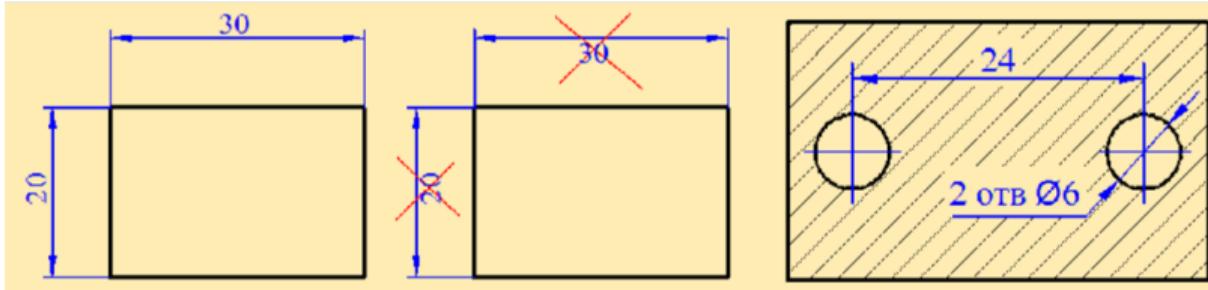
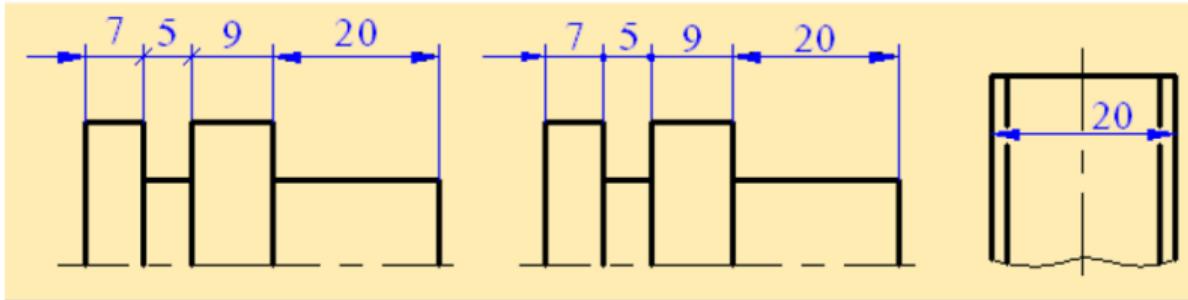


Type of lines

| Наименование | Начертание | Толщина линии | Основное назначение |
|----------------------------|------------|------------------|--|
| Сплошная толстая основная | | S | Линии видимого контура |
| Сплошная тонкая | | от S/3 до S/2 | Линии контура наложенного сечения, линии размерные и выносные, линии штриховки |
| Сплошная волнистая | | от S/3 до S/2 | Линии обрыва, линии разграничения вида разреза |
| Штриховая | | от S/3 до S/2 | Линии невидимого контура |
| Штрихпунктирная тонкая | | от S/3 до S/2 | Линии осевые, центровые |
| Разомкнутая | | от S до 1.5S | Линии сечений |
| Сплошная тонкая с изломами | | от S/3 до S/2 | Длинные линии обрыва |

