



# Introduction to Mechanical Engineering, Lecture 1

Introduction

Computer Aided Design (CAD)

Engineering Drawings



# Lecturers/Instructors



**Oleg Bulichev**

*Mail:* [o.bulichev@innopolis.ru](mailto: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

1	cp	05.06.2024 Lecture 1 (Introduction; Engineering Drawings)
2	чт	06.06.2024 Lab 1 CAD_DET1 (Intro to subject; History of CAD; Solid modeling) Lecture 2 (Intro to Theory of Mechanisms and Machines; Links, Joints (Kinematic pairs); Kinematic chains, Degrees of Freedom, Mobility)
3	чт	13.06.2024 Lab 2 CAD_DET2 (Workflow, Work in groups; CAD file formats; Threads) Lecture 3 (Types of drives: kinematics, where to find other info; Drives: friction, belts, chains, gears, universal, geneva, ballscrew)
4	чт	14.06.2024 Lab 3 CAD_ASM1 (Bottom-Up approach; Basics)
7	чт	20.06.2024 Lecture 4 (Links, Joints, Connections; Shafts, Axles, Shaft couplings; Bearings) Lab 4 CAD_ASM2 (Top - Down approach: WAVE; Assembly Load Options; GOST Naming)
8	чт	20.06.2024 convection; Common Parts Library; Sequence (Assembling animation))
9	пт	21.06.2024 Lecture 5_1 (Connections: Detachable (Threaded, Keyed, ...)) Lab 5 CAE_DYN1 (Introduction to CAE; Animation Designer; Mechatronics Concept Designer; Motion; Measure; Interference; Density; Assign Materials)
10	пт	21.06.2024 Measure; Interference; Density; Assign Materials
11	чт	27.06.2024 Lecture 5_2 (Permanent (Riveting, Welding, ...))
12	чт	27.06.2024 Lab 6 CAD_RENDER1 (Render)
13	пт	28.06.2024 Lecture 6 (Design Thinking and Manufacturing)
14	пт	28.06.2024 Lecture 7 (Basics of FDM Printing)
15	чт	04.07.2024 EXAM
16	чт	05.07.2024 COMPETITION

Quiz

Lab

Exams



# Grading criteria

## What will be evaluated on the course

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

**CP:** Competition: 20%

**FE:** Final Exam: 30%

**Lbs:** Lab assignments: 10%

**HWs:** Homework assignments: 30%

**Extra:** Slide fixes in Github: 5%

**Late policy:** -100% 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 will have theoretical questions on final exam. Quizzes encourage you to study material more seriously.



# Competition (Previous year)

*Bottle lifting mechanism*





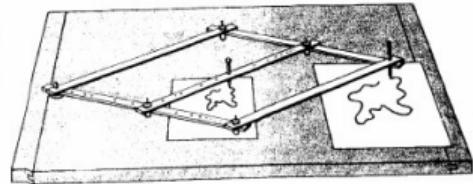
# Competition: Let's vote



(a) Ball throwing mechanism



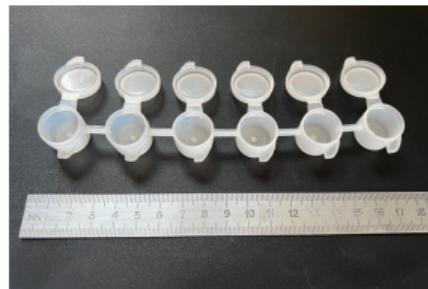
(b) Bizarre Teabag dropper



(c) Image copier



(d) Autoclicker for smartphone games

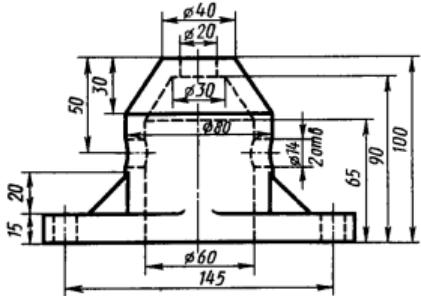


(e) Closing mechanism for paint cans



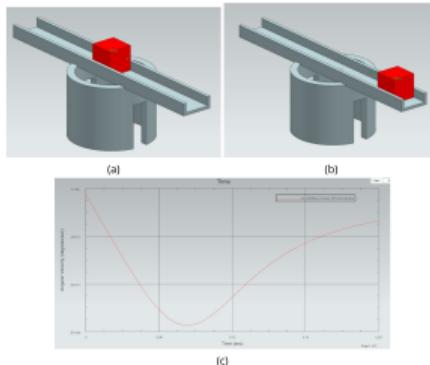
# Final Exam (Previous Year)

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?

