

Mechanics and Machines, 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

Week	Lecture topic	Lab topic	Project milestones	Date
1	Engineering drawings	CAD, details 1		27.08
2	Kinematic pairs	CAD, details 2		03.09
3	Type of drives Overview of materials used in mechanical engineering	CAD, assembly 1 Overview of materials used in mechanical engineering	Project Selection Defence selection	10.09
4	mechanical engineering 1	mechanical engineering 2		17.09
5	Basics of FDM Printing	CAD, assembly 2		24.09
6	Motor sizing (selection)	CAE, motion simulation 1	Defence Kinematics, analytical solution	01.10
7	Friction	CAE, motion simulation 2		08.10
8	Synthesis of planar mechanisms	CAE, motion simulation 3	Defence Dynamics, analytical solution	15.10
9	Links, Joints, Connections, Bearings	Render Overview of manufacturing methods		22.10
10	Connections: Detachable		Defence Dynamics, simulation	29.10
11	Connections: Permanent	How to make such details?		05.11
12	Overview of Strength of Materials	CAE, durability analysis 1	Defence CAD modeling	12.11
13	Finite Difference Method, FEM 1	CAE, durability analysis 2	Defence Durability analysis	19.11
14	Finite Element Method, FEM 2			26.11
15			Defence the complete project	15.12



Grading criteria

What will be evaluated on the course

Qz: Quizzes: $2 \times 5 = 10\%$

Lbs: Lab assignments: 10%

HWs: Homework assignments: 20%

CP: Course project: 40%

FE: Final Exam: 20%

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. A project should be implemented in hardware.



Quizzes

Purpose: You will have theoretical questions on final exam. Quizzes encourage you to study material more seriously.



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

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^{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

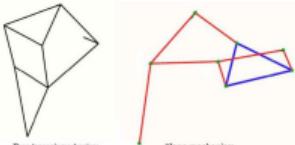


Fig 1. Jansen & Klann Mechanism

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





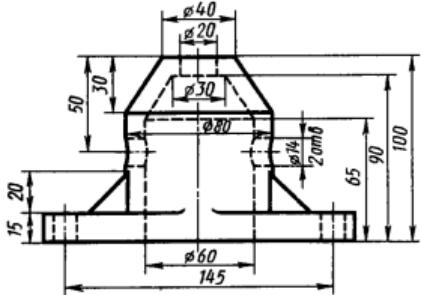
Information about project

In «Project» slides



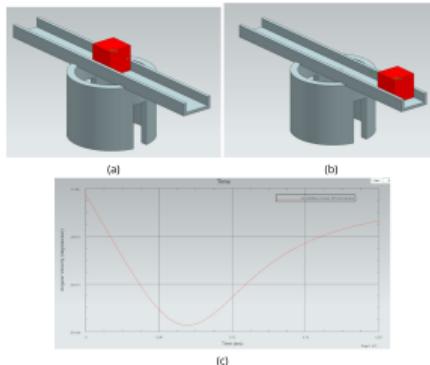
Final Exam (Previous Year)

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



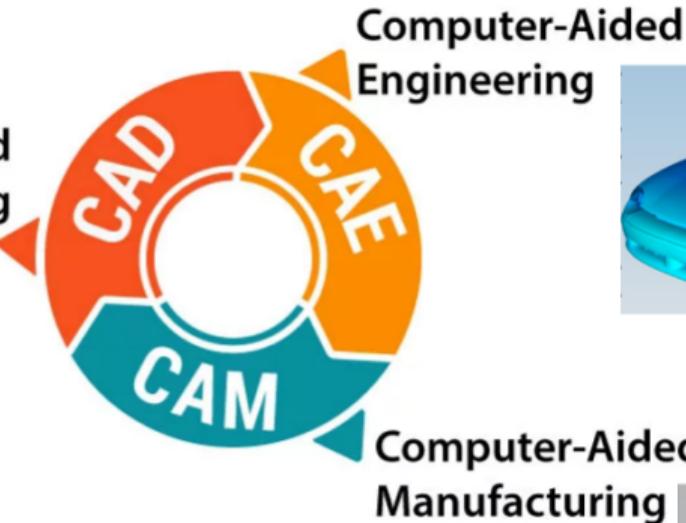
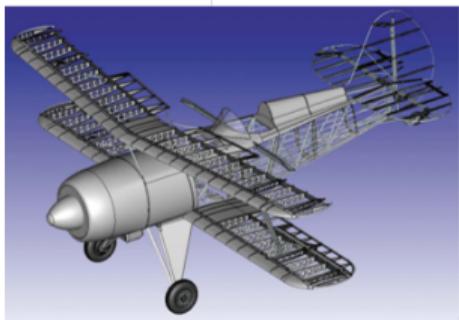
Lab Goals

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

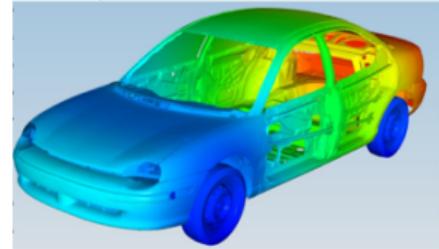


Computer Aided Design

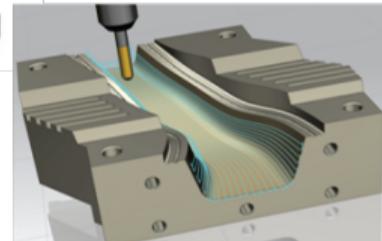
Computer-Aided
Drafting



Computer-Aided
Engineering



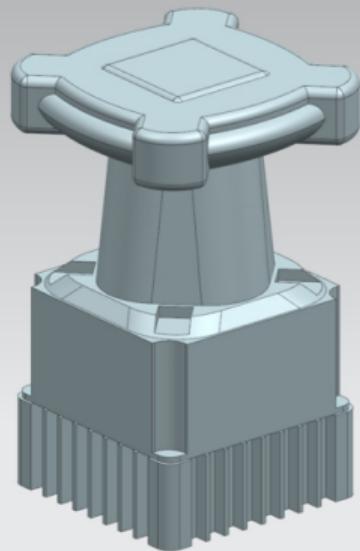
Computer-Aided
Manufacturing





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

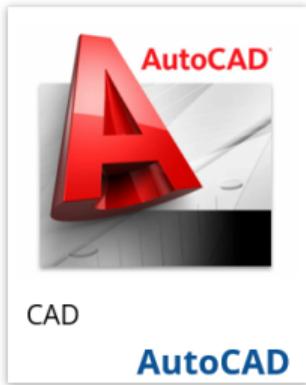
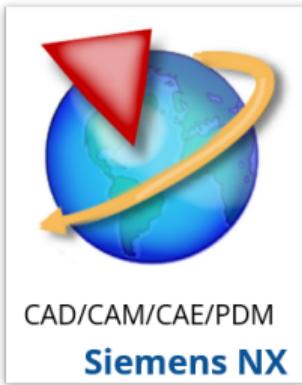
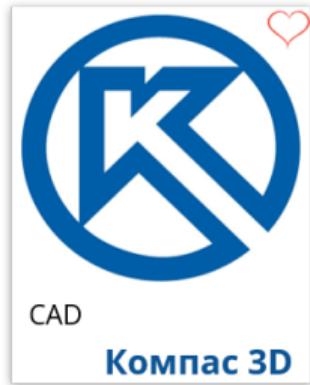
Cheaper

Safer

Faster



Popular CAD systems in Russia



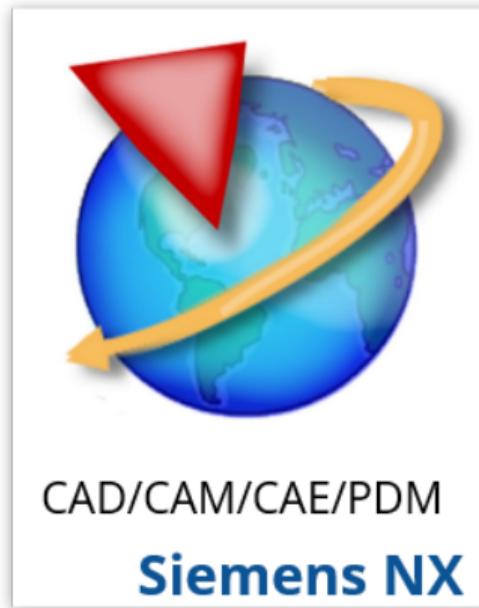
Siemens NX

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.