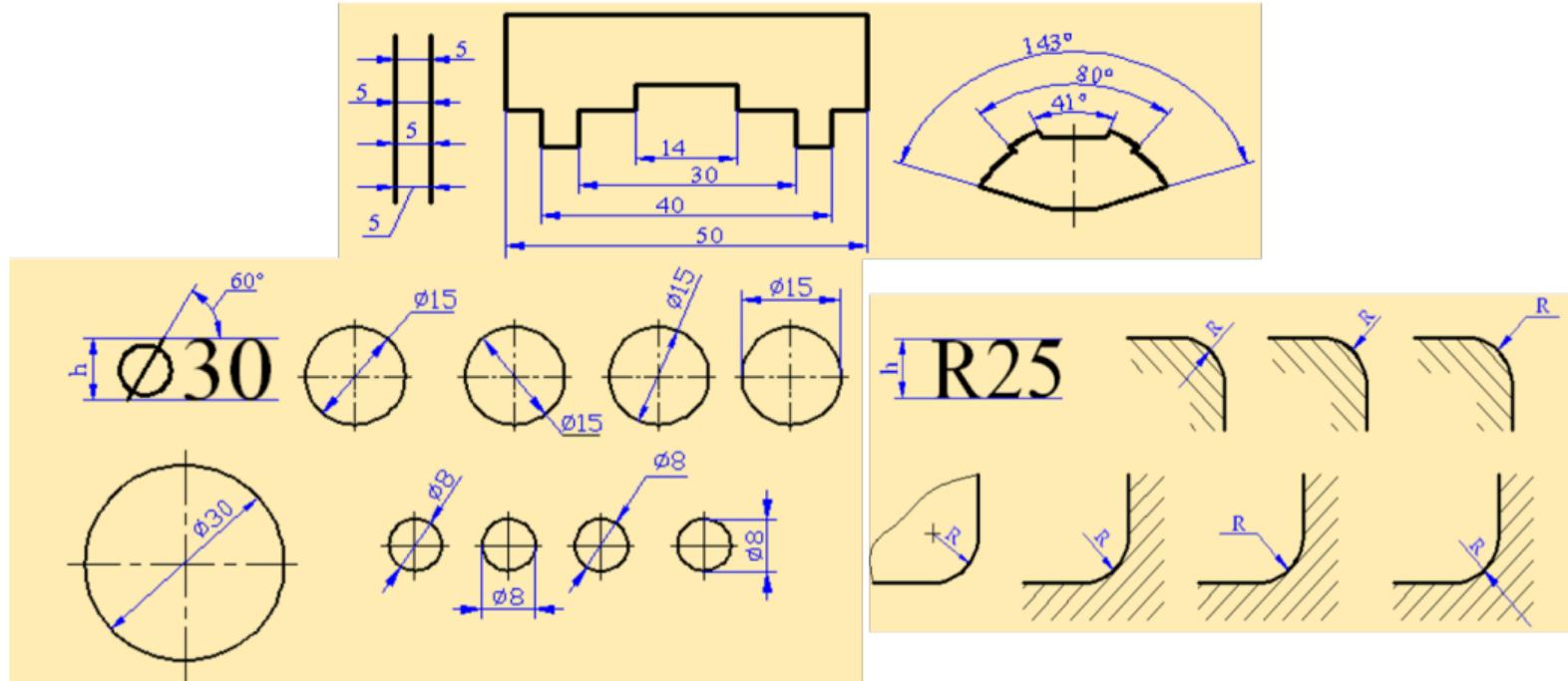


GOST Standard



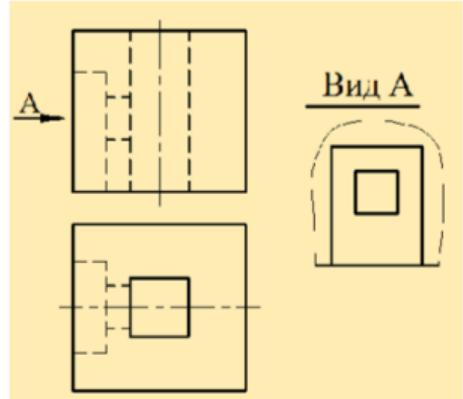
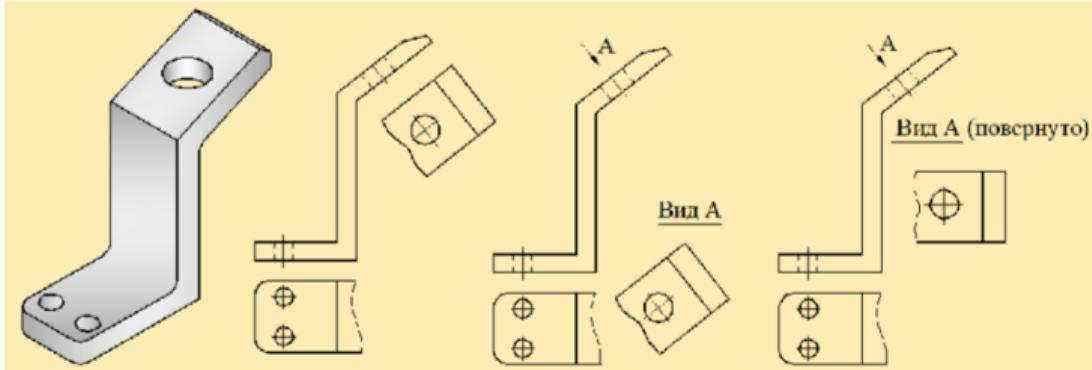