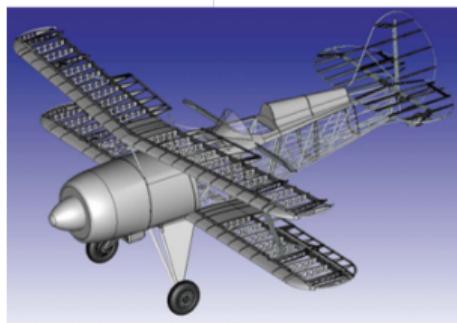
Theory part



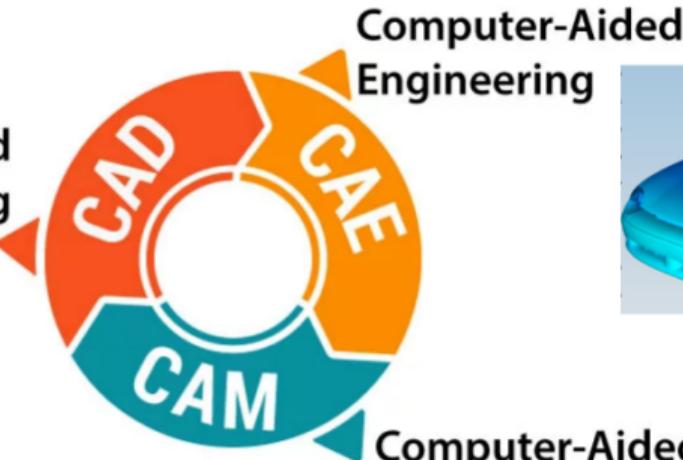
## Lab Goals

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

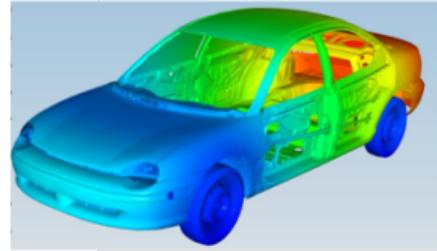
# Computer Aided Design



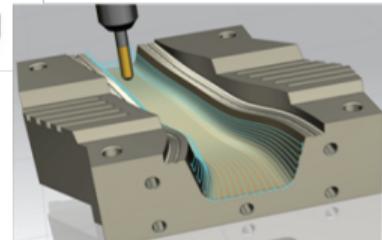
Computer-Aided  
Drafting



Computer-Aided  
Engineering



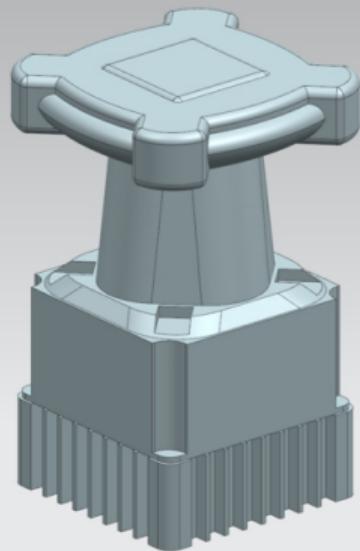
Computer-Aided  
Manufacturing





# 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

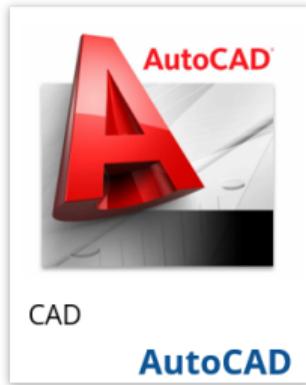
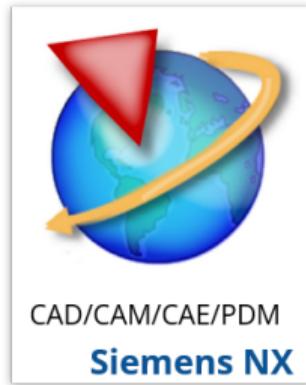
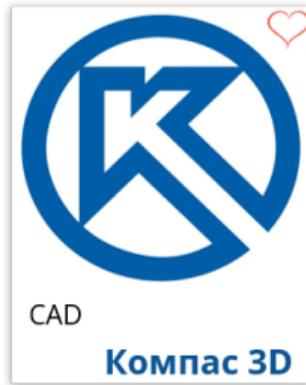
Cheaper

Safer

Faster



# Popular CAD systems in Russia



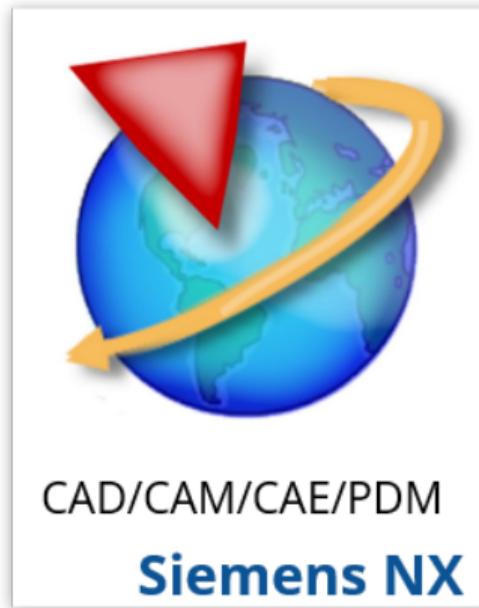
# Siemens NX

## 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 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.

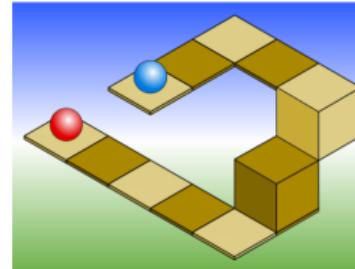
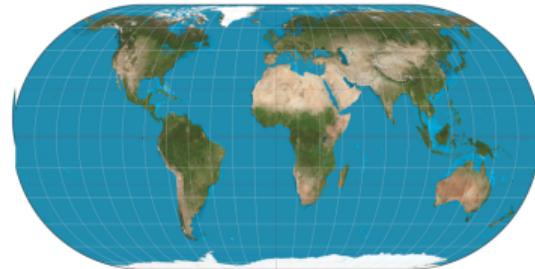
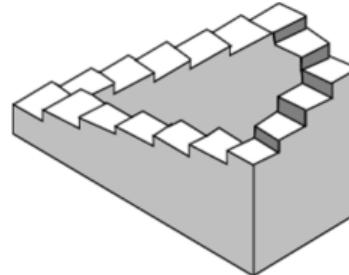




# Projections

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

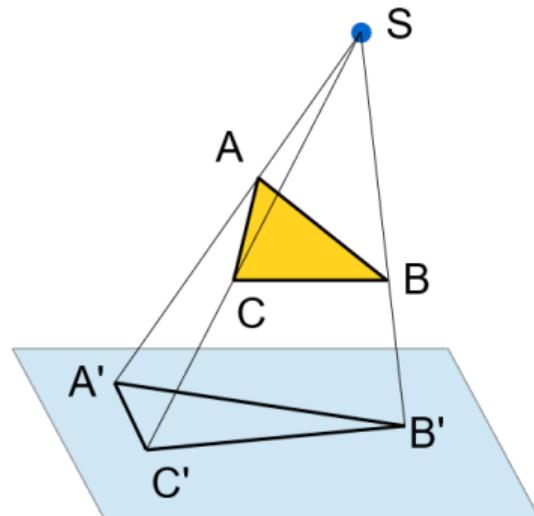
On the other hand, we can draw something absolutely impossible or something possible but unclear.