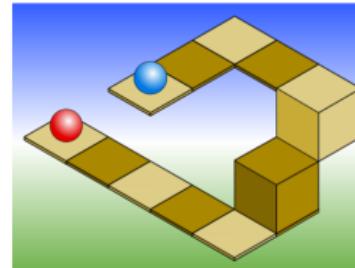
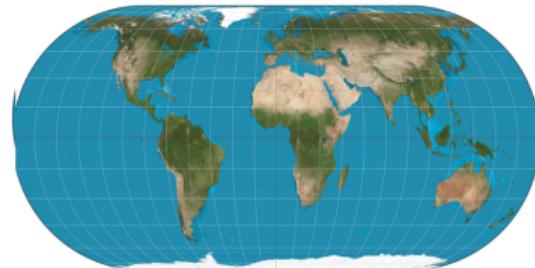
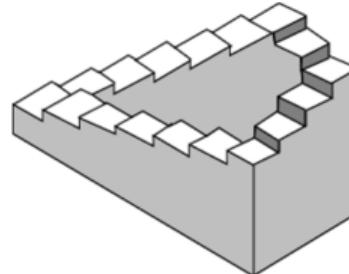




Projections

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

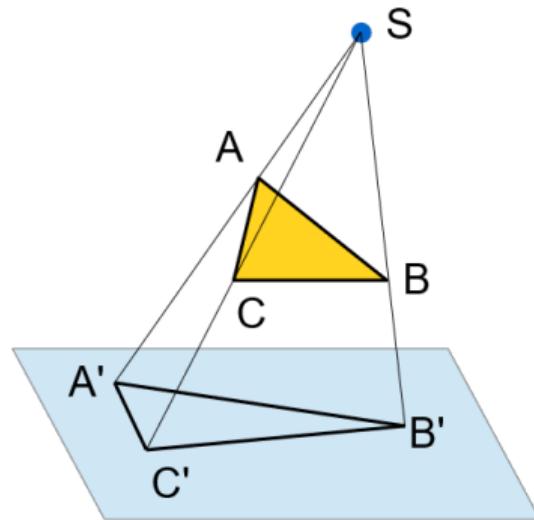
On the other hand, we can draw something absolutely impossible or something possible but unclear.





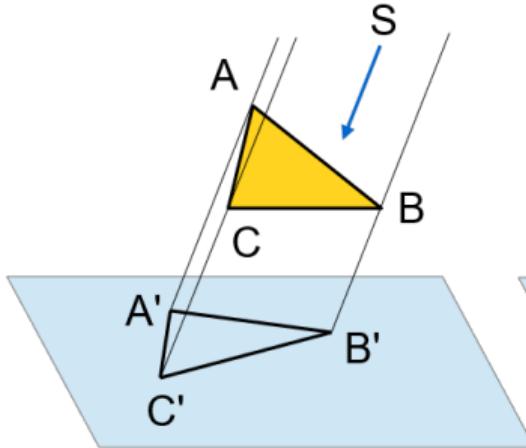
Parallel and perspective projections

Central (perspective) projection

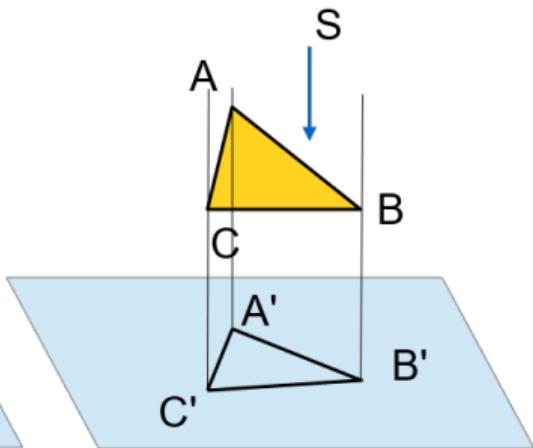


Parallel projections

General (oblique) case



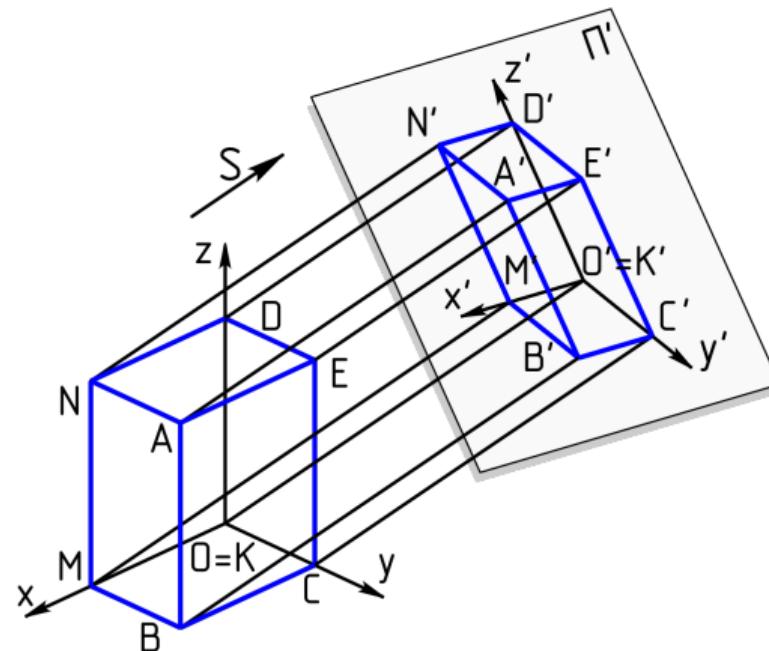
Orthographic projection





Axonometric projections

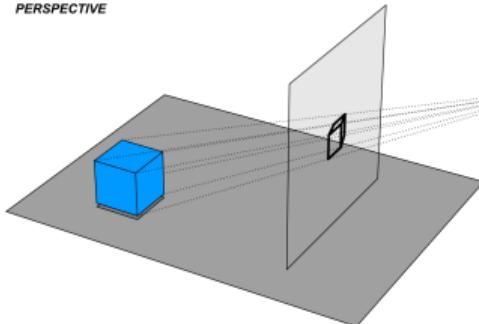
General



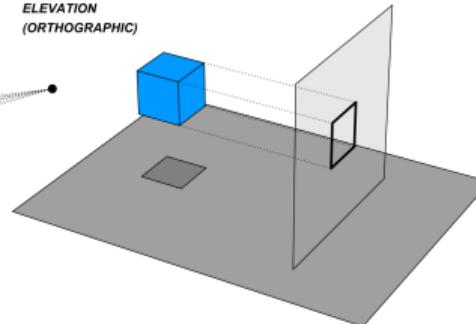


Axonometric projections

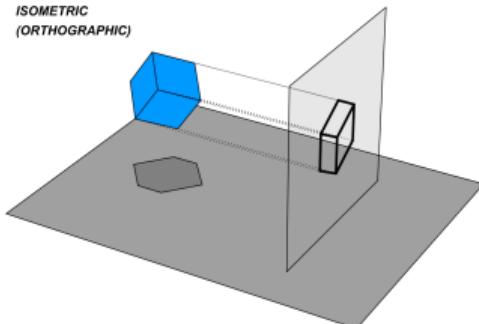
PERSPECTIVE



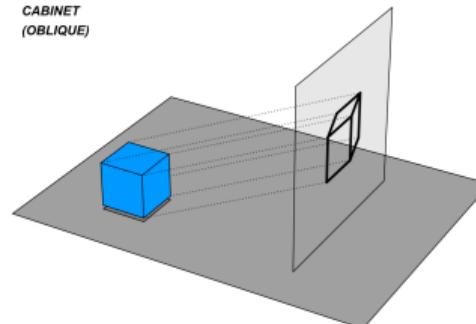
ELEVATION
(ORTHOGRAPHIC)



ISOMETRIC
(ORTHOGRAPHIC)

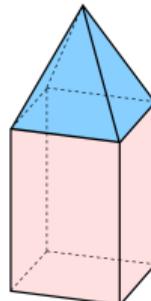
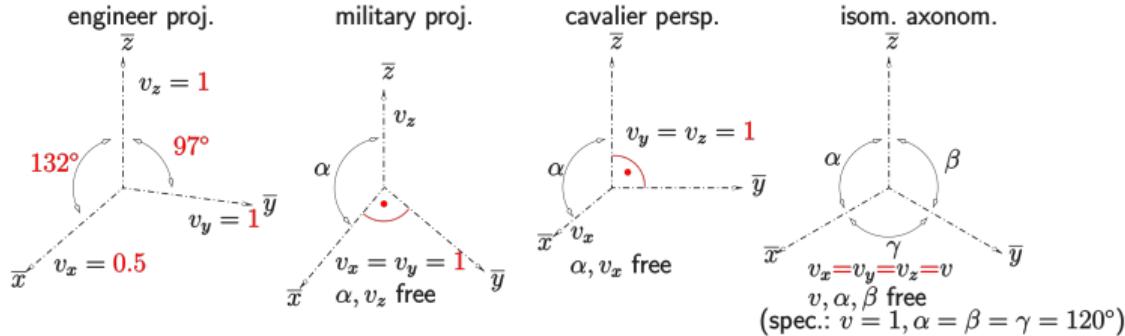


CABINET
(OBlique)

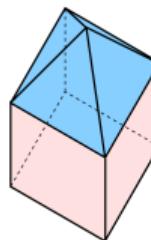




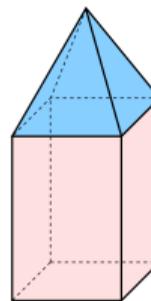
Axonometric projections



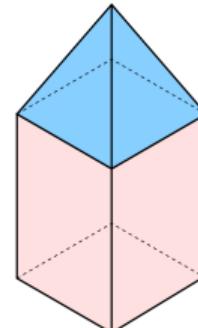
engin. proj.



milit. proj.



caval. persp.



isom. axon.