GOST Standard



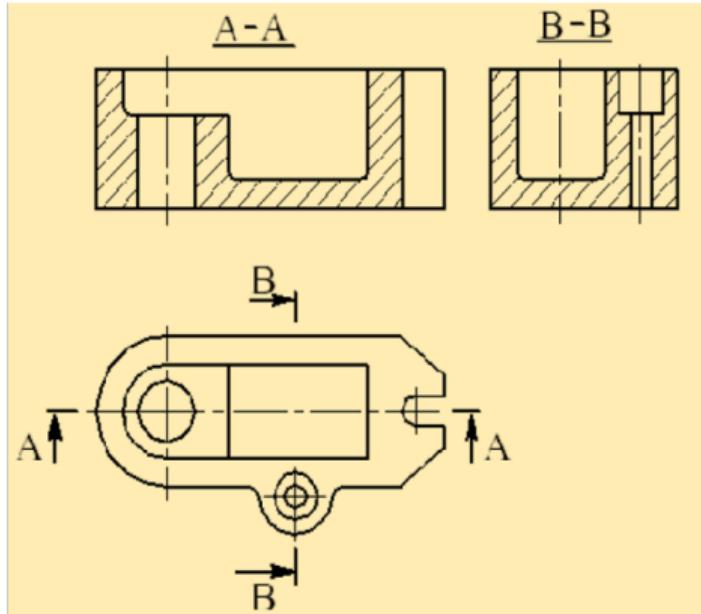
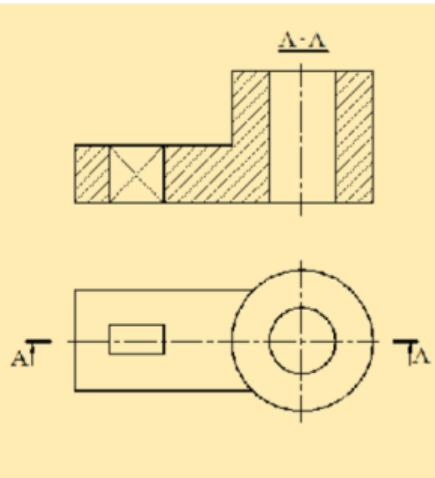
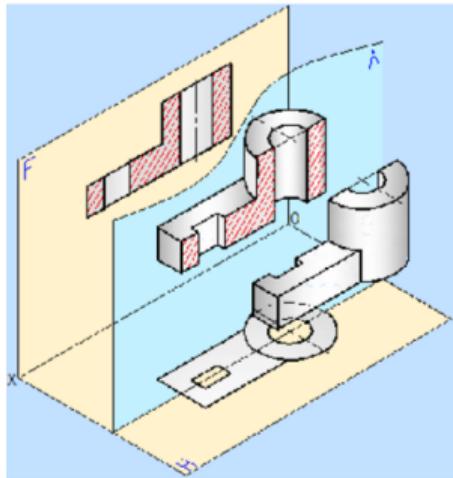


