

Mechanics and Machines, Lecture 1

Introduction

Computer Aided Design (CAD)

Engineering Drawings



Lecturers/Instructors



Oleg Bulichev

Mail: o.bulichev@innopolis.ru

TG: [@Lupasic](https://t.me/Lupasic)



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

Week	Lecture topic	Lab topic	Project milestones	Date
1	Engineering drawings	CAD, details 1		31.08
2	Kinematic pairs	CAD, details 2		07.09
3	Type of drives	CAD, assembly 1	Project Selection	14.09
4	Synthesis of planar mechanisms	CAD, assembly 2	Defence selection	21.09
5	Motor sizing (selection)	CAE, motion simulation 1	Defence Kinematics, analytical solution	28.09
6	Friction	CAE, motion simulation 2	Dynamics, analytical solution	05.10
7	Links, Joints, Connections, Bearings	CAE, motion simulation 3	Defence Dynamics, analytical solution	12.10
8	Connections: Detachable, Permanent	Render	Dynamics, simulation	19.10
9	Overview of materials used in mechanical engineering	1 Overview of materials used in mechanical engineering	Defence Dynamics, simulation	26.10
10	Overview of manufacturing methods	2 Basics of FDM Printing	CAD modeling	02.11
11	Overview of Strength of Materials	How to make such details?		09.11
12	Finite Difference Method, FEM	CAE, durability analysis 1	Defence CAD modeling	16.11
13		CAE, durability analysis 2	Defence Durability analysis	Implement a mech in hardware, Render CAD
14				23.11
15				30.11
			Defence the complete project	15.12



Grading criteria

CP: Course project: 40%

HWs: Homework assignments: 10% Lab tasks + 20% HWs

Mid: Midterm: 10%

FE: Final Exam: 20%

Late policy: -50% off 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. A project should be implemented in hardware.



Course Project

- The project covers the main stages of the development of the mechanism: idea, synthesis and analysis of kinematics, analysis of dynamics, design, manufacture, verification.
- Project gives you 40%
- Project defense will be organized as a fair at the end of the course
- Ideal project = results can be presented at international conferences or published in international journals



Project Defence





Project Publication



International Research Journal of Engineering and Technology (IRJET)
Volume: 06 Issue: 03 | Mar 2019
www.irjet.net

e-ISSN: 2395-0056
p-ISSN: 2395-0072

Design and Fabrication of Multi Legged Robot

S.N. Teli¹, Rohan Agarwal², Devang Bagul³, Pushkar Badawane⁴, Riddhesh Bandre⁵

¹Professor, Mechanical Engineering Department, BVCOE, Navi Mumbai

^{2,3,4,5}Final Year Student, Mechanical Engineering Department, BVCOE, Navi Mumbai

Abstract – On the surface of the earth, there is the presence of wheeled and tracked vehicles. People, as well as animals, can go anywhere by the help of legs. Machine mainly consists of various mechanisms for their successful operation to get the desired output. Some of the famous mechanisms are the four-bar mechanism, single slider crank mechanism, double slider crank mechanism, etc., used for transmitting motion, force, torque etc. Our aim is to design and fabricate mechanical multi-legged robot and deformation in the kinematics links by using CADD software. The analytical data can be further used for reference purpose to design a walking robot to attain better design qualities. The analysis of the robot is based on the FEM concept integrated into Cad software called ANSYS R16.2. The aim of this project is to create an eight-legged robot to test new walking algorithm. We loosely based our design on spider because there has an advanced way in robotics on octopodal locomotion. Hopefully, the algorithm developed will be of use for the robotics community and in

mechanism and Jansen mechanism are most popular and are considered best in design.

The Fig.1 illustrates the main two mechanisms i.e. Jansen Mechanism and Klann Mechanism

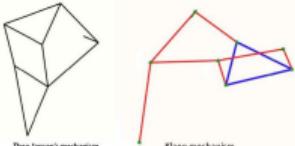


Fig 1. Jansen & Klann Mechanism

IROS 2020 - Best Student Paper Award

Computational Design of Balanced Open Link Planar Mechanisms with Counterweights from User Sketches

Takuto Takahashi, Hiroshi G. Okuno, Shigeki Sugano, Stelian Coros and Bernhard Thomaszewski





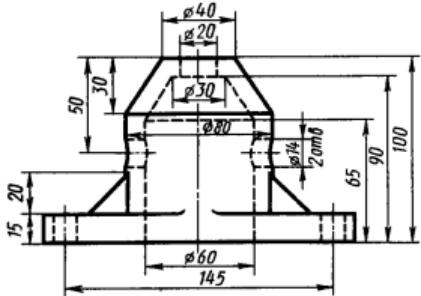
Information about project

In «Project» slides



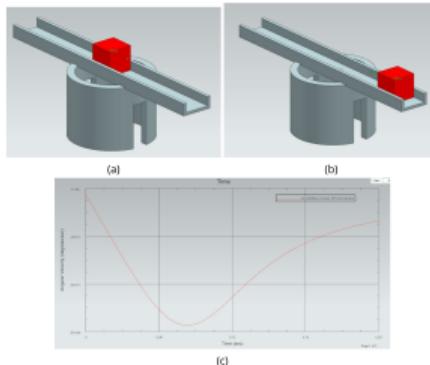
Final Exam (Previous Year)

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 chosing? 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



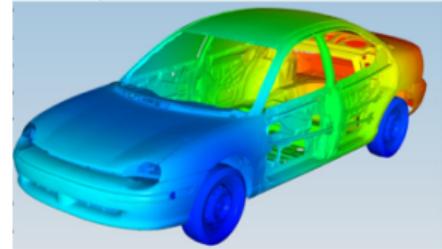
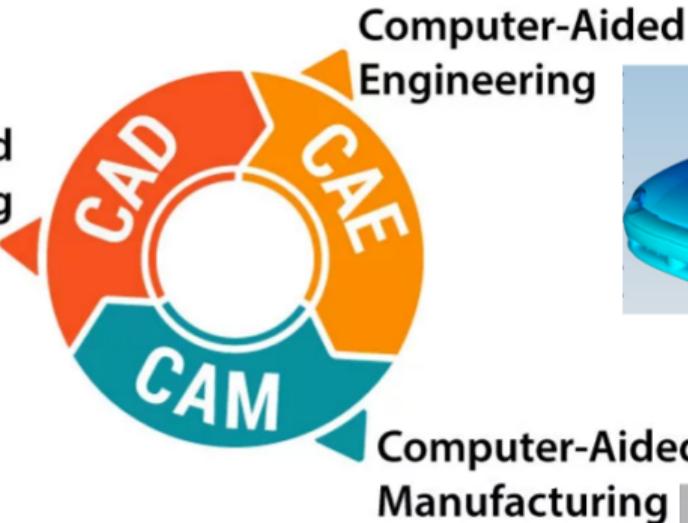
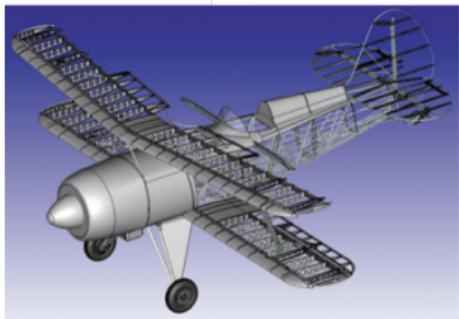
Lab Goals

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



Computer Aided Design

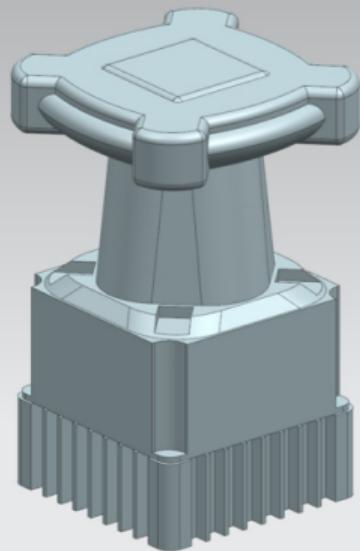
Computer-Aided
Drafting





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

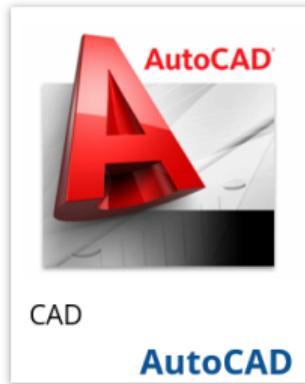
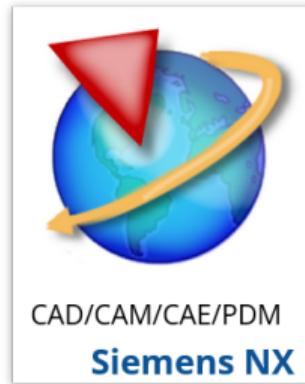
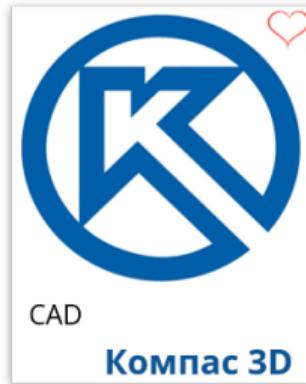
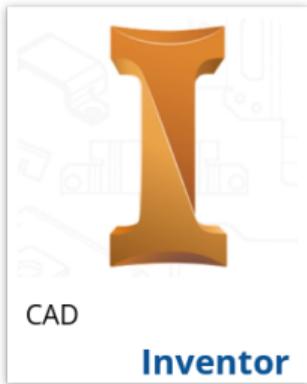
Cheaper