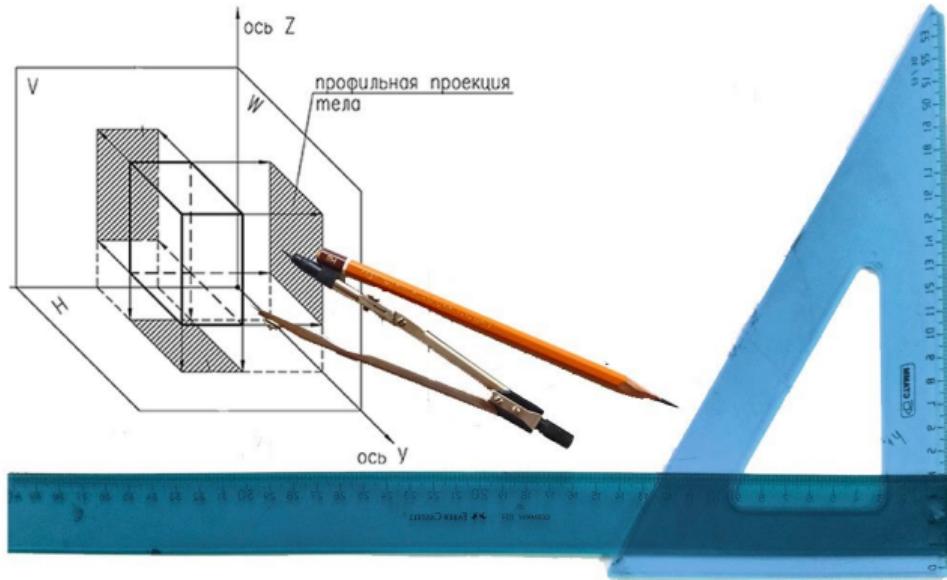


Make a line projection

Video

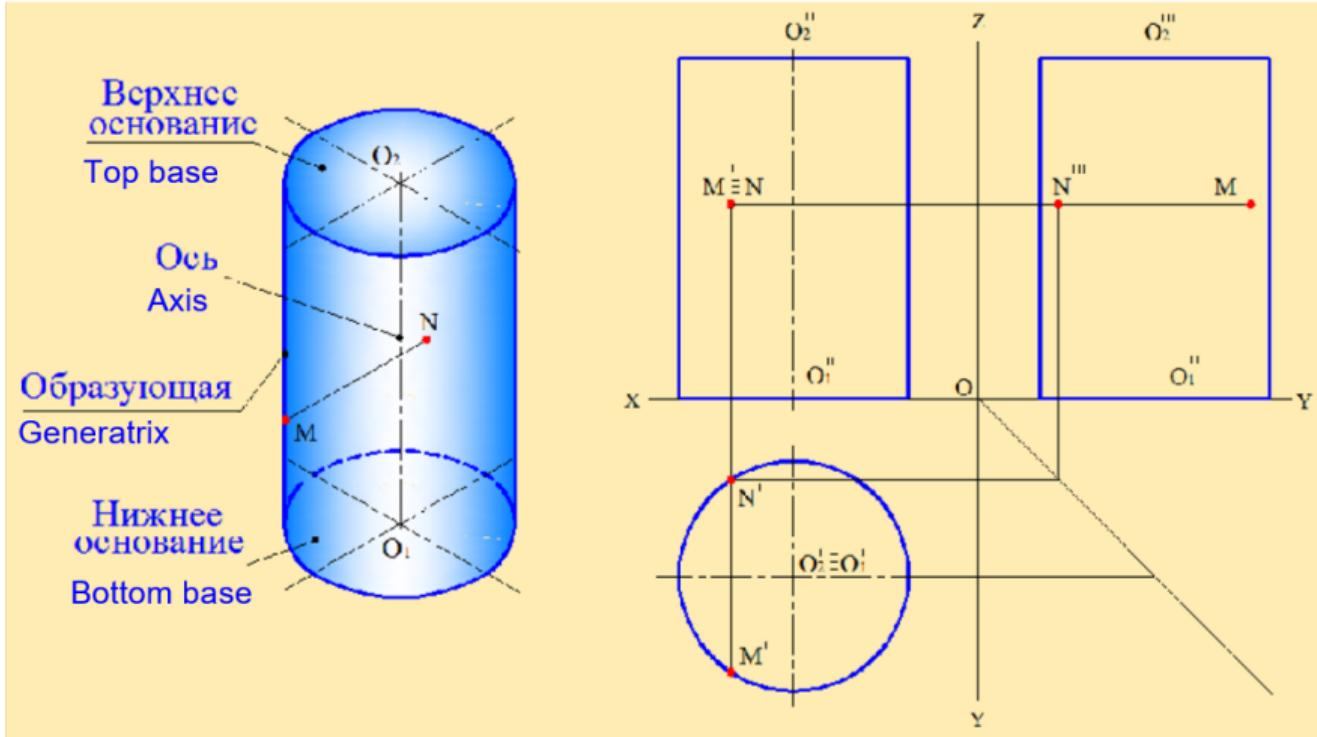
Черчение
школа архитектурный ВУЗ

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



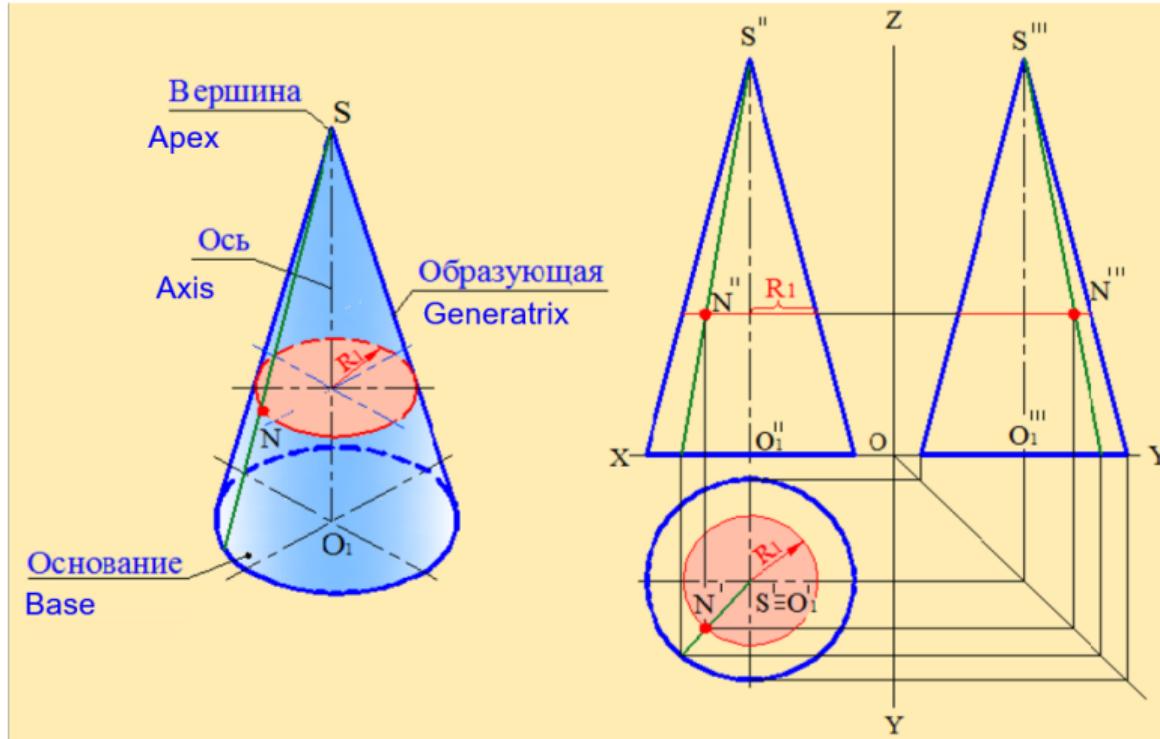


Orthographic Multiview projections