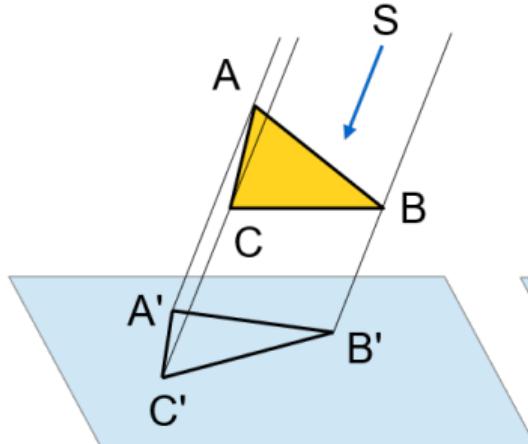
# Parallel and perspective projections

## Central (perspective) projection

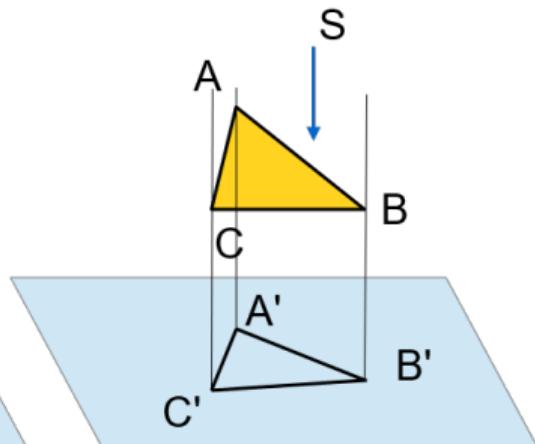


## Parallel projections

### General (oblique) case



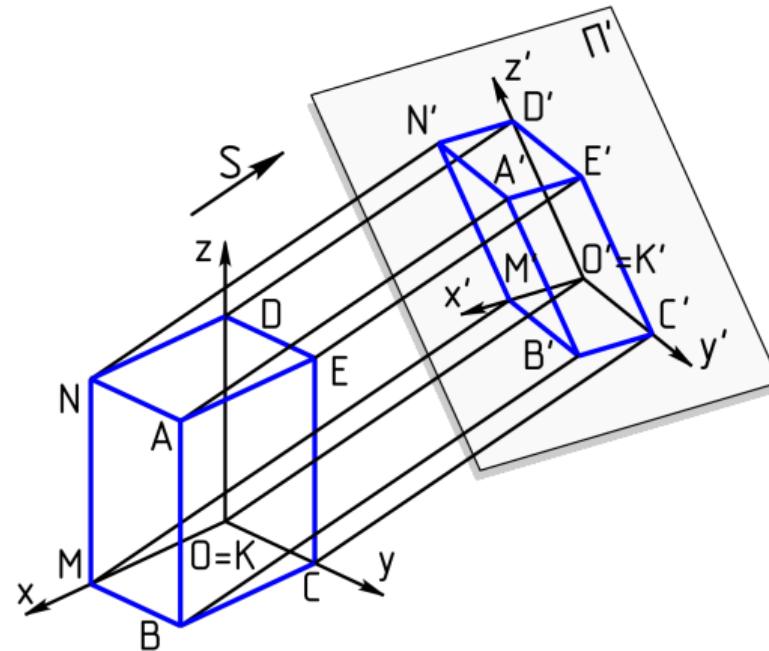
### Orthographic projection





# Axonometric projections

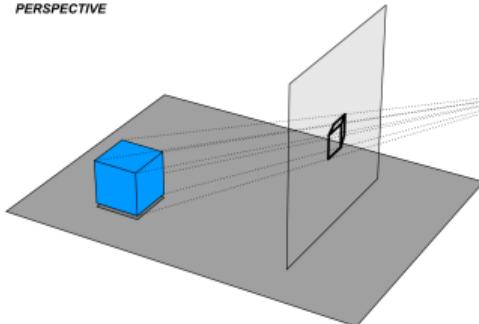
General



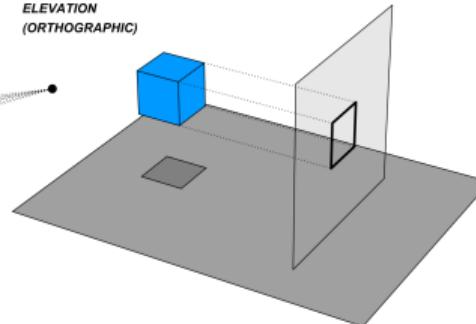


# Axonometric projections

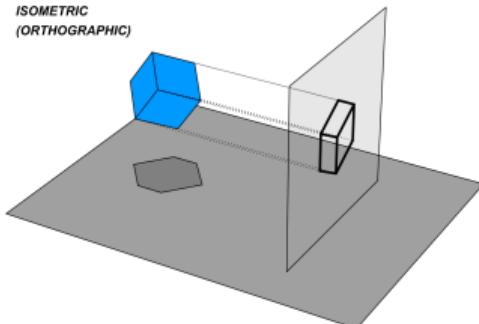
PERSPECTIVE



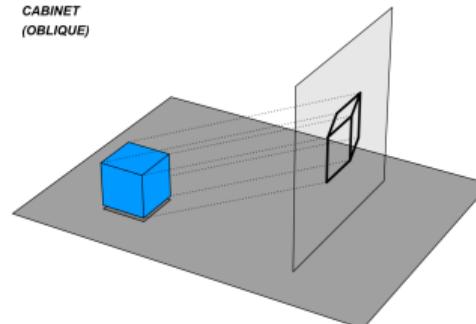
ELEVATION  
(ORTHOGRAPHIC)



ISOMETRIC  
(ORTHOGRAPHIC)