GOST Standard



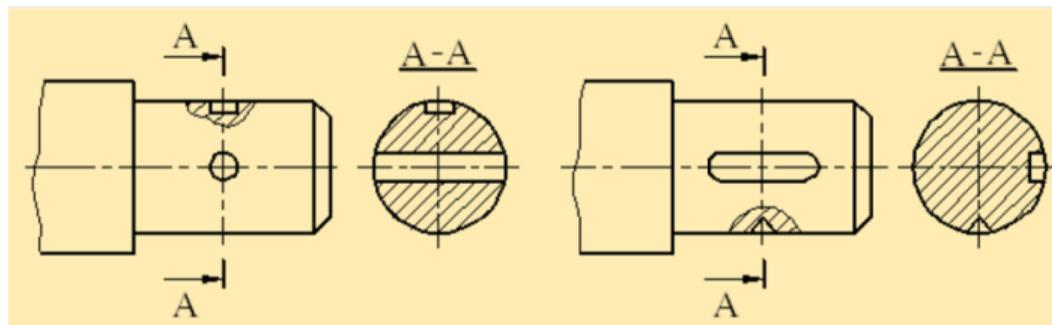
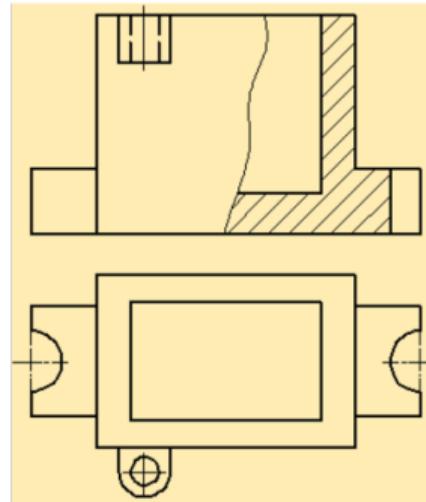
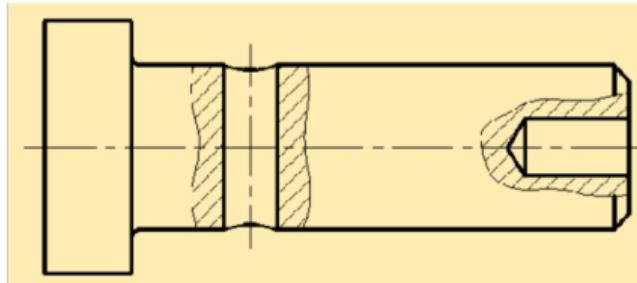


GOST Standard



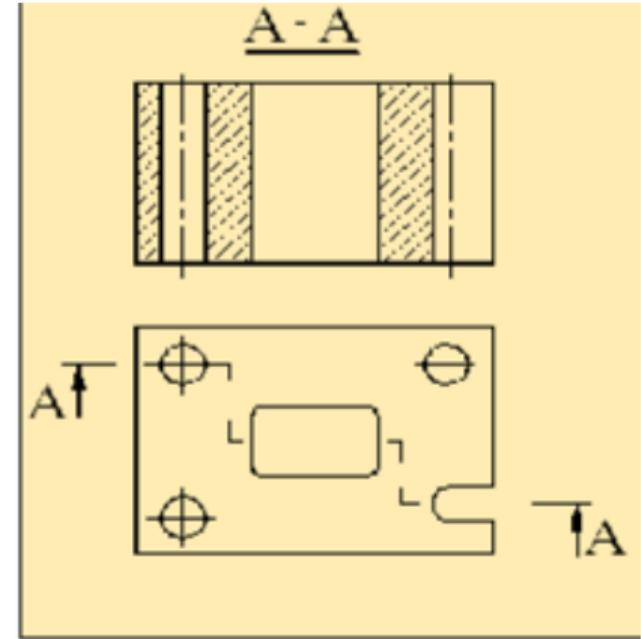
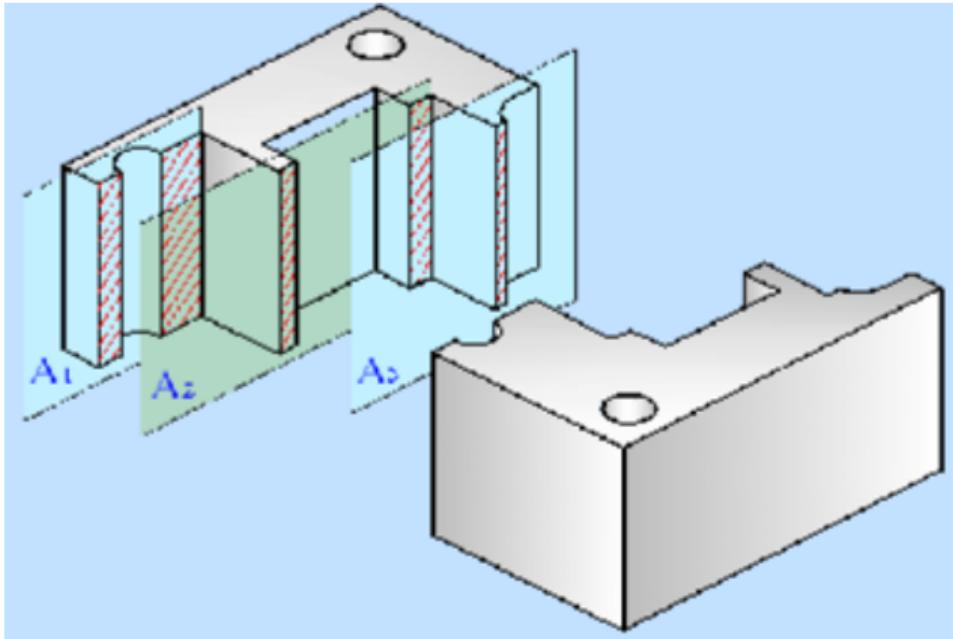