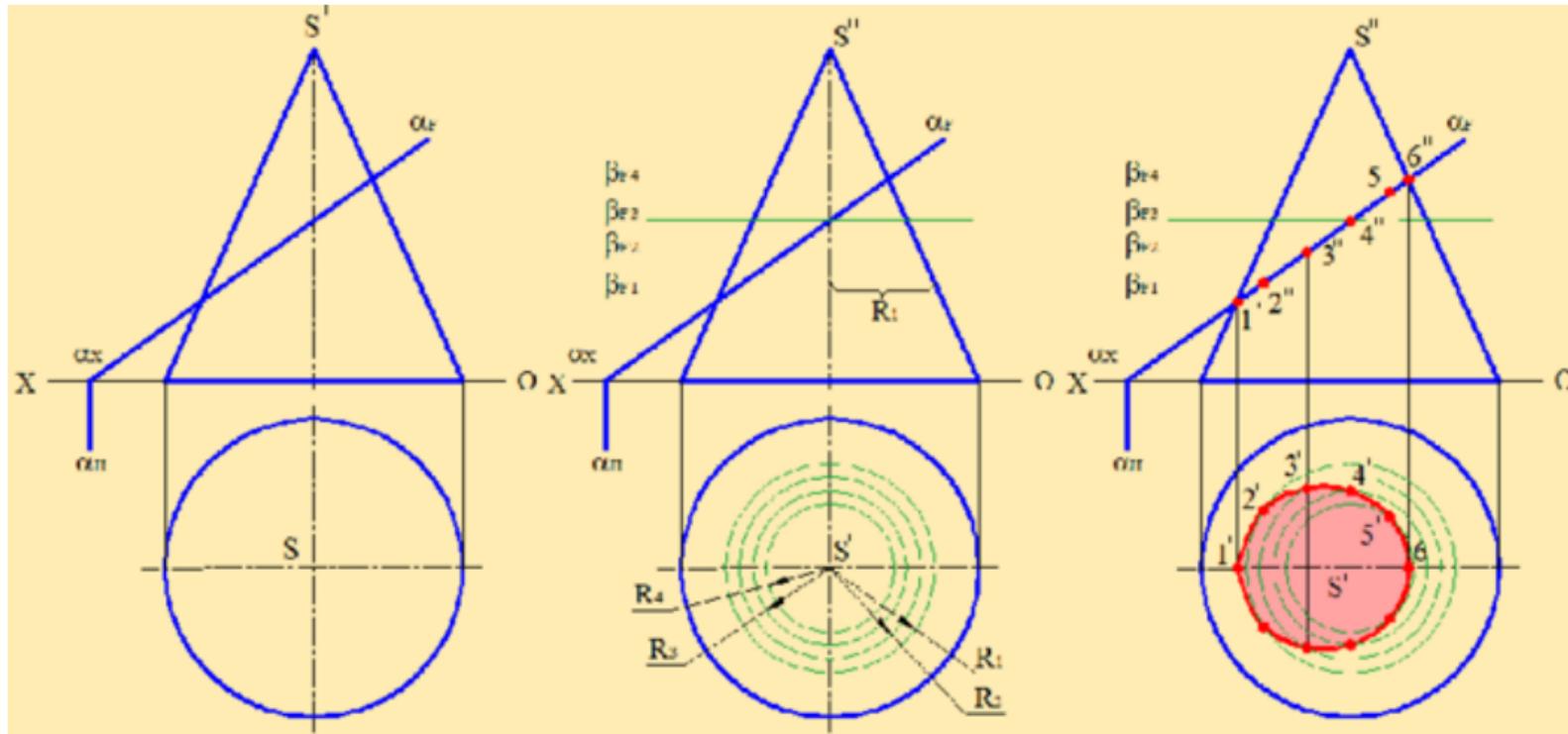


Orthographic Multiview projections



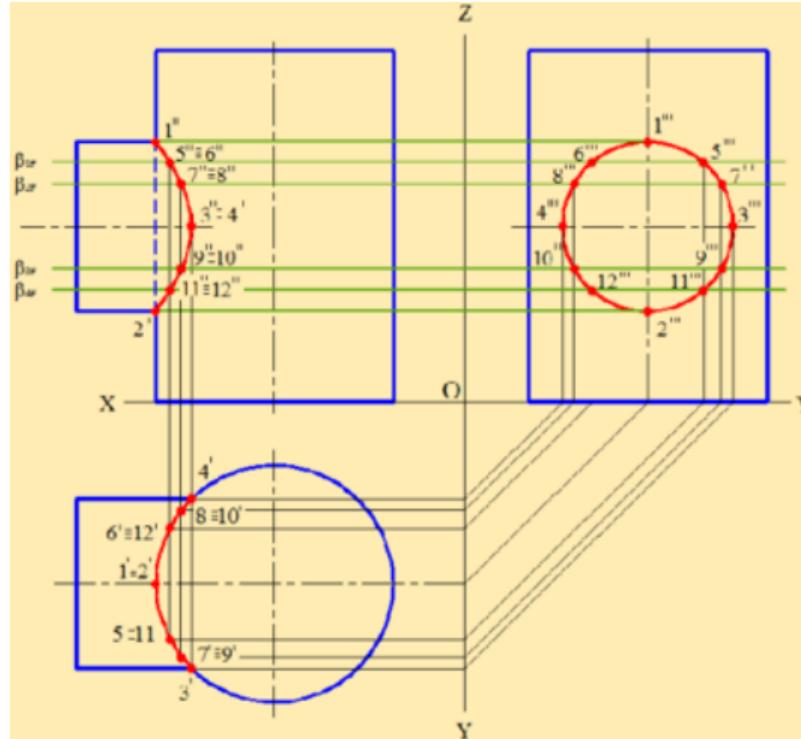


Orthographic Multiview projections





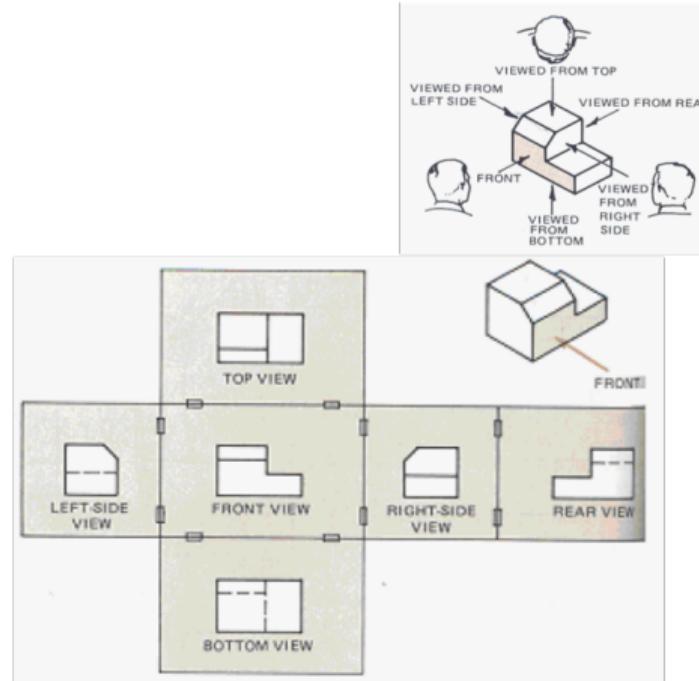
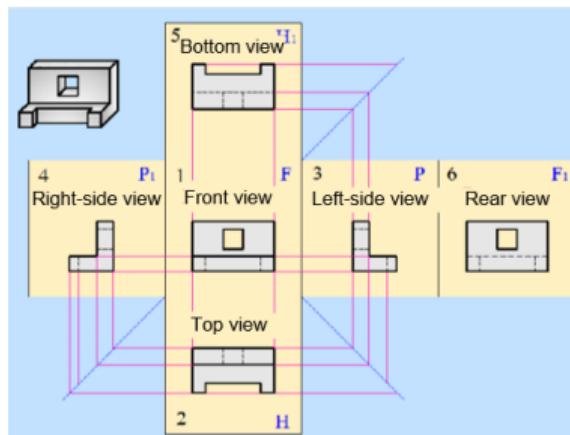
Orthographic Multiview projections