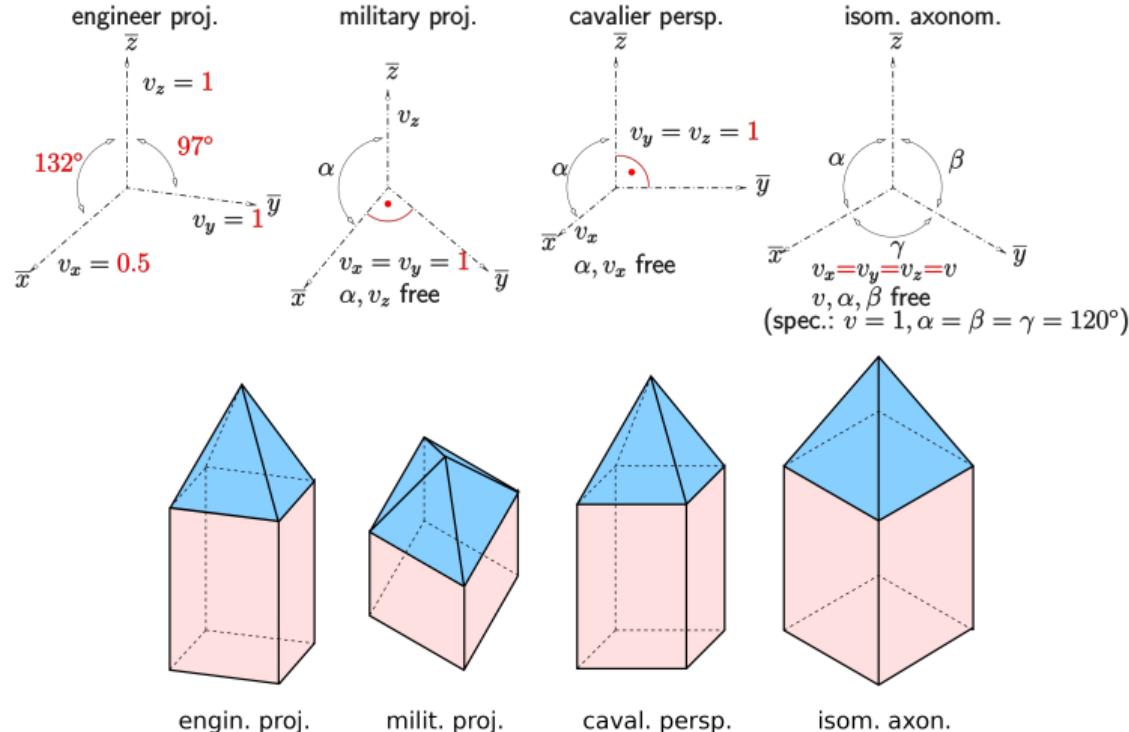


CABINET  
(OBlique)