GOST Standard

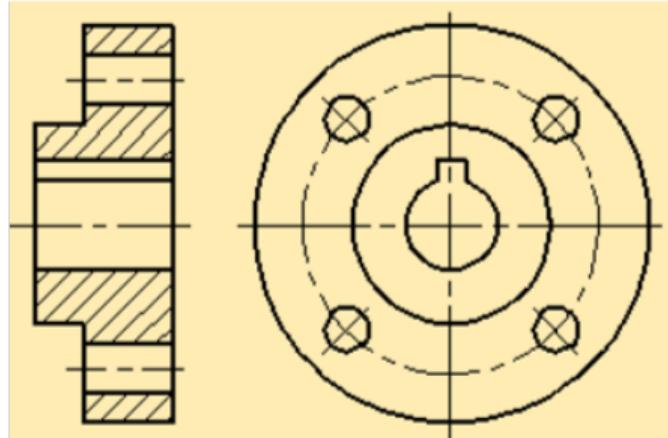
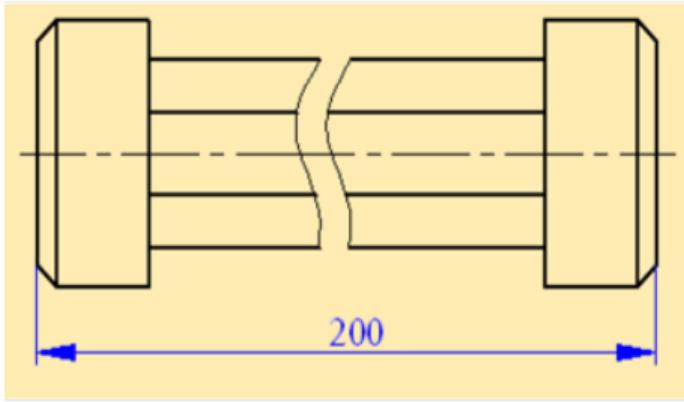




GOST Standard

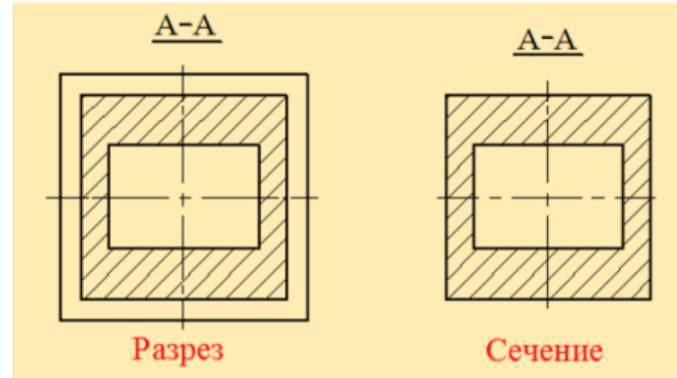
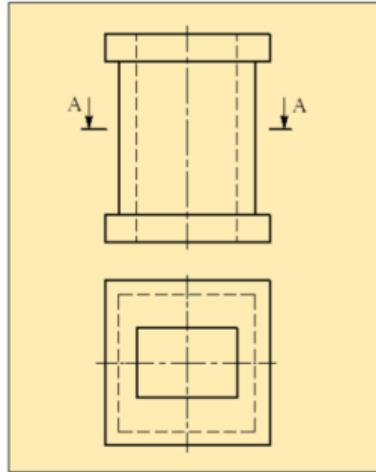
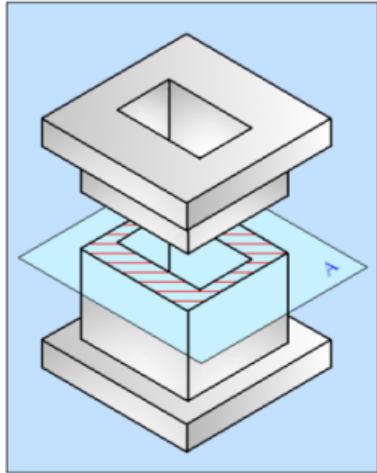