Safer

Faster



Popular CAD systems in Russia

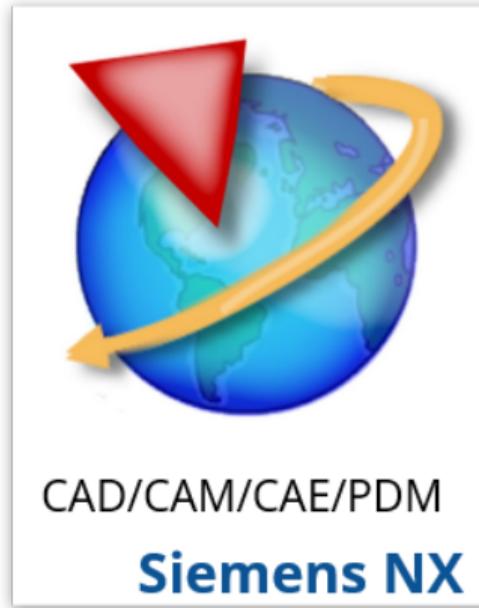




Siemens NX

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 HW and Lab in Moodle (formal stuff for late policy).

Lab 2

1. Oleg explains some new concepts.
2. Oleg provides new HW, which should be done after the lab.
3. You defend previous lab task solutions and HW results.
4. 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.

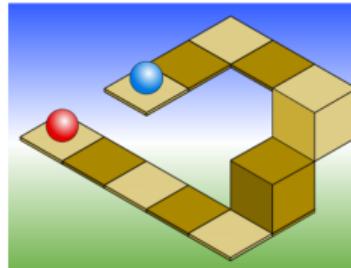
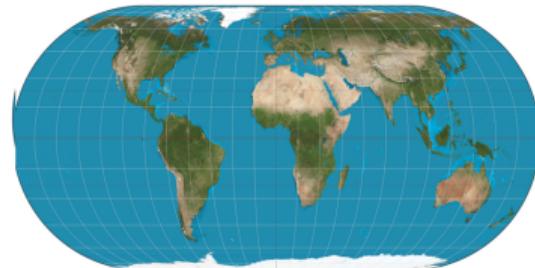
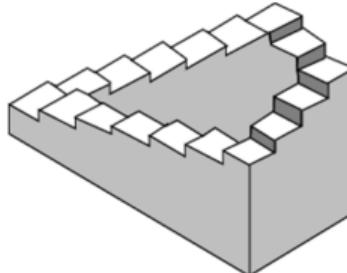
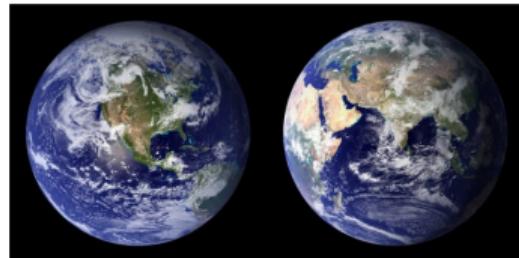




Projections

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

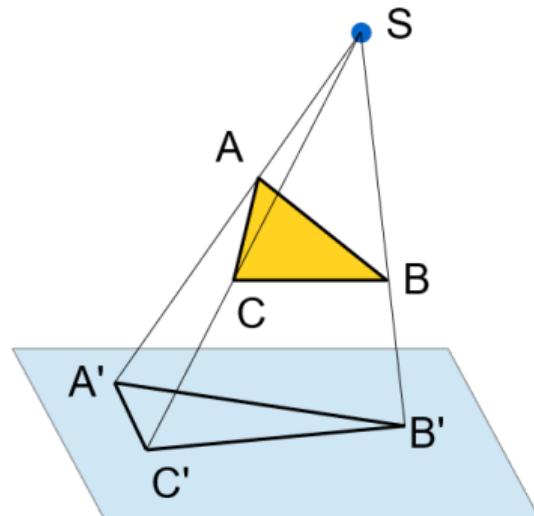
On the other hand, we can draw something absolutely impossible or something possible but unclear.





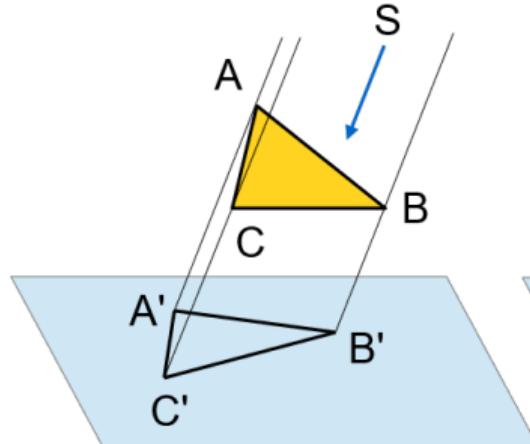
Parallel and perspective projections

Central (perspective) projection

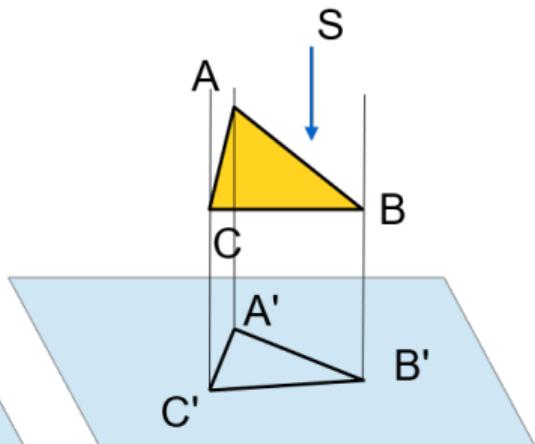


Parallel projections

General (oblique) case



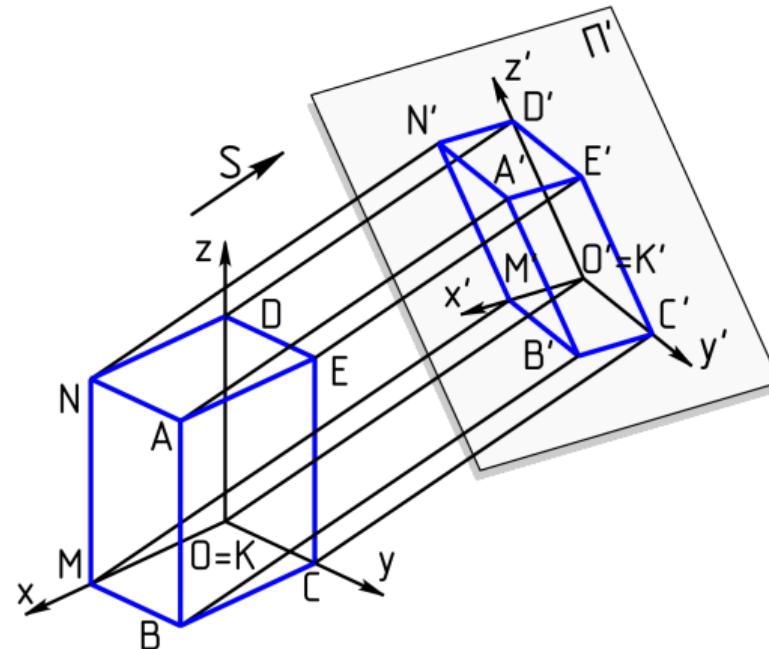
Orthographic projection





Axonometric projections

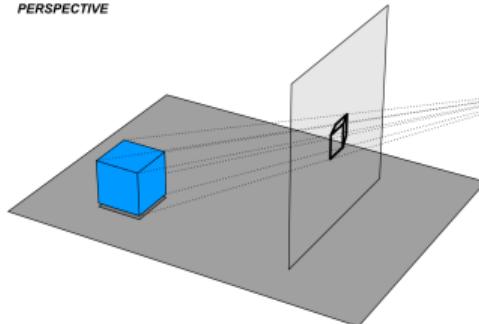
General



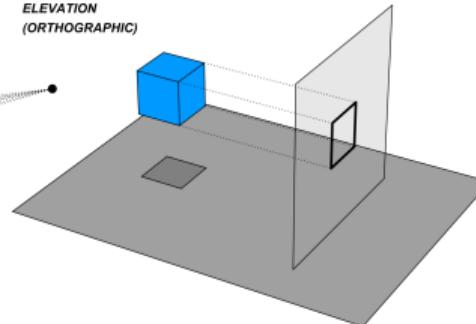


Axonometric projections

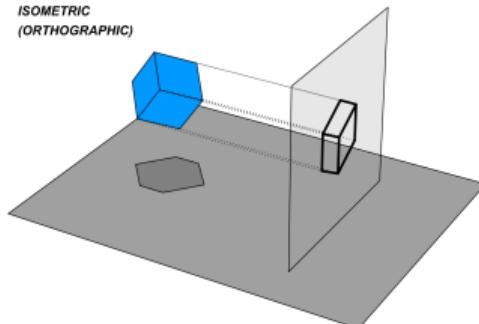
PERSPECTIVE



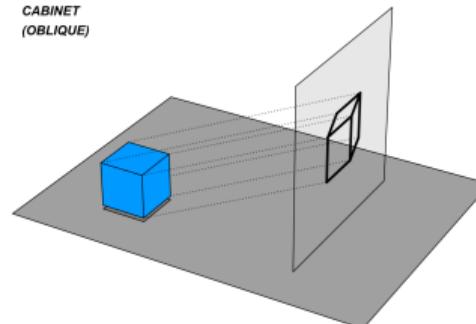
ELEVATION
(ORTHOGRAPHIC)