# Axonometric projections



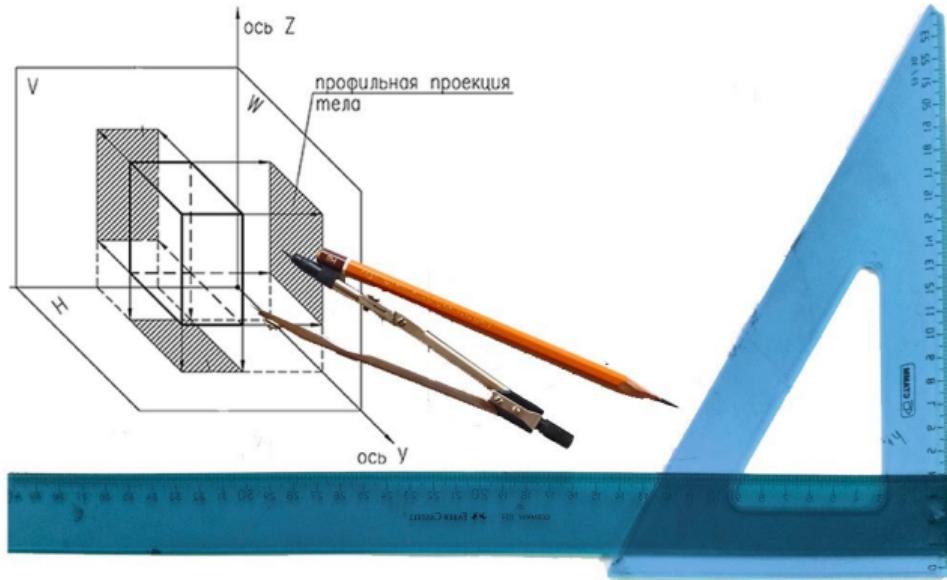


# Make a line projection

Video

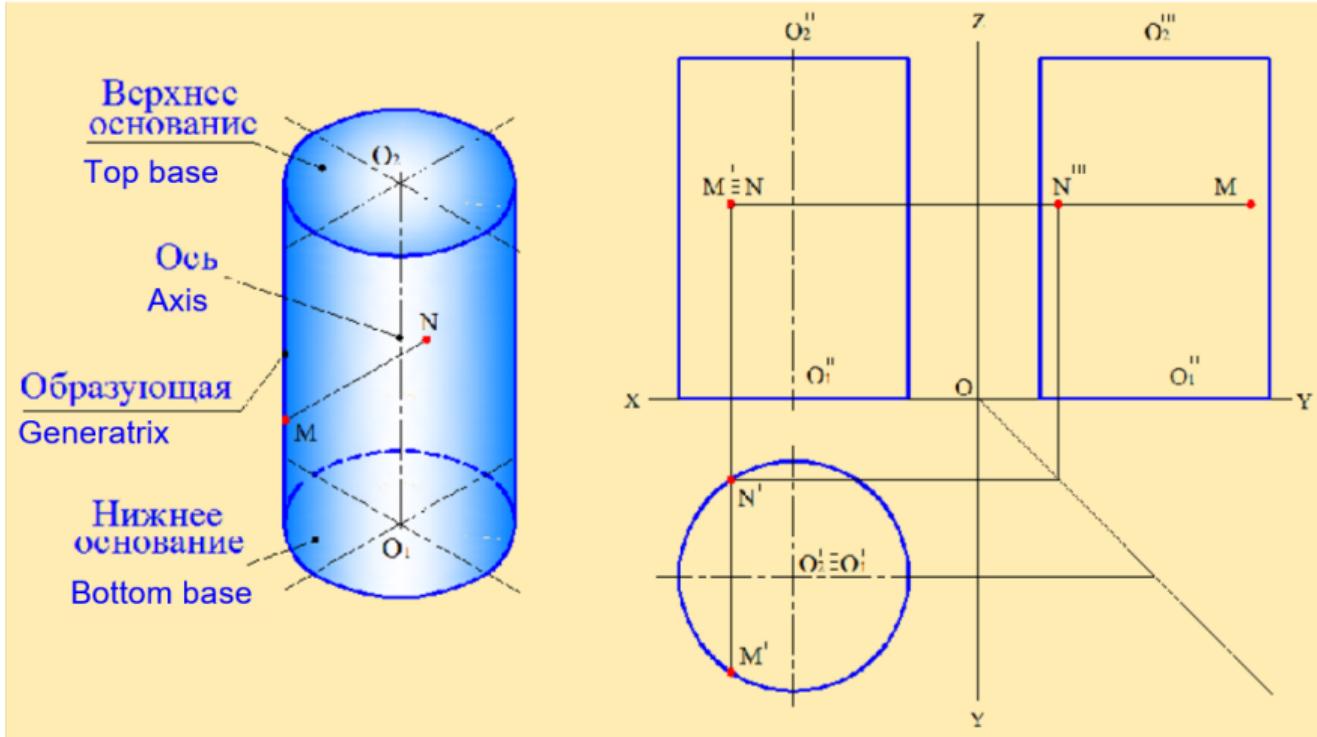
## Черчение школа архитектурный ВУЗ

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



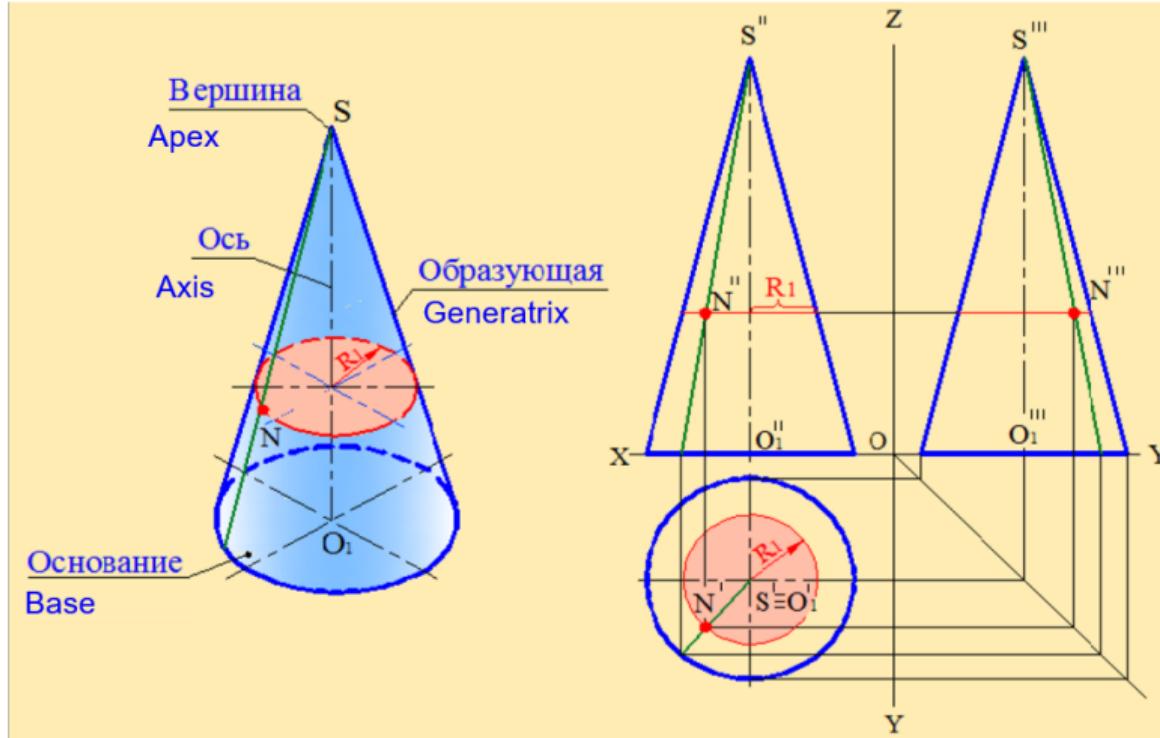