GOST Standard





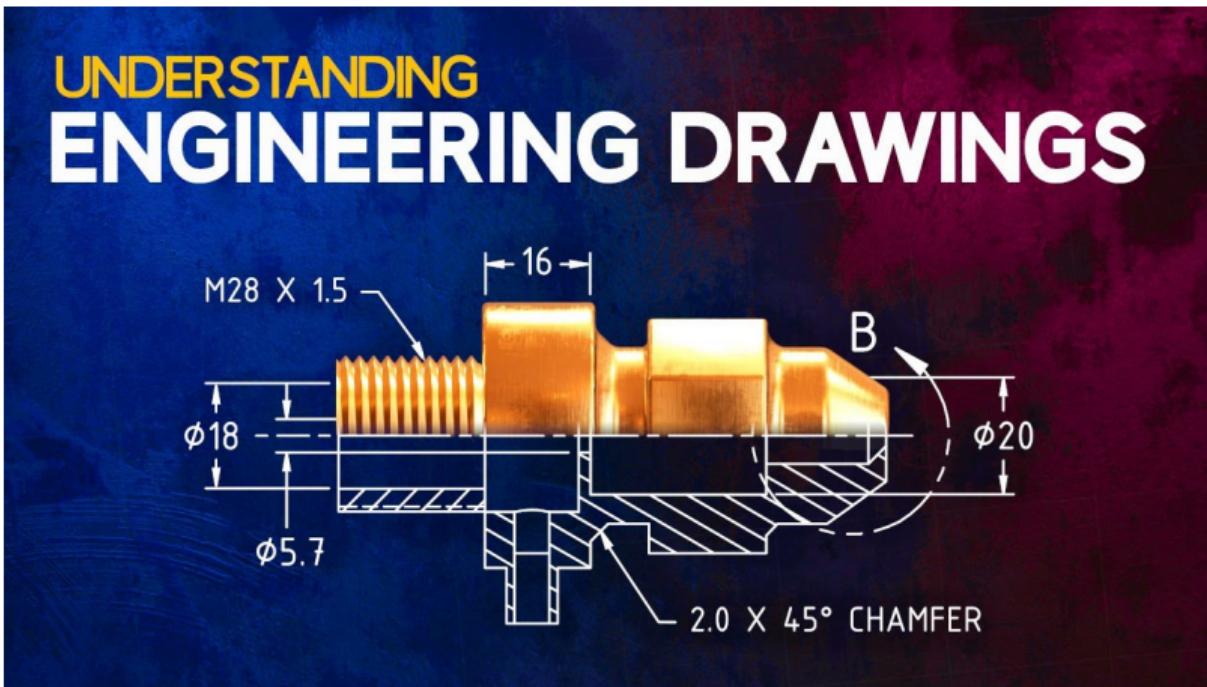
GOST Standard





Understanding Engineering Drawings

Video





Reference Materials

1. Title Block
2. Методы проецирования (RUS)
3. Инженерная графика (RUS)

Deserve “A” grade!

– Oleg Bulichev

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↗ @Lupasic

🚪 Room 105 (Underground robotics lab)