ISOMETRIC
(ORTHOGRAPHIC)

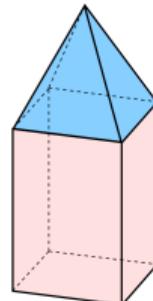
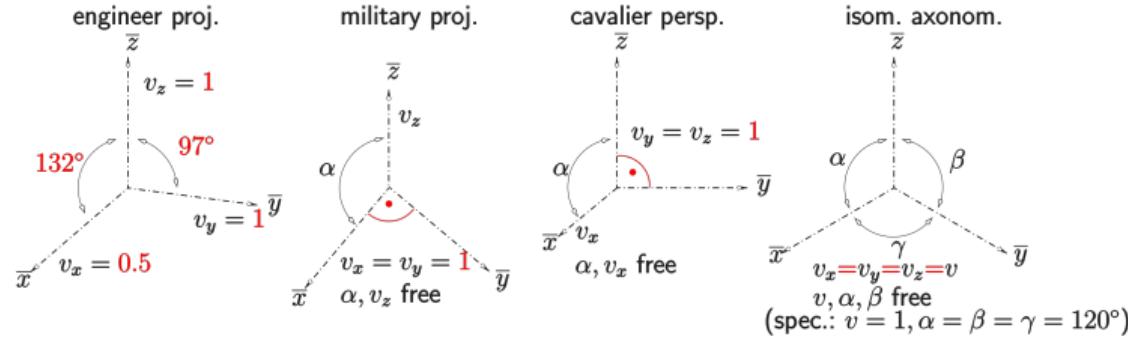


CABINET
(OBlique)

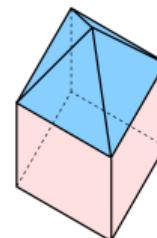




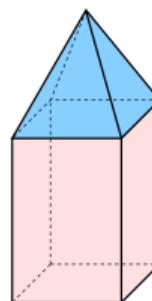
Axonometric projections



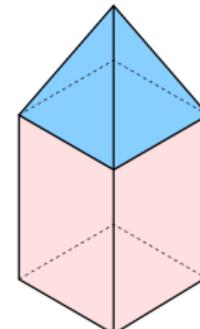
engin. proj.



milit. proj.



caval. persp.



isom. axon.