# Orthographic Multiview projections



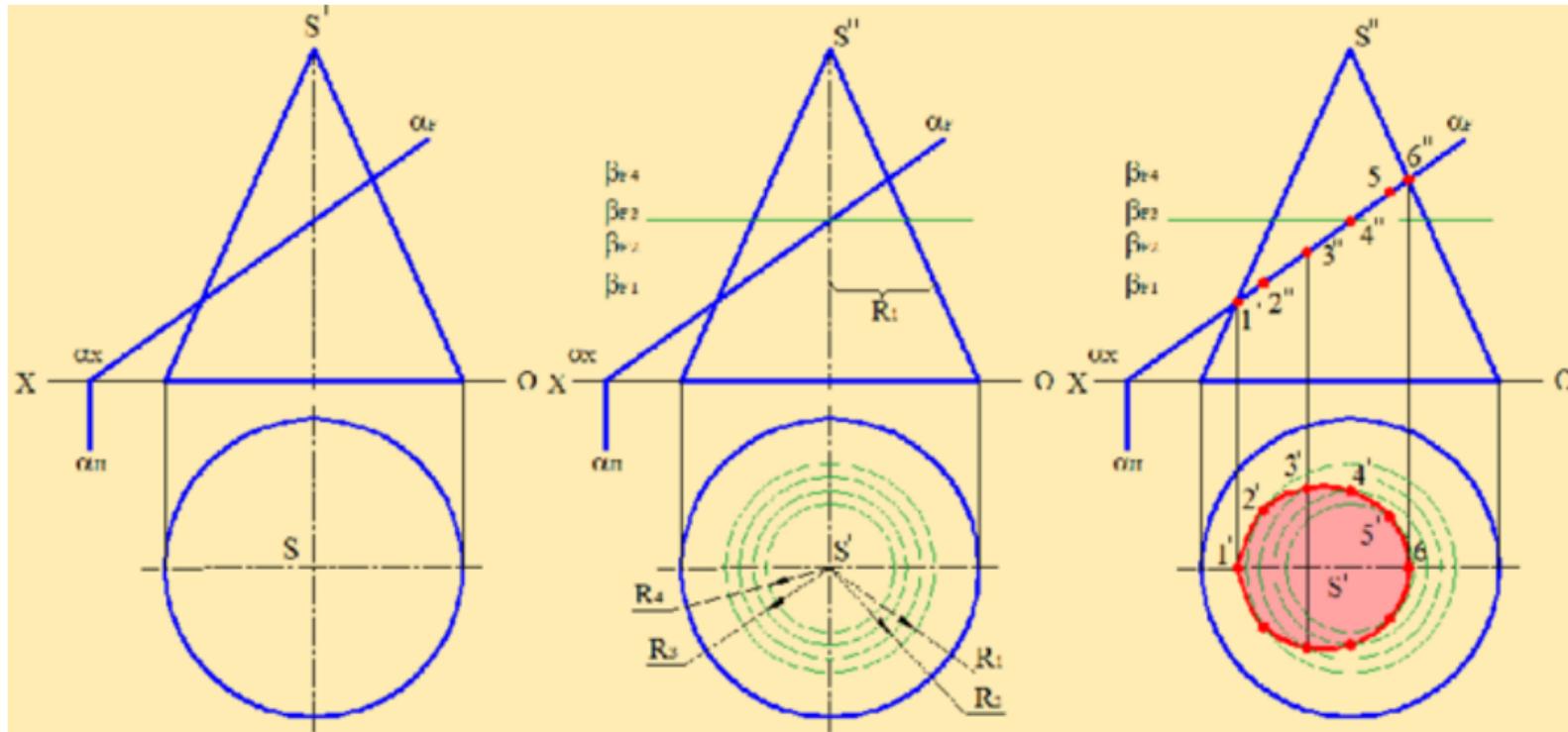


# Orthographic Multiview projections



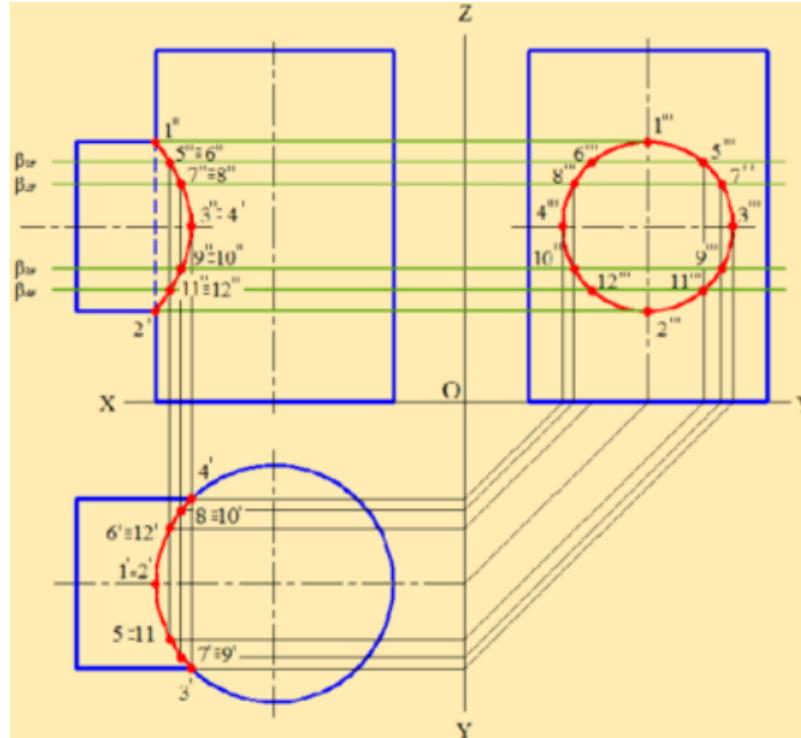


# Orthographic Multiview projections





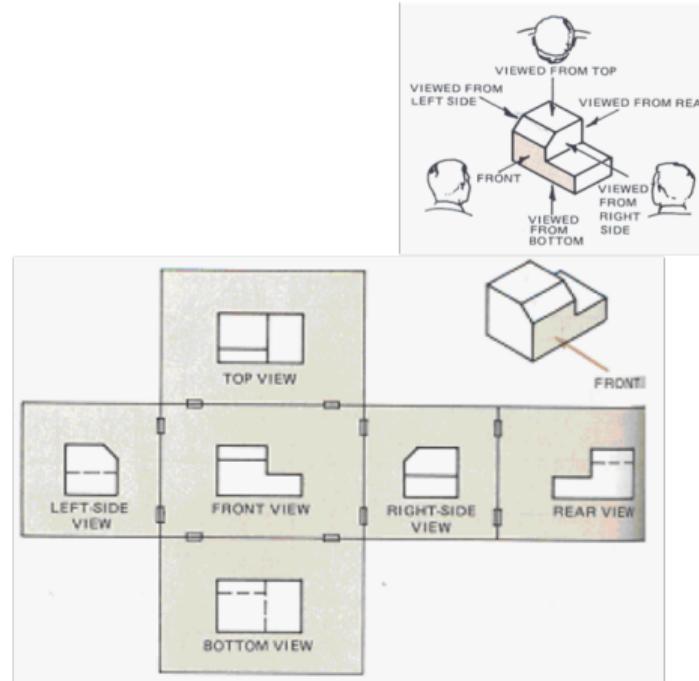
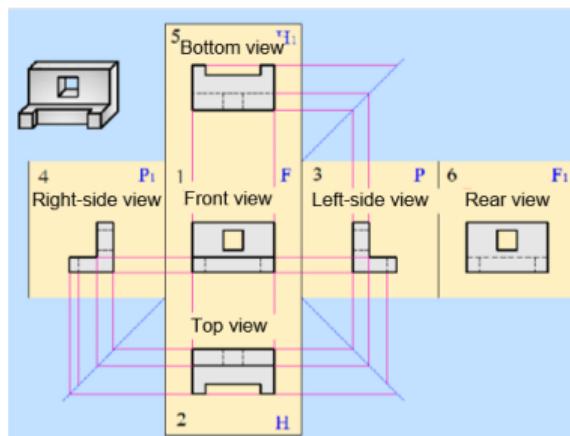
# Orthographic Multiview projections