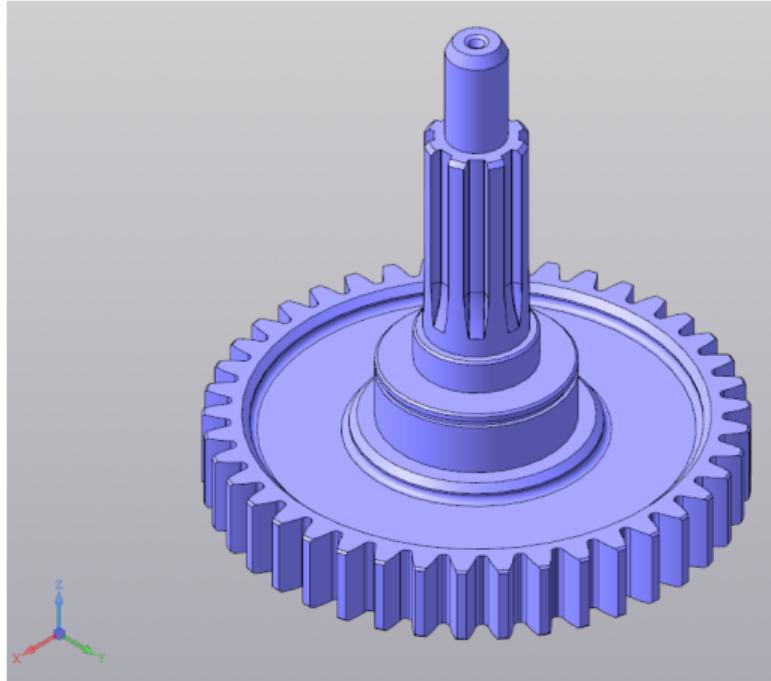


Orthographic Multiview projections

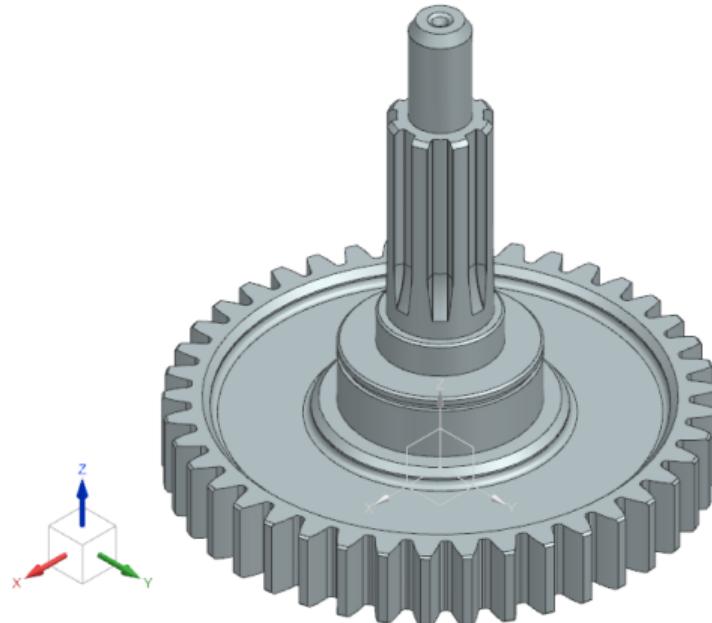
The difference between European and American standards



Orthographic Multiview projections



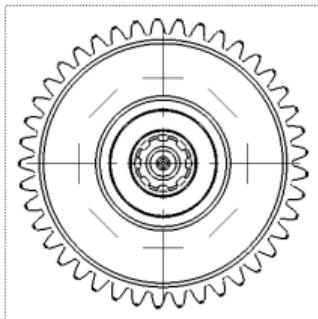
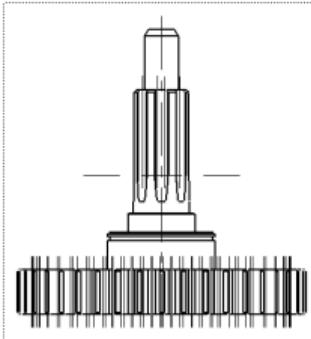
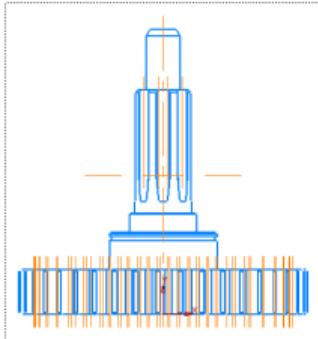
Kompas 3D



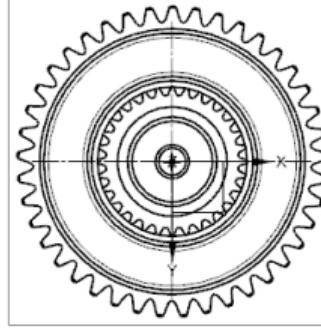
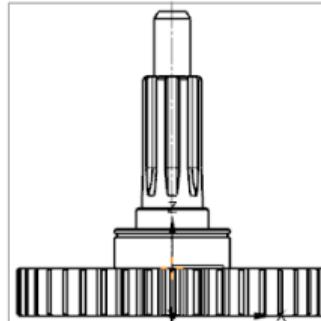
Siemens NX



Orthographic Multiview projections



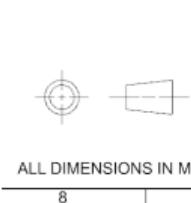
Kompas 3D (European system)



Siemens NX (American system)



Drawing standards



ANSI standard Title Block

Имя	Лист	№ докум	Подп.	Дата	Лист.	Масса	Масштаб
Разраб.	Буличев ОВ						
Пров	Кузьминченко РР						
Т. контр							
Н. контр							
Чтв							

АНЦП.014.00.00.003

Корпус для вала

Лист: 1 Листов: 1

0,13 1,51

Д16Т ГОСТ 4784-97

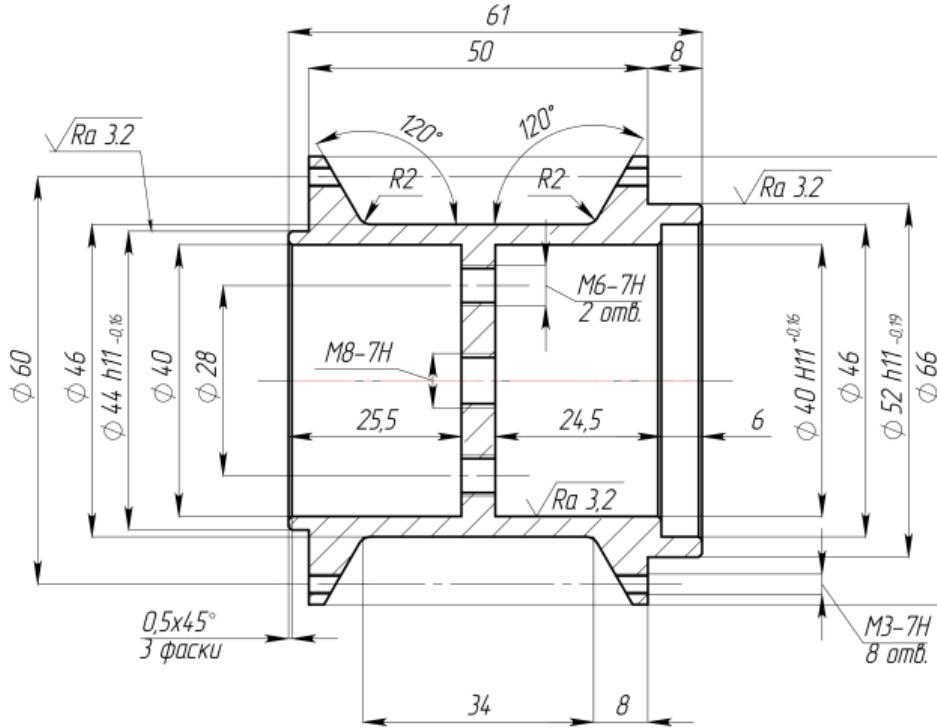
АНО ВО
"Университет Иннополис"