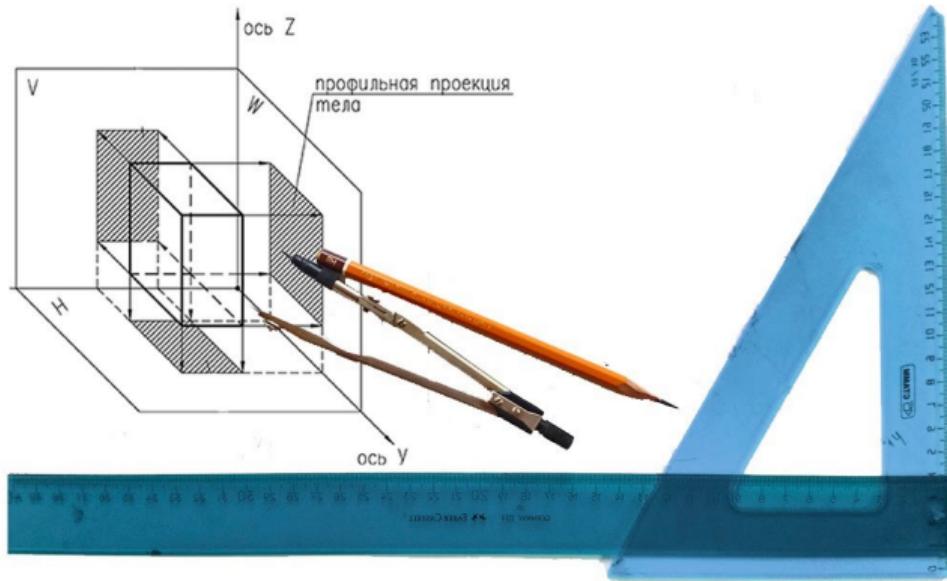


Make a line projection

Video

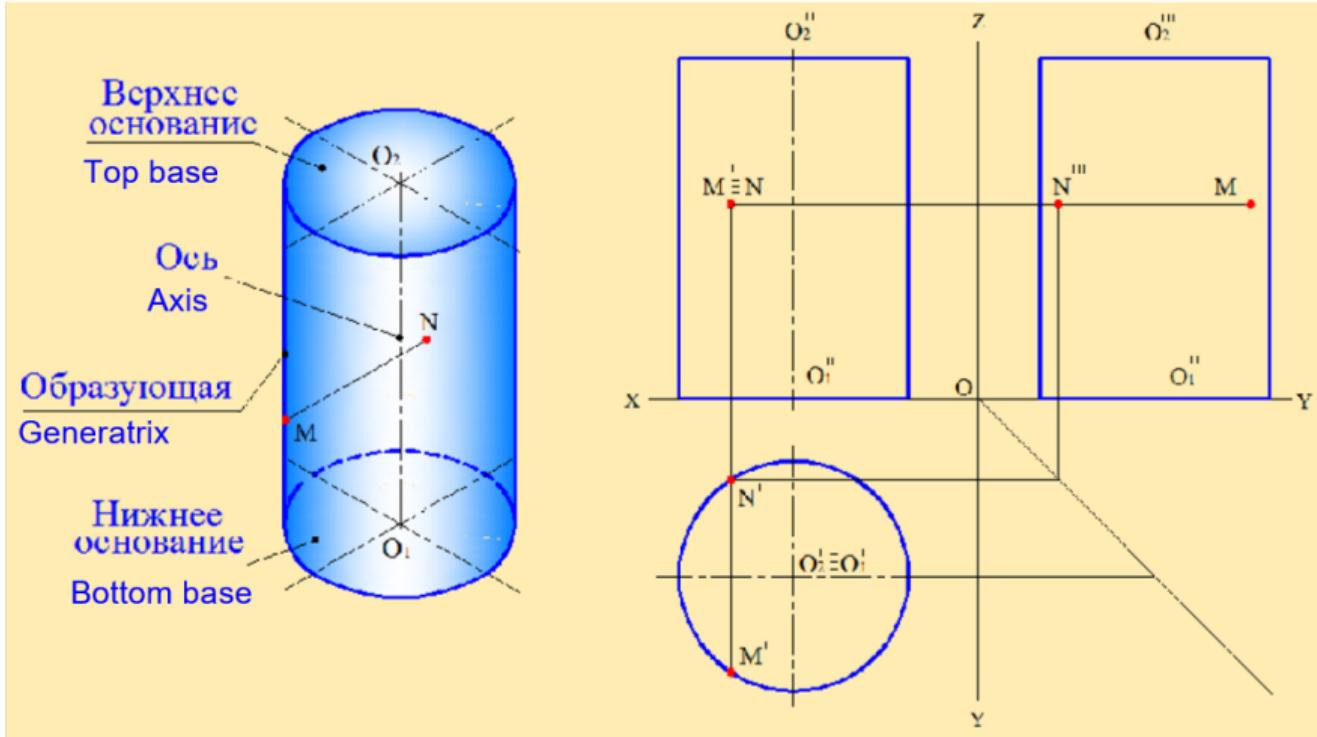
Черчение
школа архитектурный ВУЗ

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



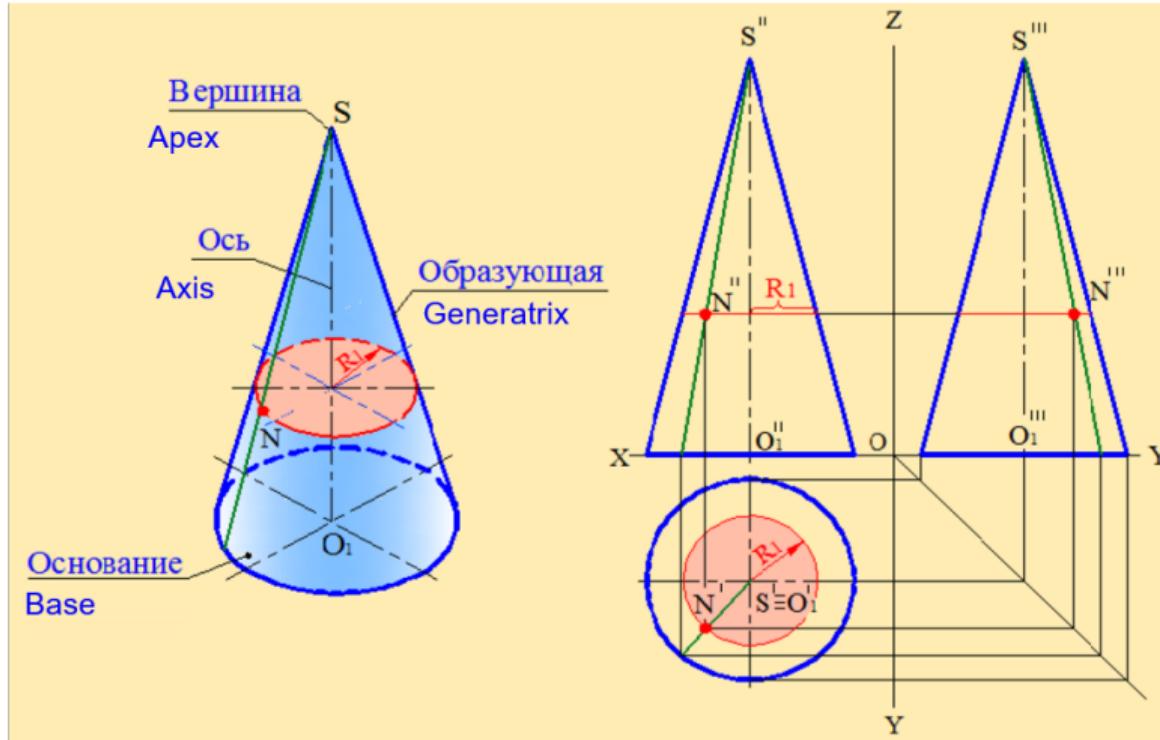


Orthographic Multiview projections



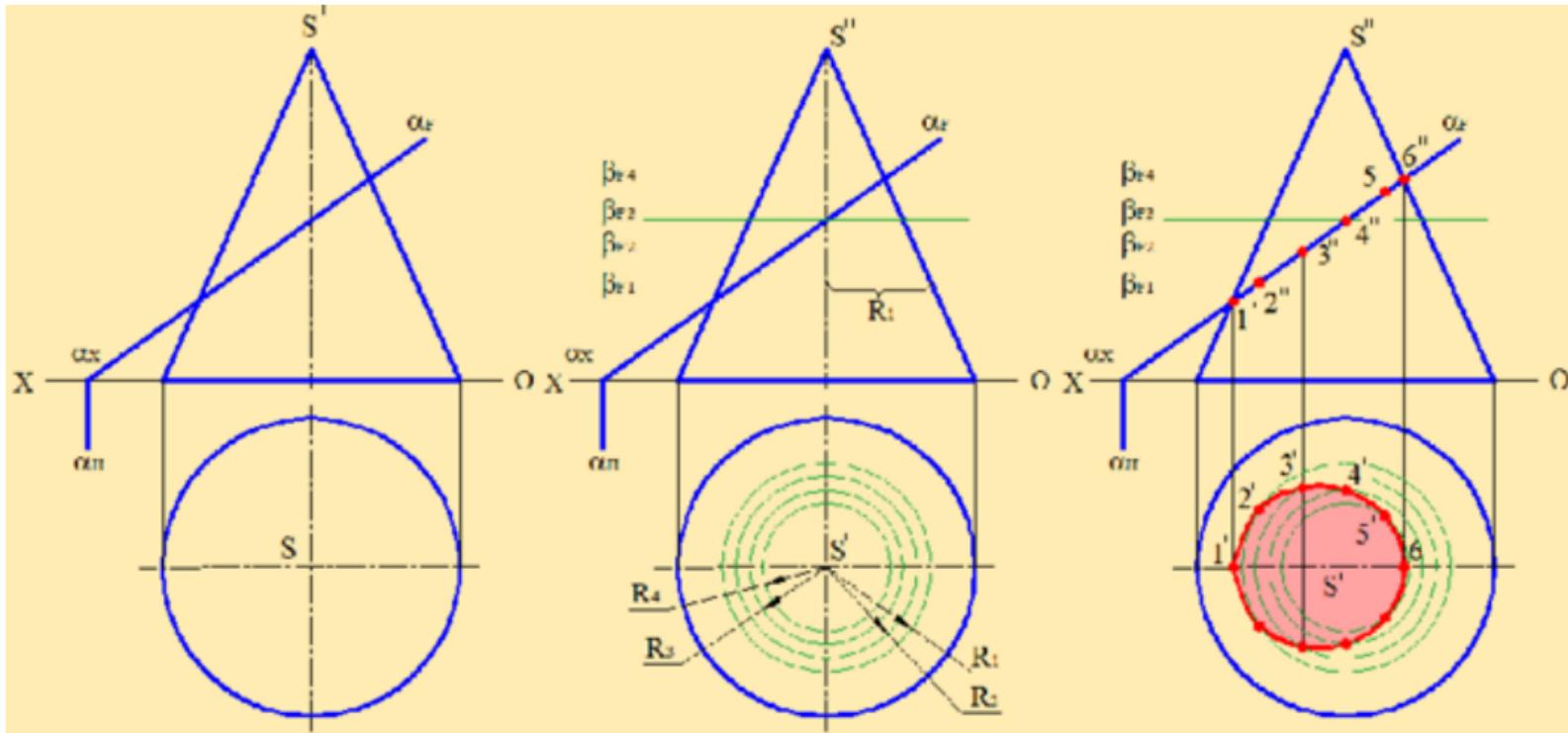


Orthographic Multiview projections



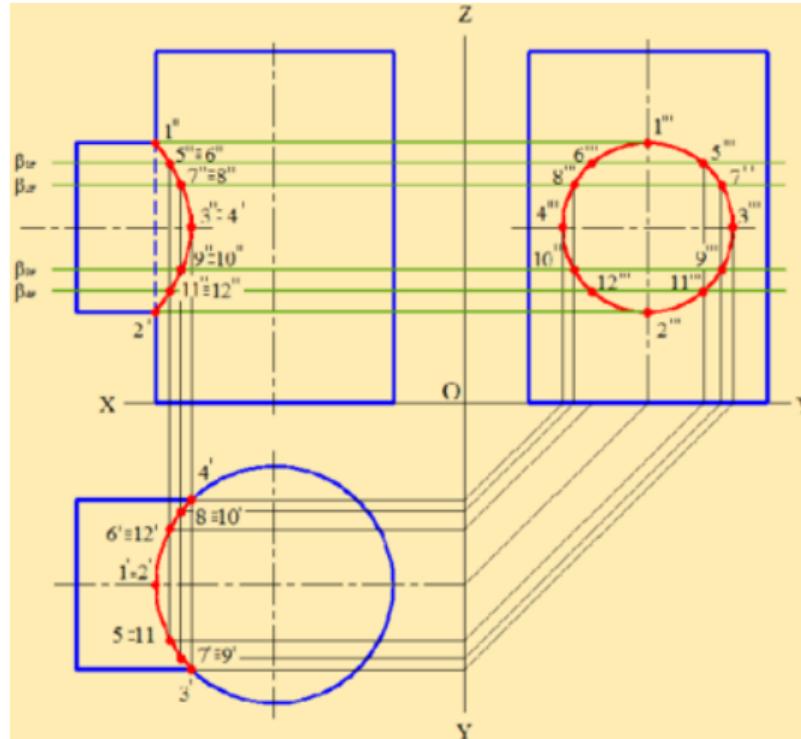


Orthographic Multiview projections





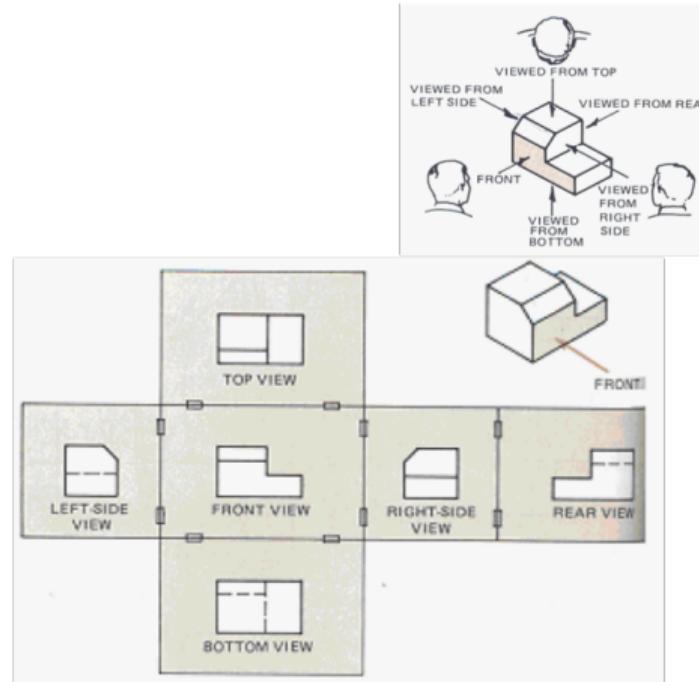
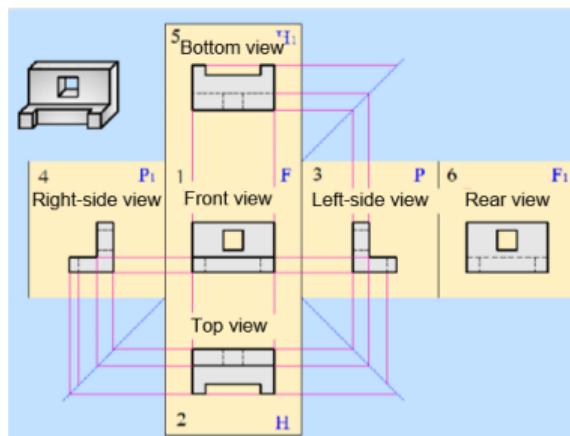
Orthographic Multiview projections