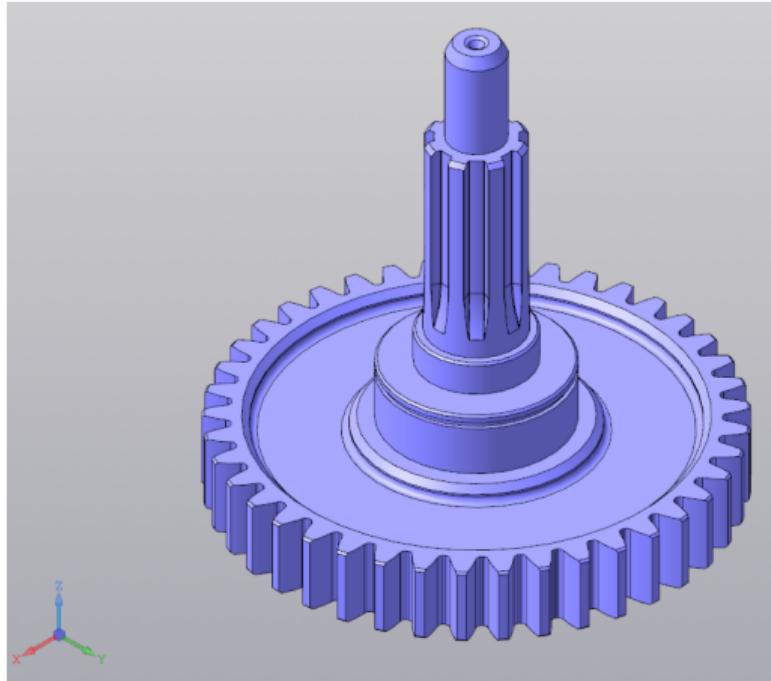
# Orthographic Multiview projections

The difference between European and American standards

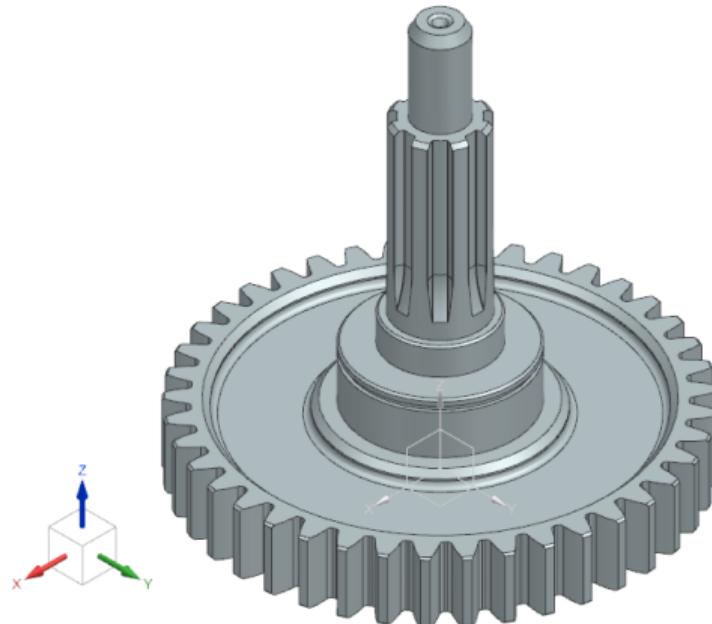




# Orthographic Multiview projections



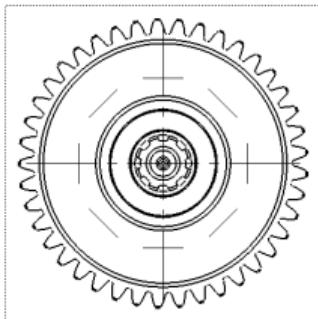
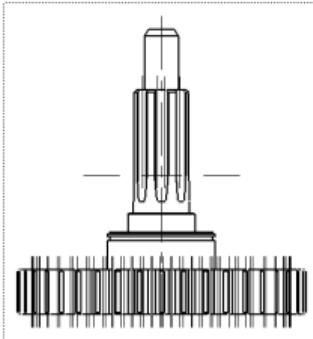
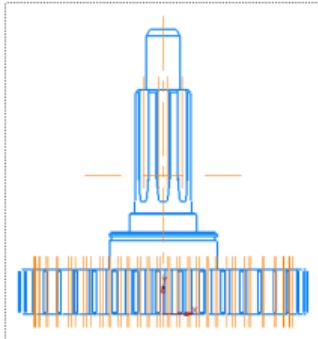
Kompas 3D



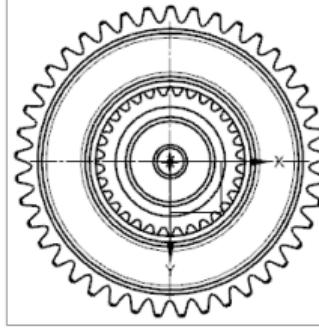
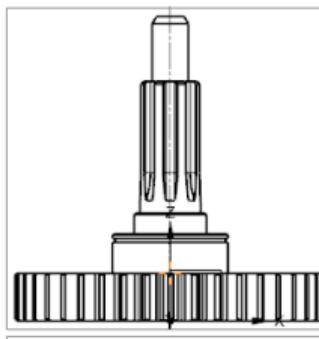
Siemens NX



# Orthographic Multiview projections



Kompas 3D (European system)



Siemens NX (American system)

## Drawing standards



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ALL DIMENSIONS IN MM

<b>SIEMENS</b>		THIS DRAWING HAS BEEN PRODUCED USING AN EXAMPLE TEMPLATE PROVIDED BY SIEMENS PLM SOFTWARE		
FIRST ISSUED	Kek	TITLE		
DRAWN BY	Student			
CHECKED BY	Oleg			
APPROVED BY	Ged	SIZE	DRW NO.	SHEET REV
		A2	dwg1	A
SCALE 1:1		SHEET 1 OF 1		
9	10	11	A2	

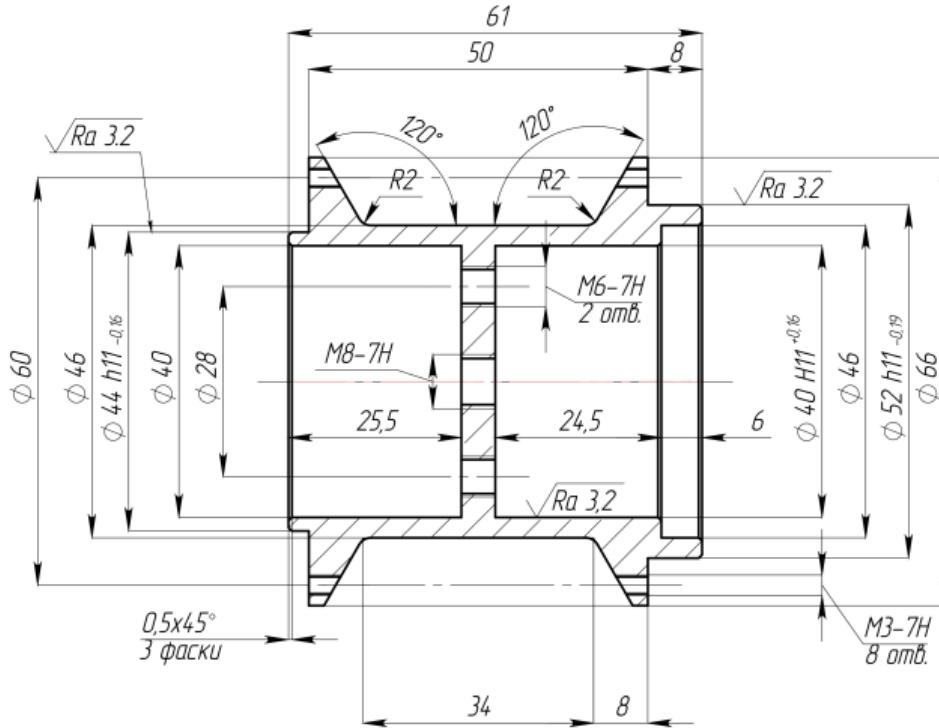
## ANSI standard Title Block

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Проб.	Кузьминичев 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