Копировано

Формат A2

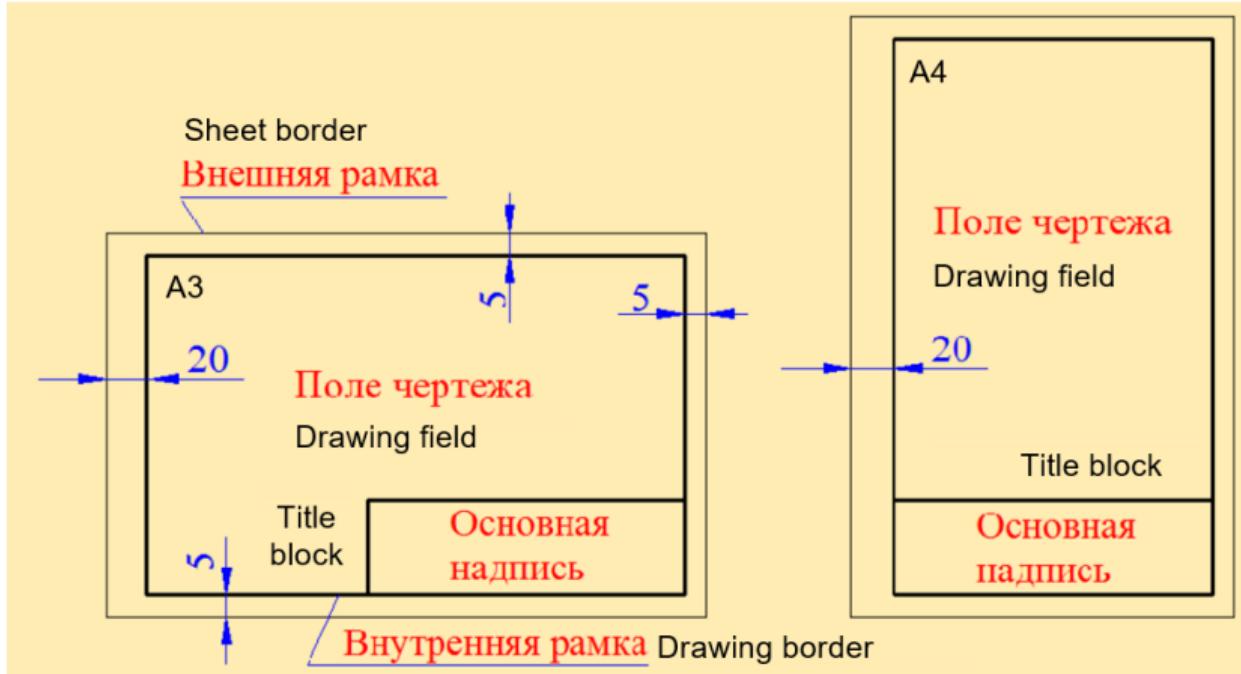
GOST standard Title Block

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

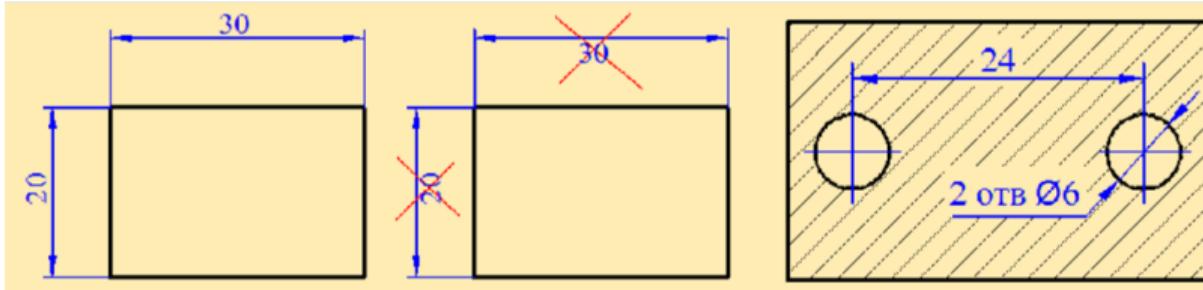
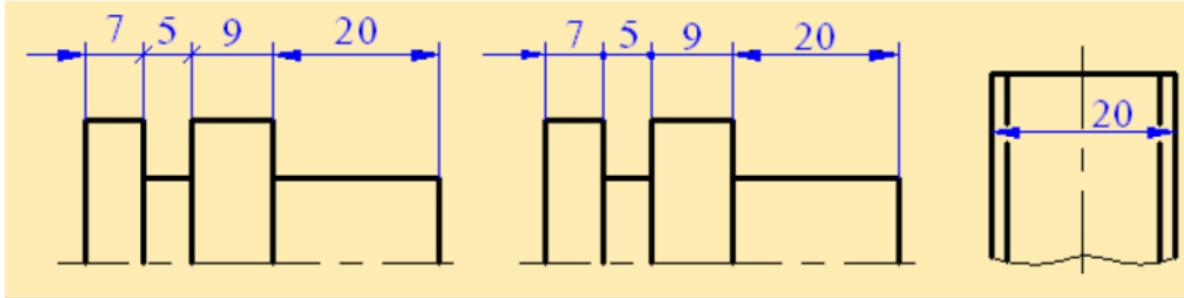