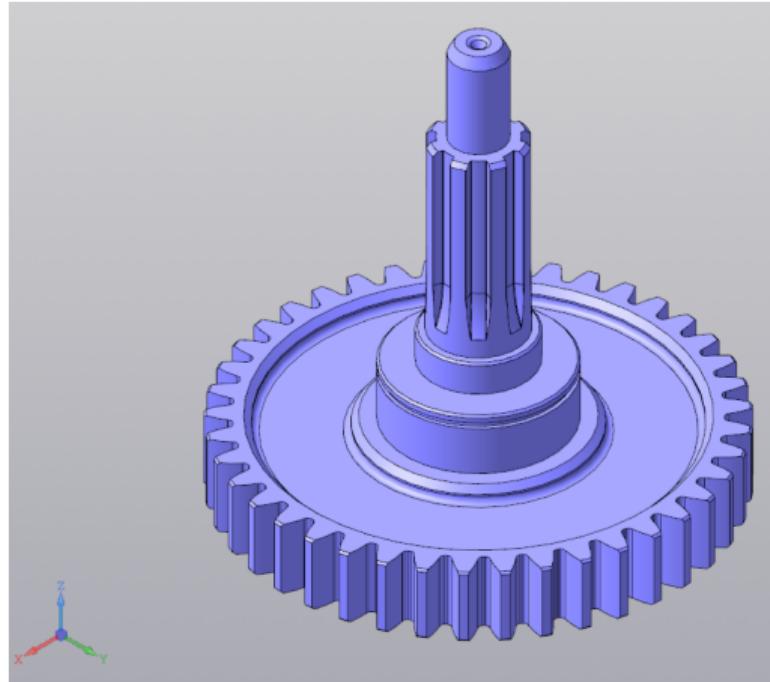
Orthographic Multiview projections

The difference between European and American standards

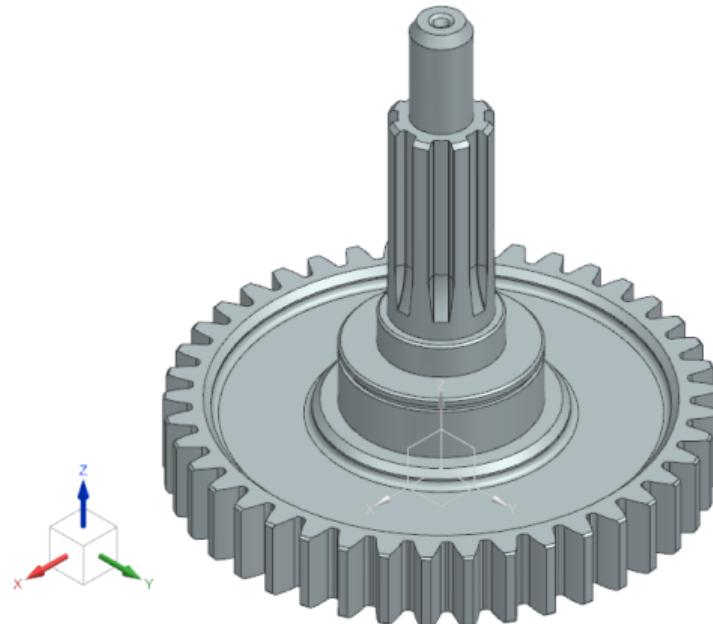




Orthographic Multiview projections



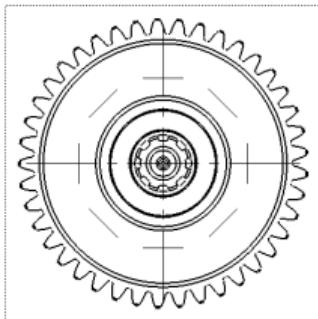
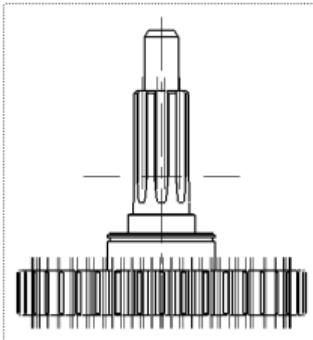
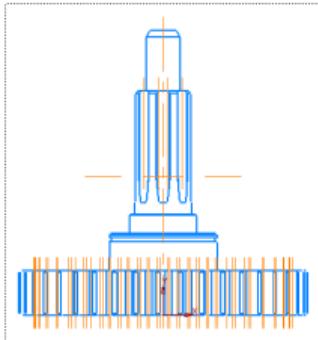
Kompas 3D



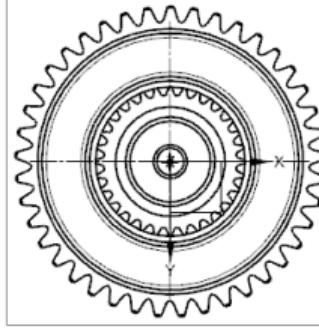
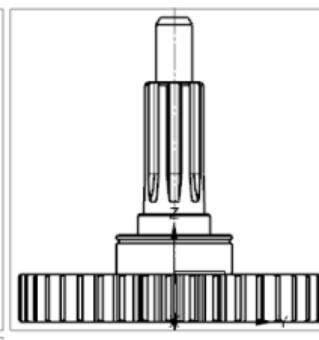
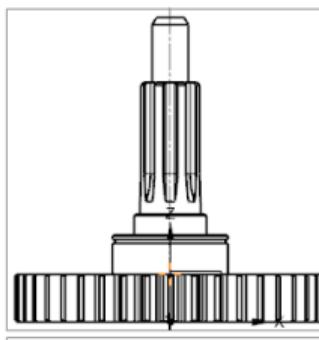
Siemens NX



Orthographic Multiview projections



Kompas 3D (European system)



Siemens NX (American system)

Drawing standards



SIEMENS

THIS DRAWING HAS BEEN PRODUCED USING AN EXAMPLE TEMPLATE PROVIDED BY SIEMENS PLM SOFTWARE

FIRST ISSUED: Kuk TITLE:

DRAWN BY: Student

CHECKED BY: Oleg

APPROVED BY: God

SIZE: A2 Dwg No.: dwg1 SHEET REV: A

SCALE 1:1 SHEET 1 OF 1

ALL DIMENSIONS IN MM

8 9 10 11 A2

ANSI standard Title Block

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Пров	Кузьминченко РР						
Т. контр							
Н. контр							
Чтв							

АНЦП.014.00.00.003

Корпус для вала

Д16Т ГОСТ 4784-97

АНО ВО
"Университет Иннополис"

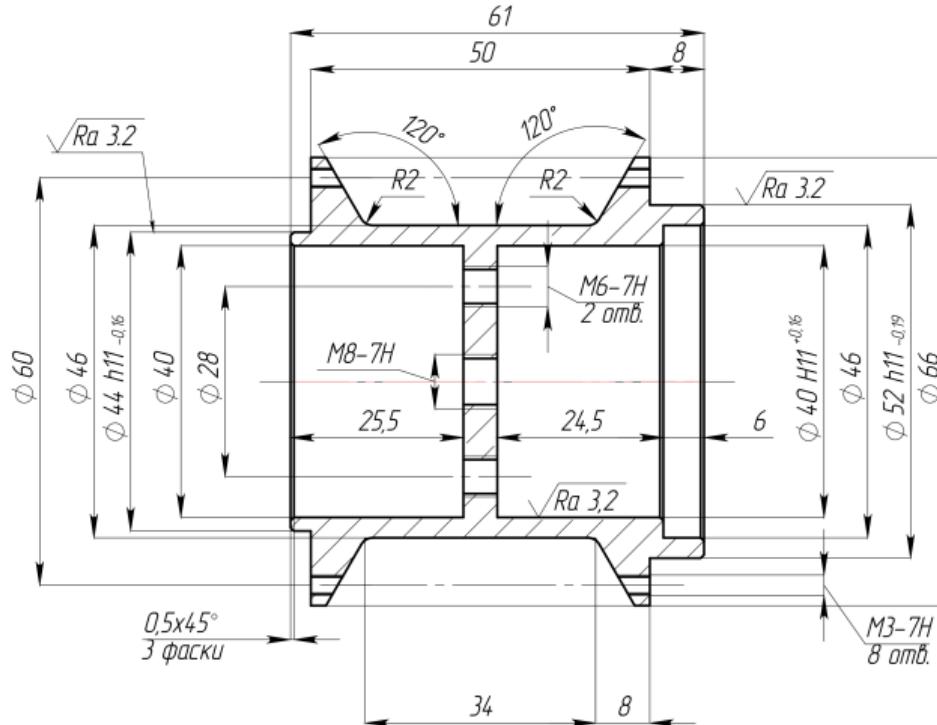
Копировано

Формат А2

GOST standard Title Block

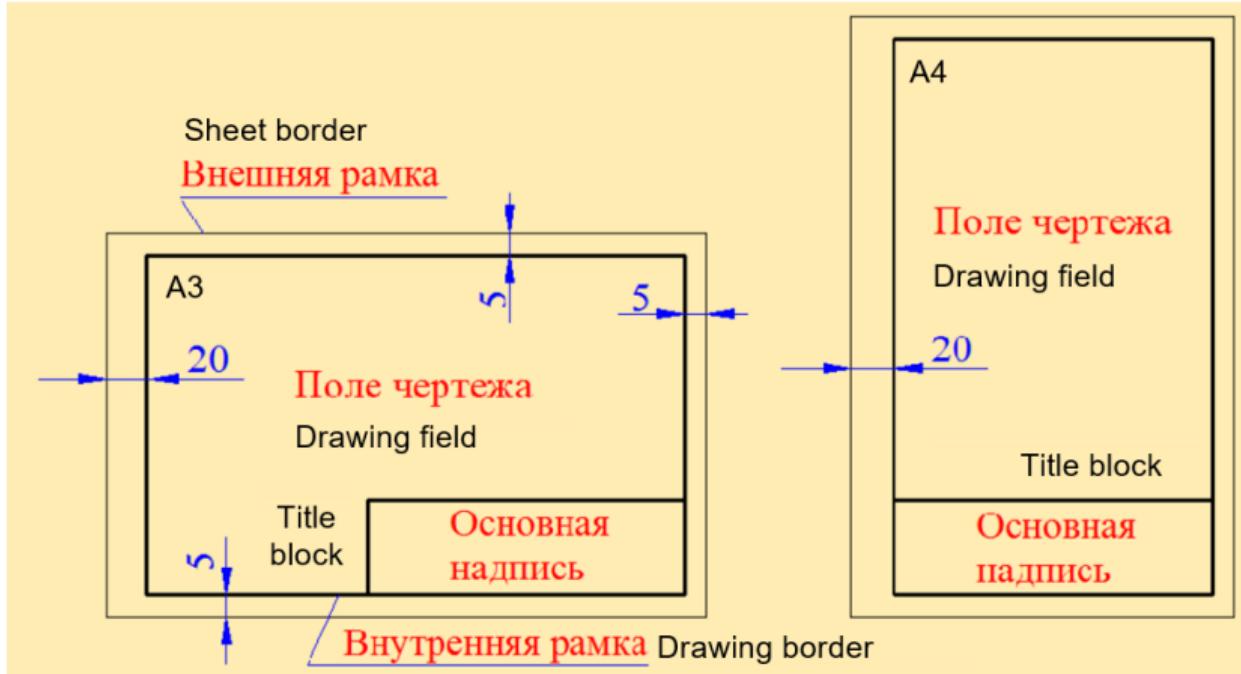


GOST Drawing Example





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	$1:2$ $1:3$ $1:5$ $1:10$ $1:100$

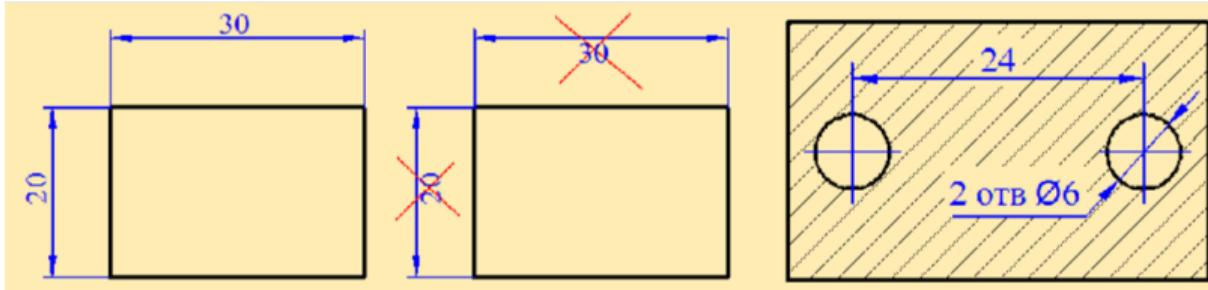
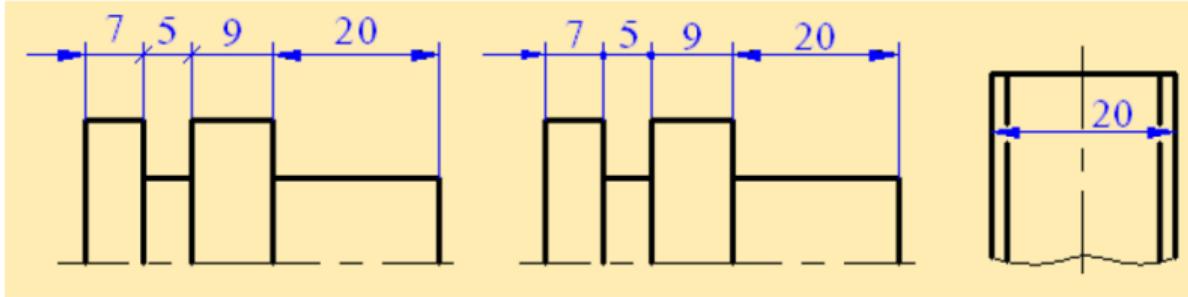