Type of lines

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

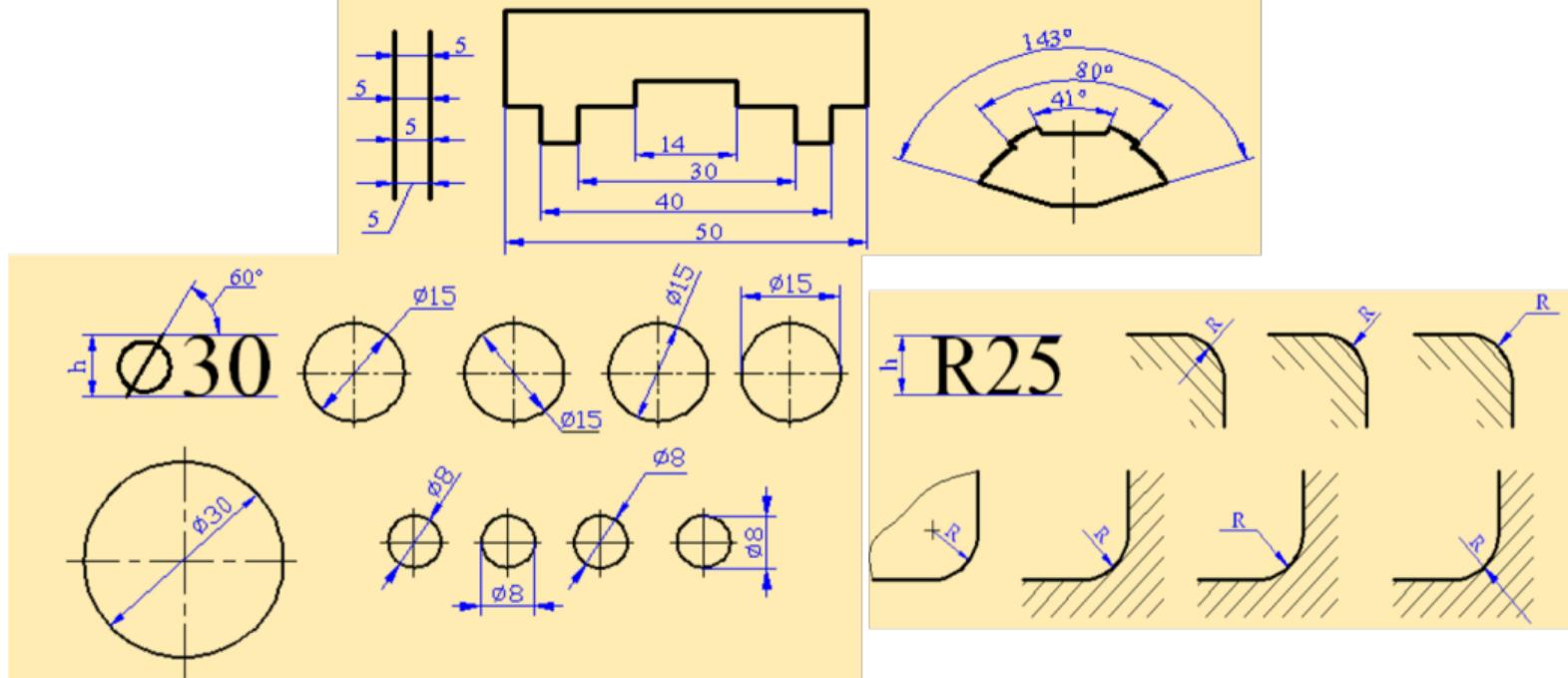


GOST Standard



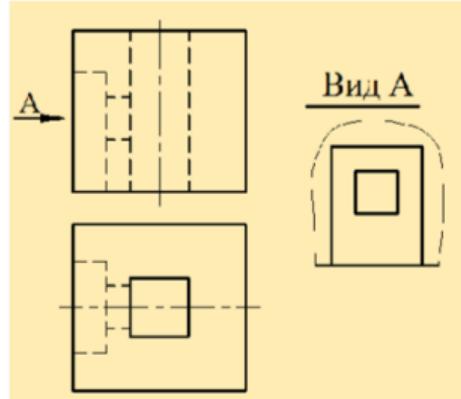
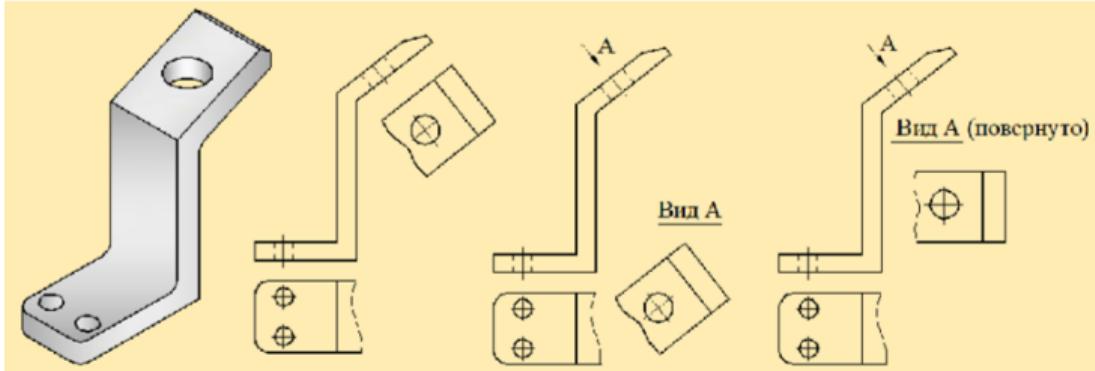


GOST Standard

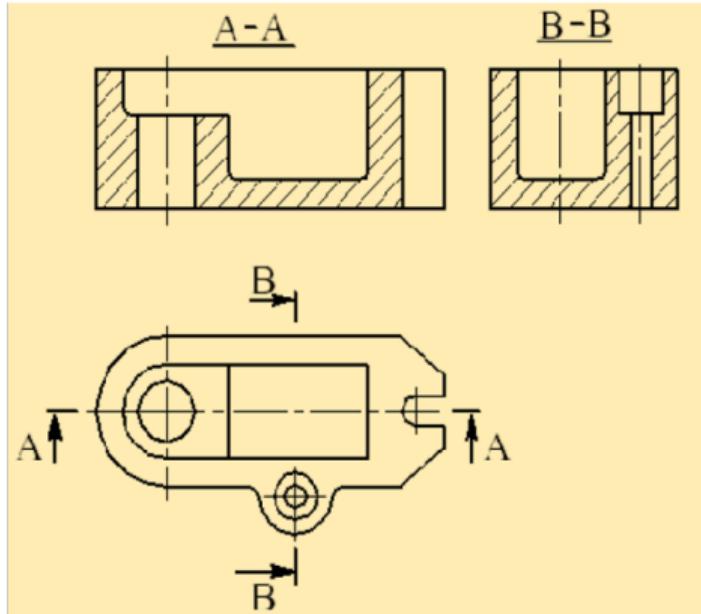
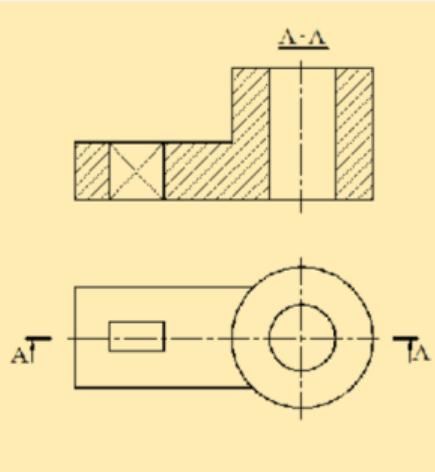
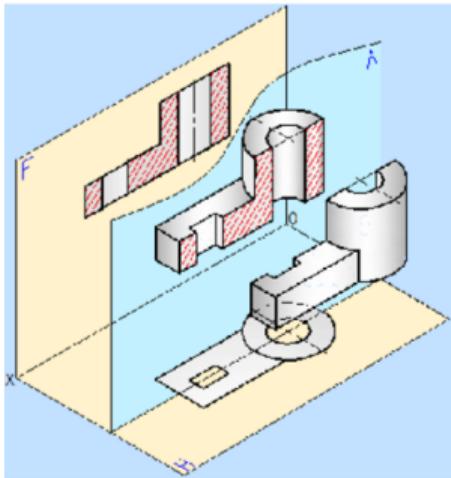




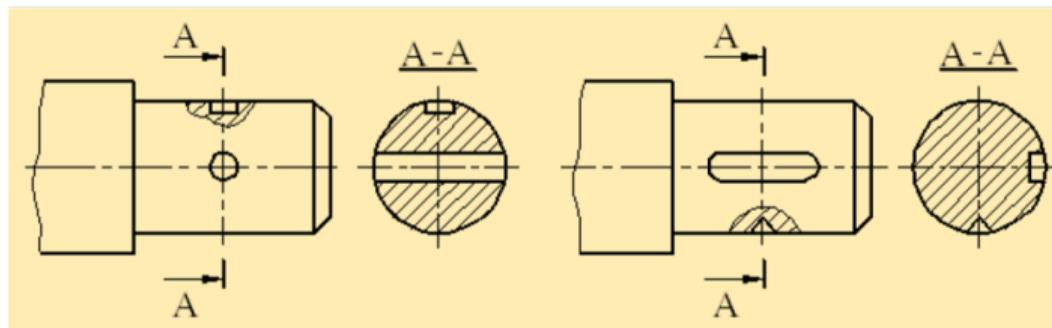
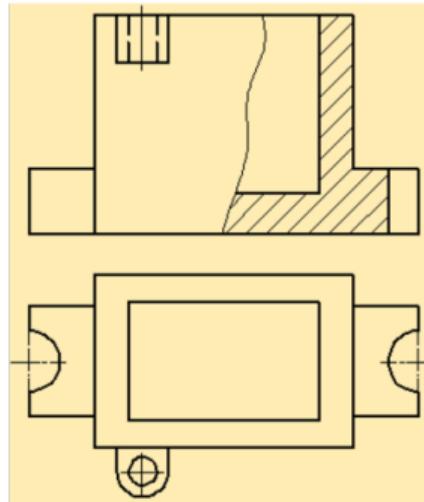
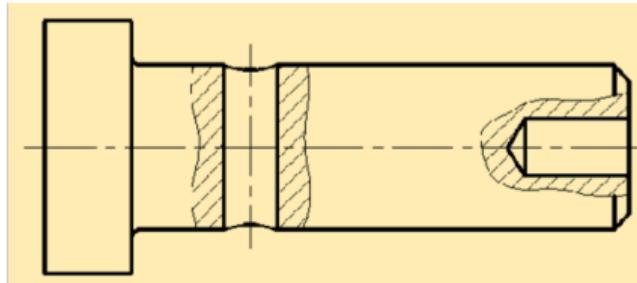
GOST Standard