Type of lines

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

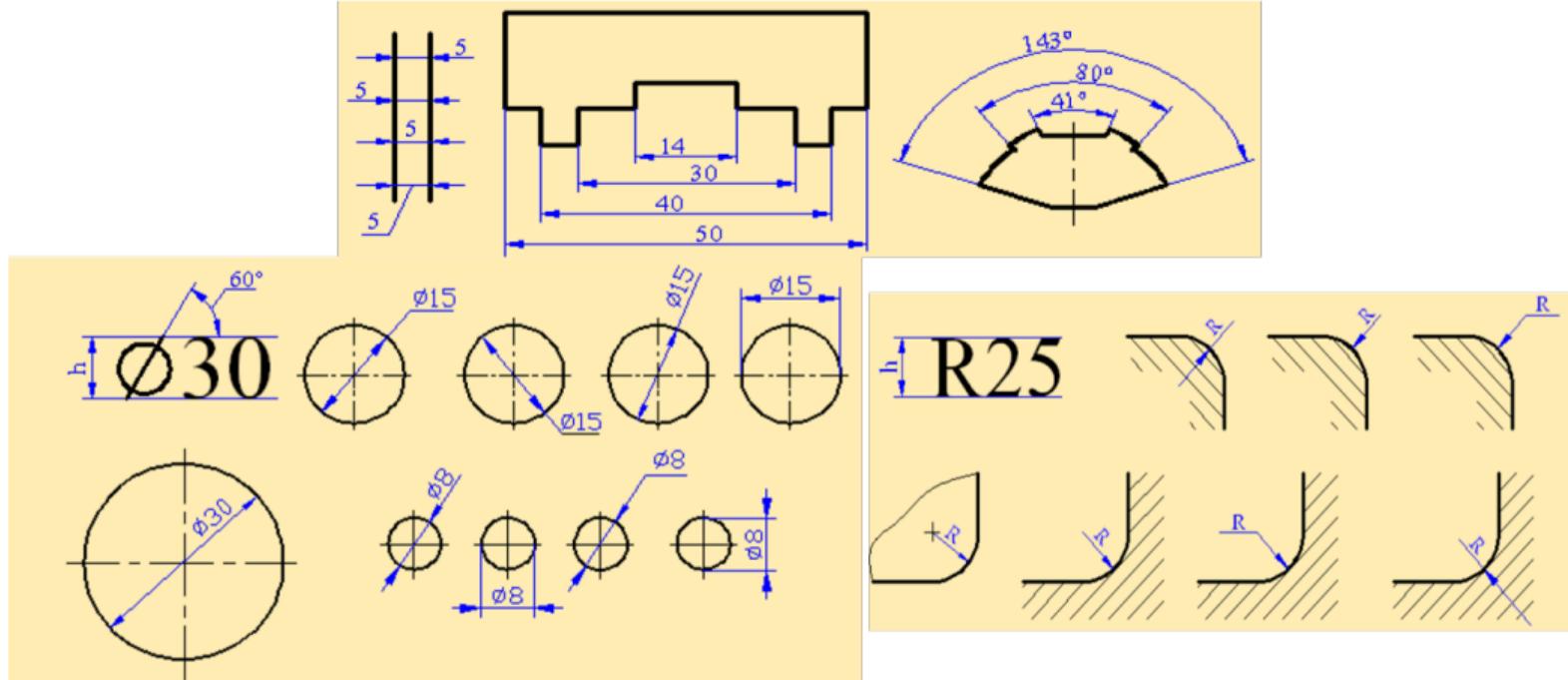


GOST Standard



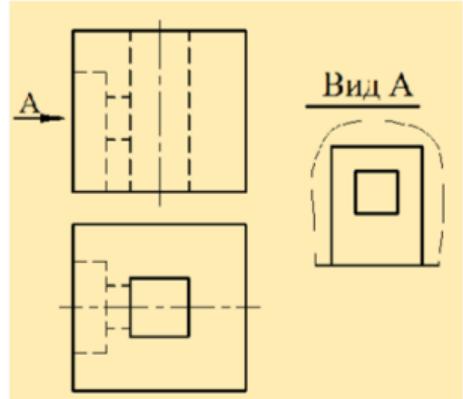
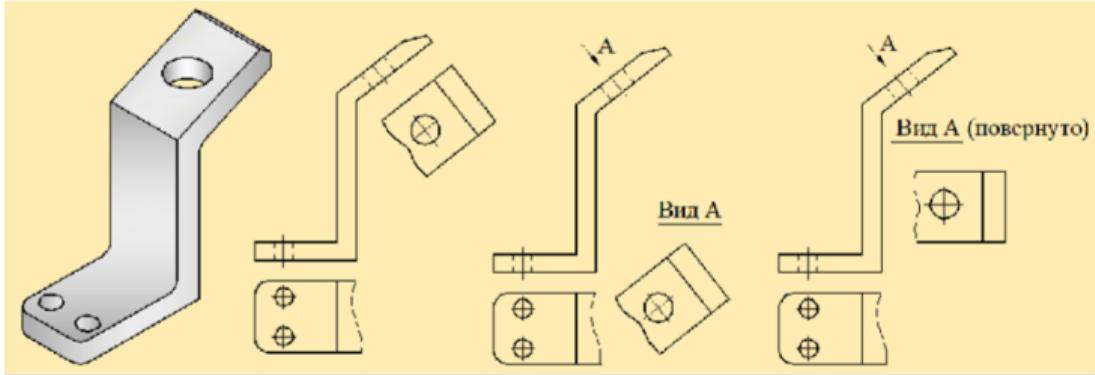


GOST Standard

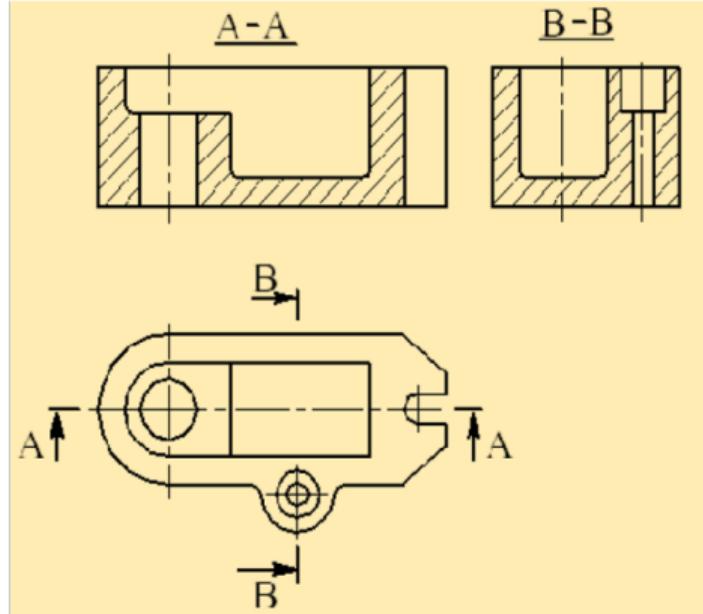
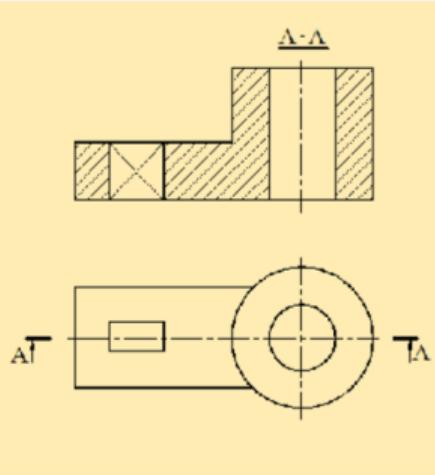
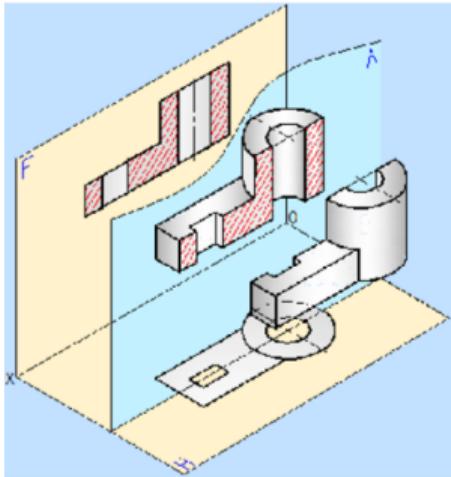




GOST Standard

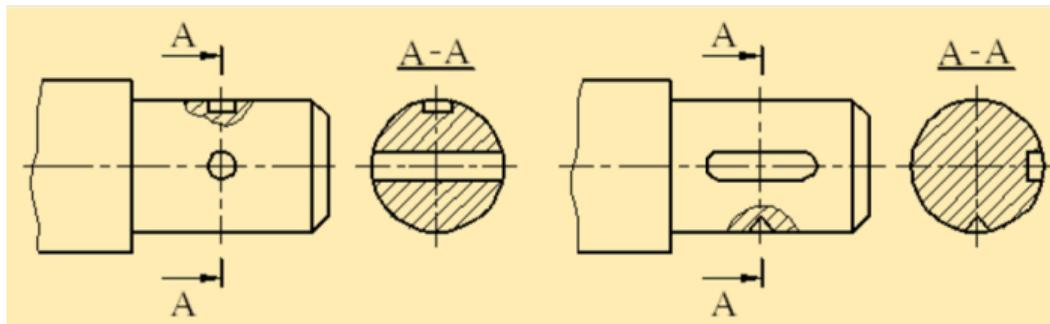
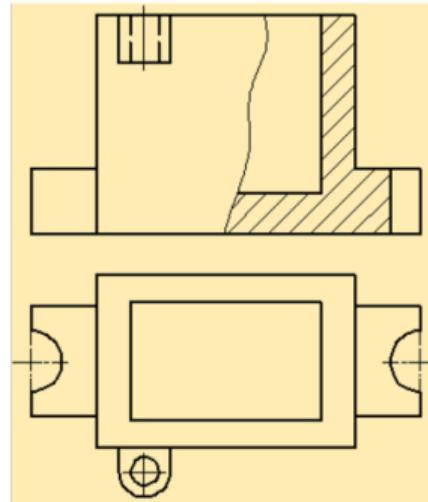
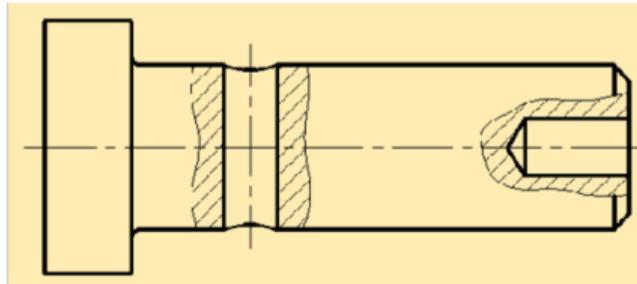


GOST Standard

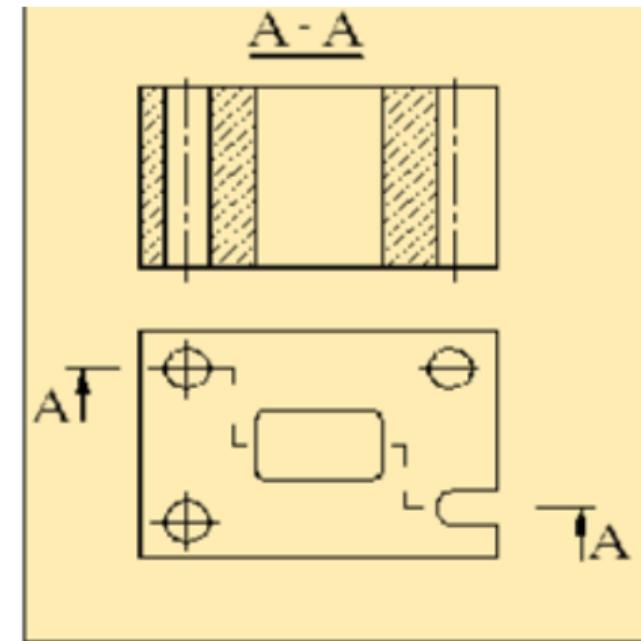
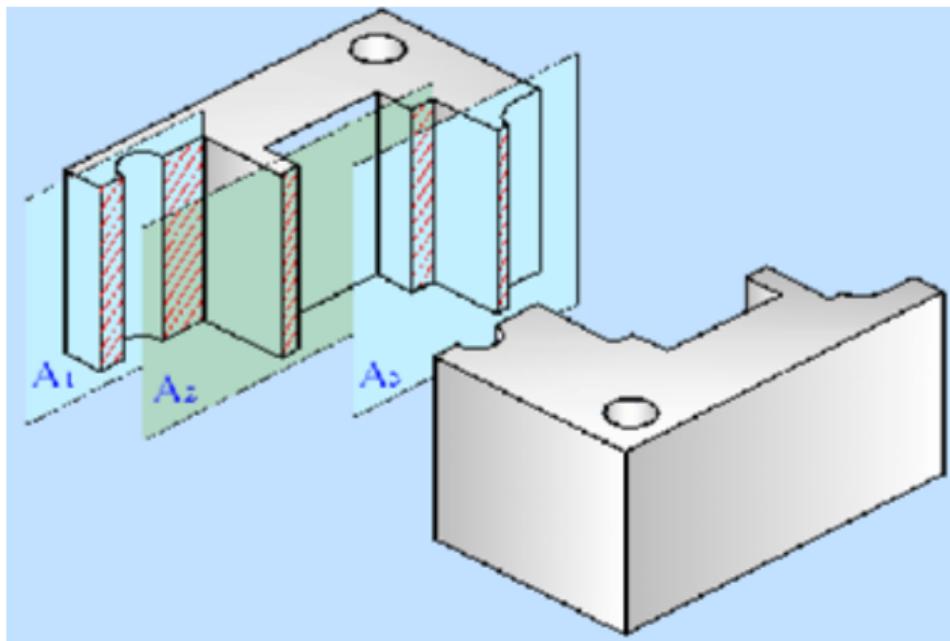




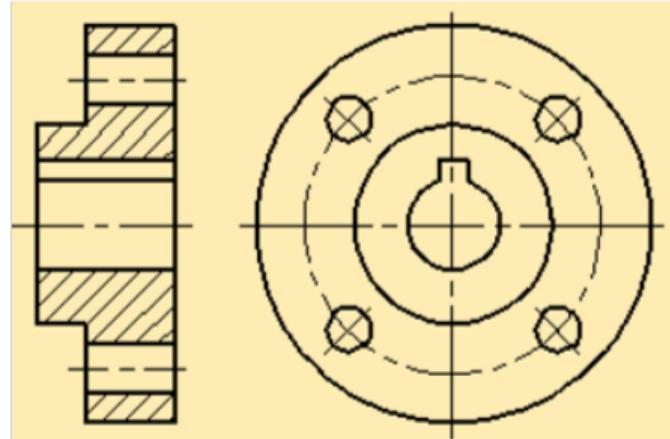
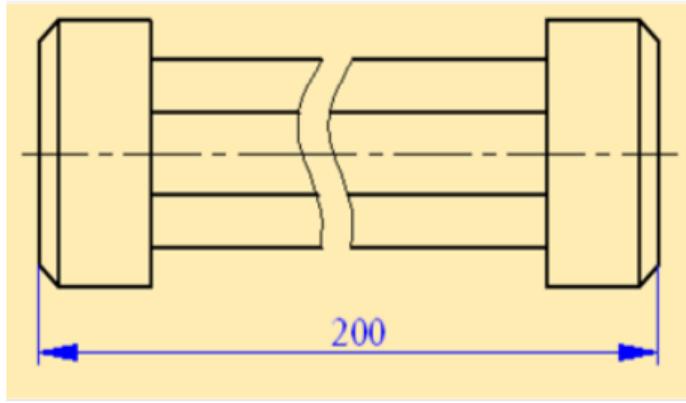
GOST Standard



GOST Standard

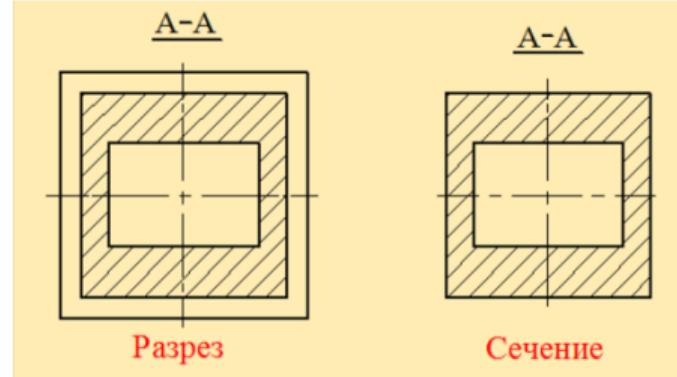
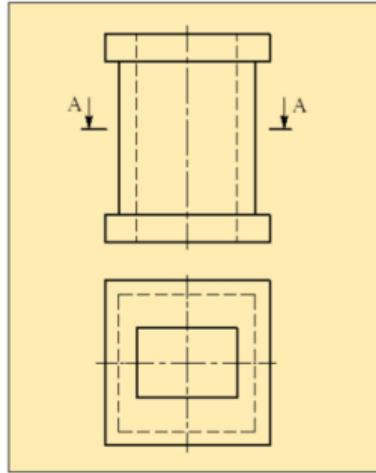
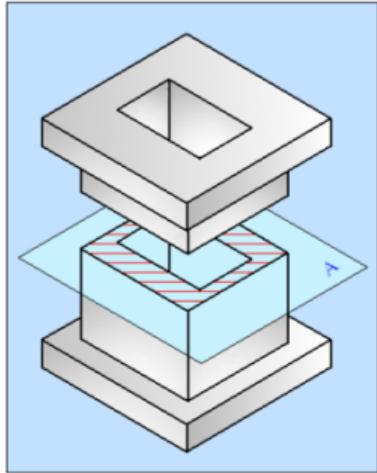


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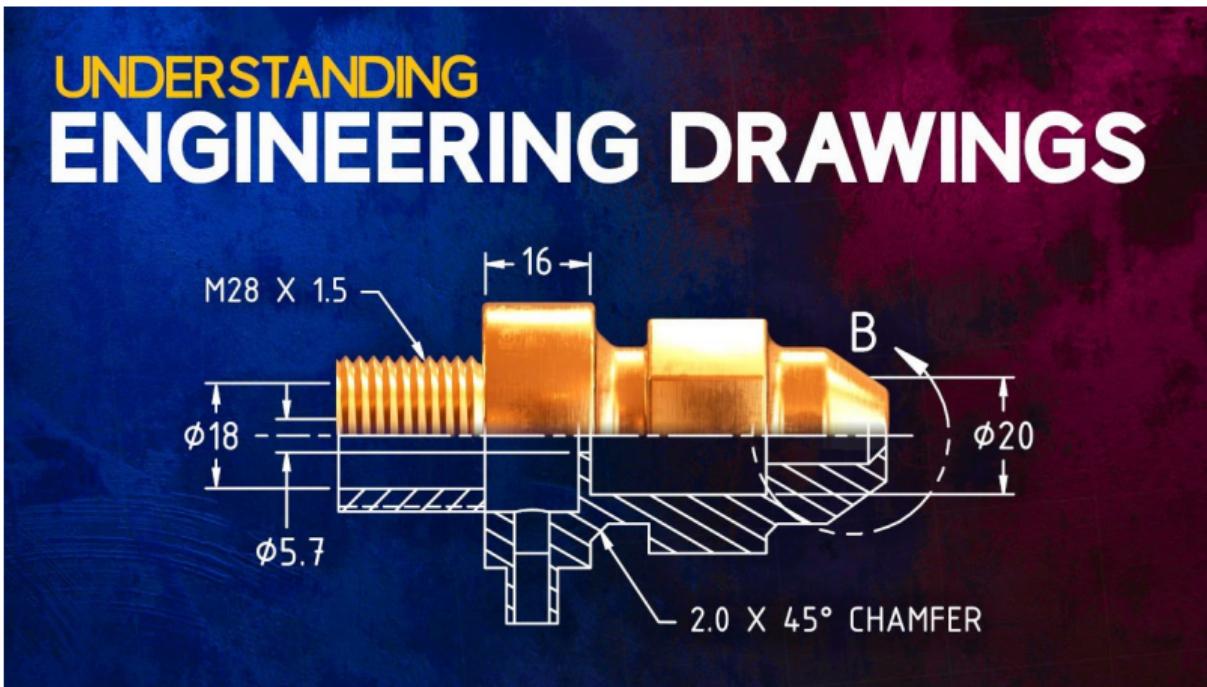
GOST Standard





Understanding Engineering Drawings

Video





Reference Materials

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

Deserve “A” grade!

– Oleg Bulichev

✉ o.bulichev@innopolis.ru

↗ @Lupasic

🚪 Room 105 (Underground robotics lab)