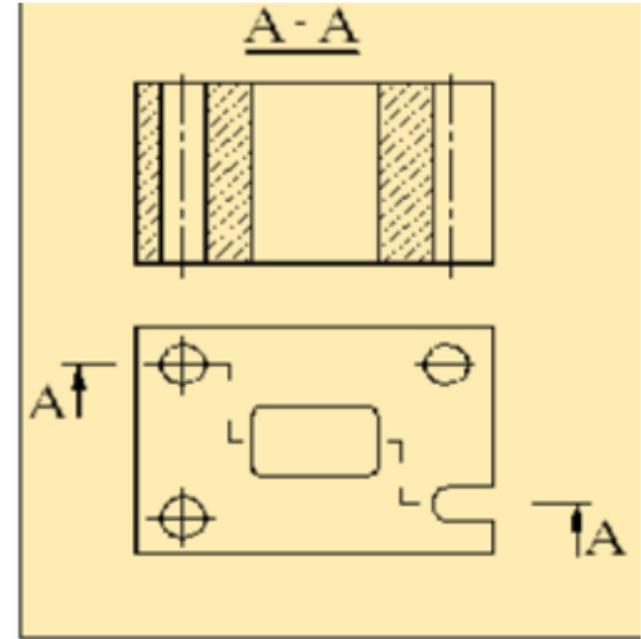
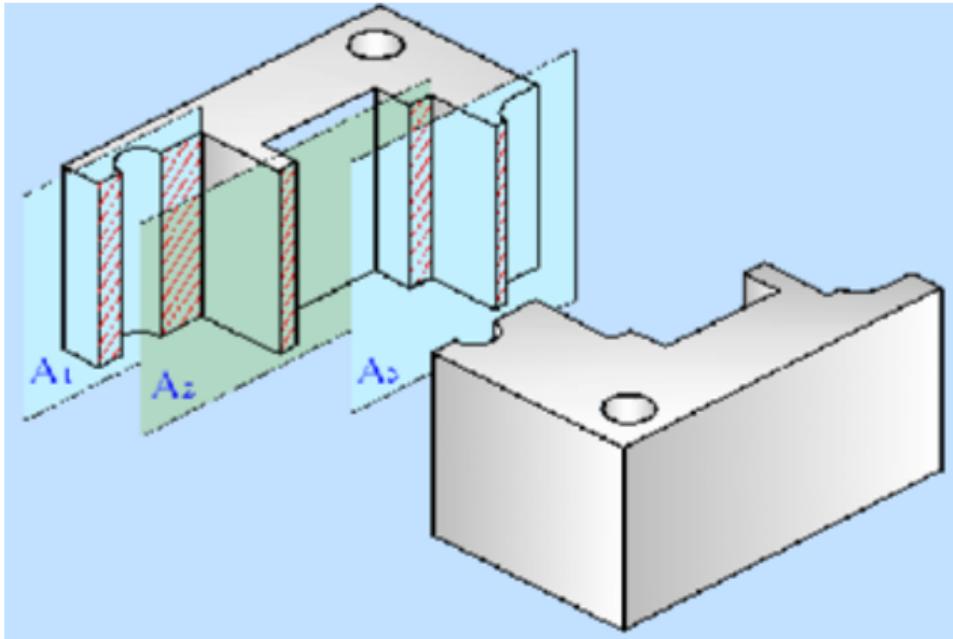
GOST Standard



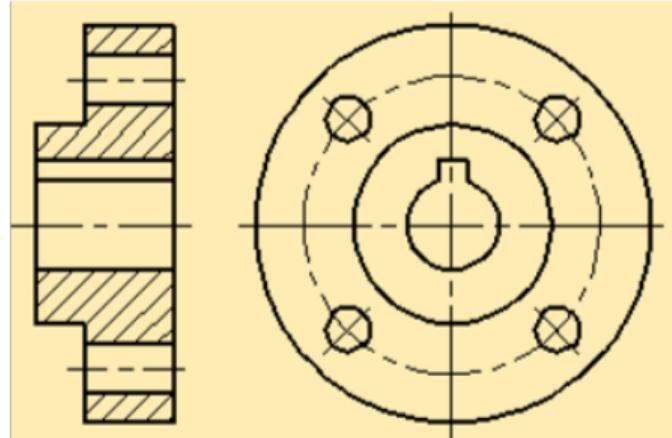
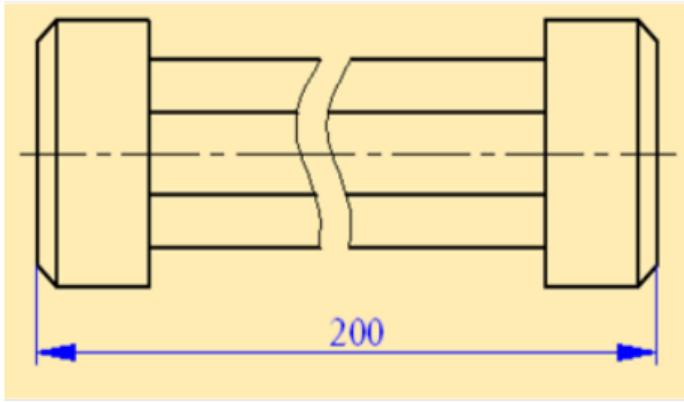
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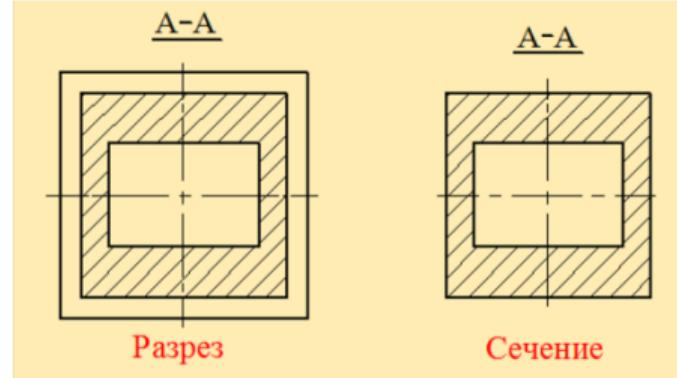
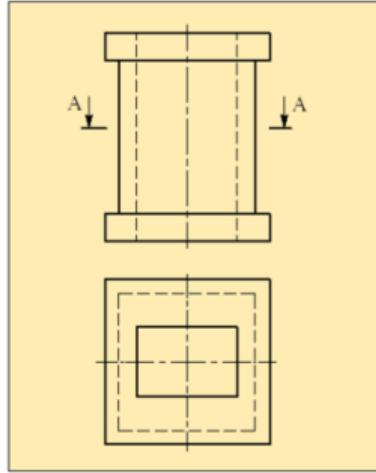
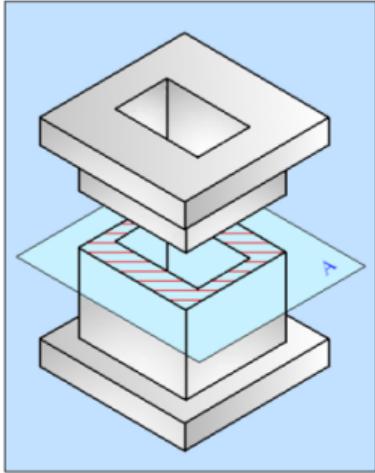
GOST Standard



GOST Standard



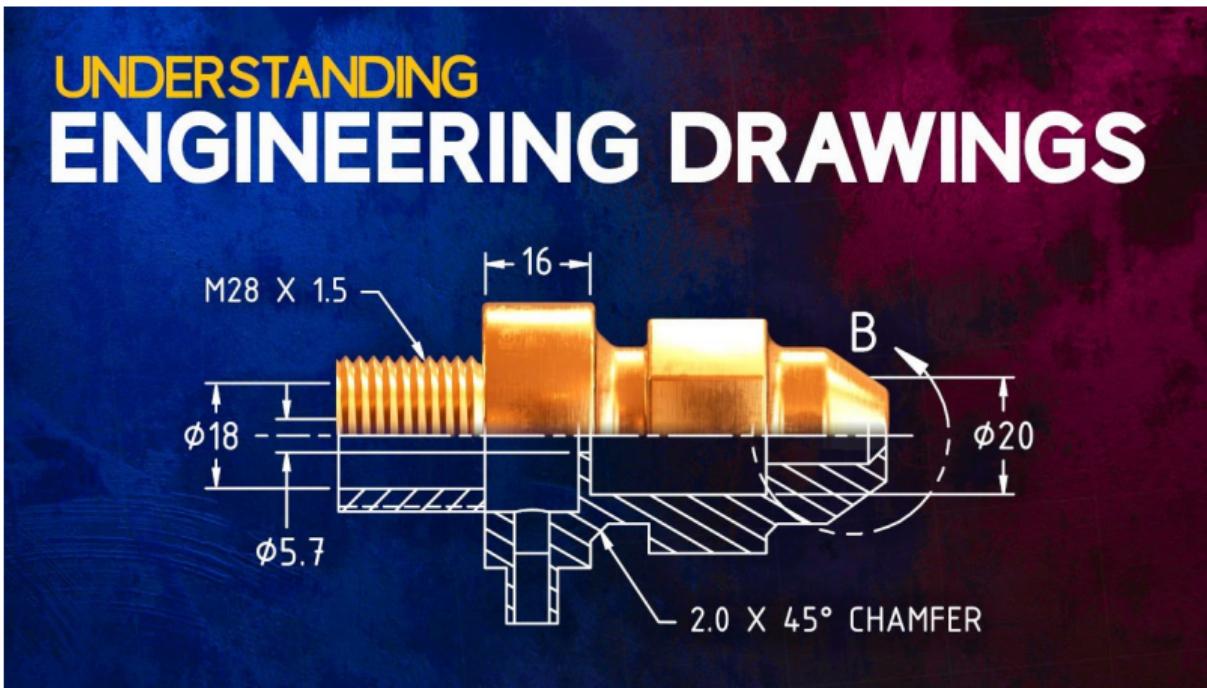
GOST Standard





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)