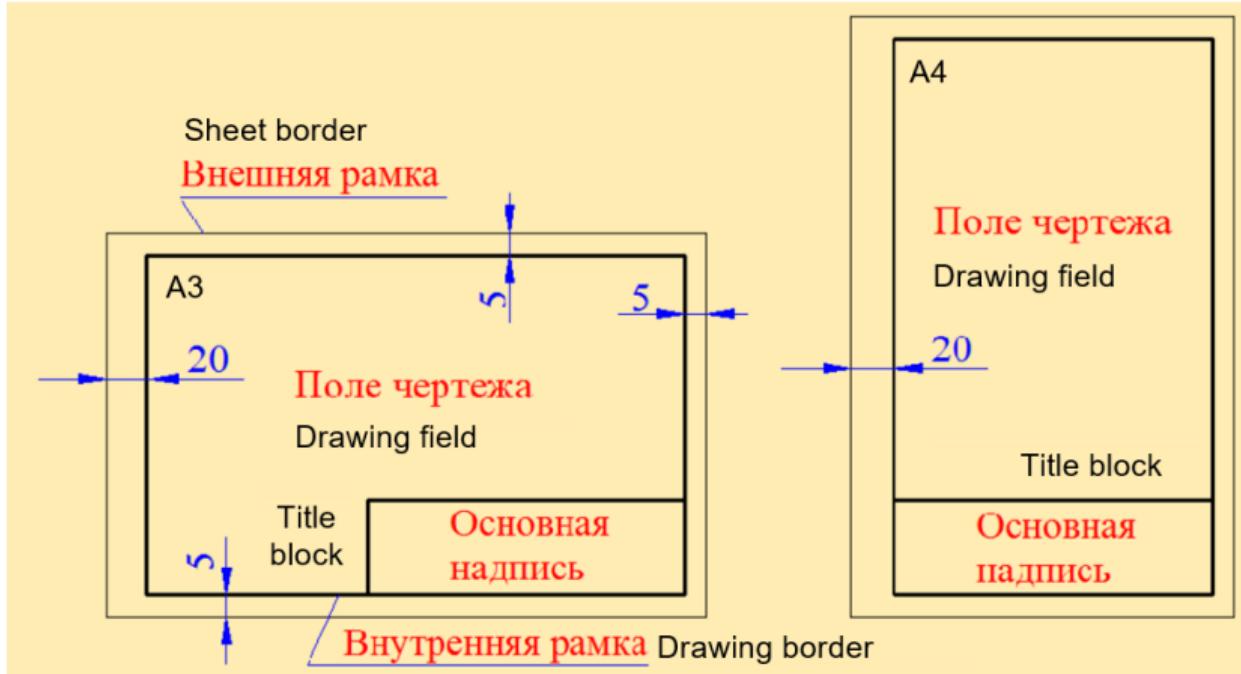


# GOST Drawing Example





# 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
<b>Enlargement Scale</b>	$50:1$ $25:1$ $10:1$ $5:1$ $2:1$
<b>Full Scale</b>	$1:1$
<b>Reduction Scale</b>	$1:2$ $1:3$ $1:5$ $1:10$ $1:100$

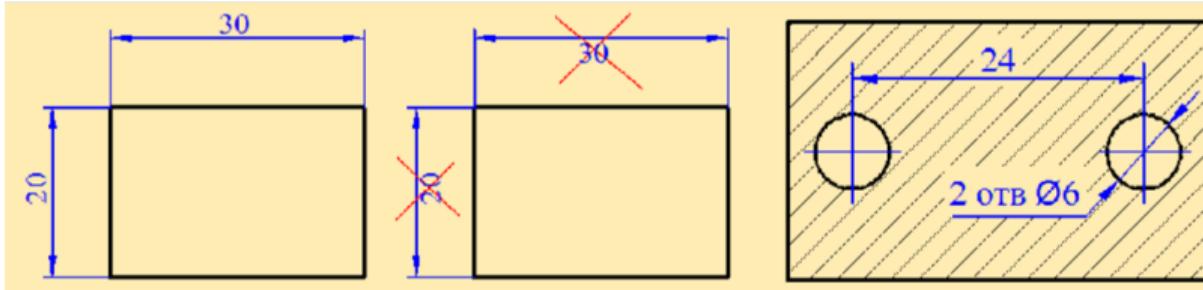
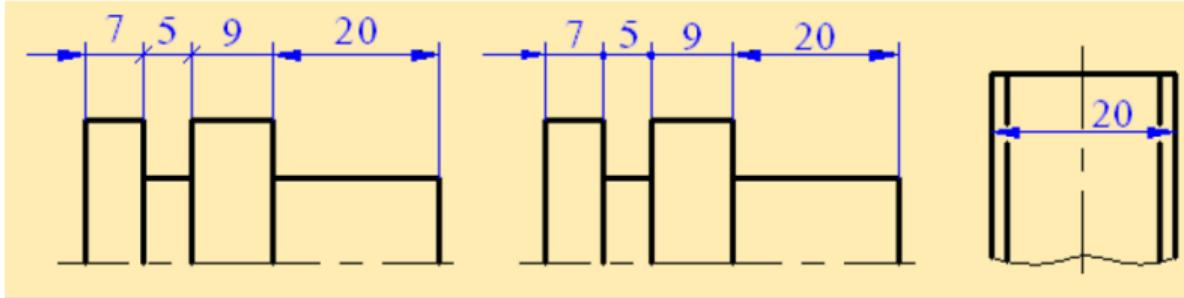


# Type of lines

Наименование	Начертание	Толщина линии	Основное назначение
Сплошная толстая основная		<b>S</b>	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

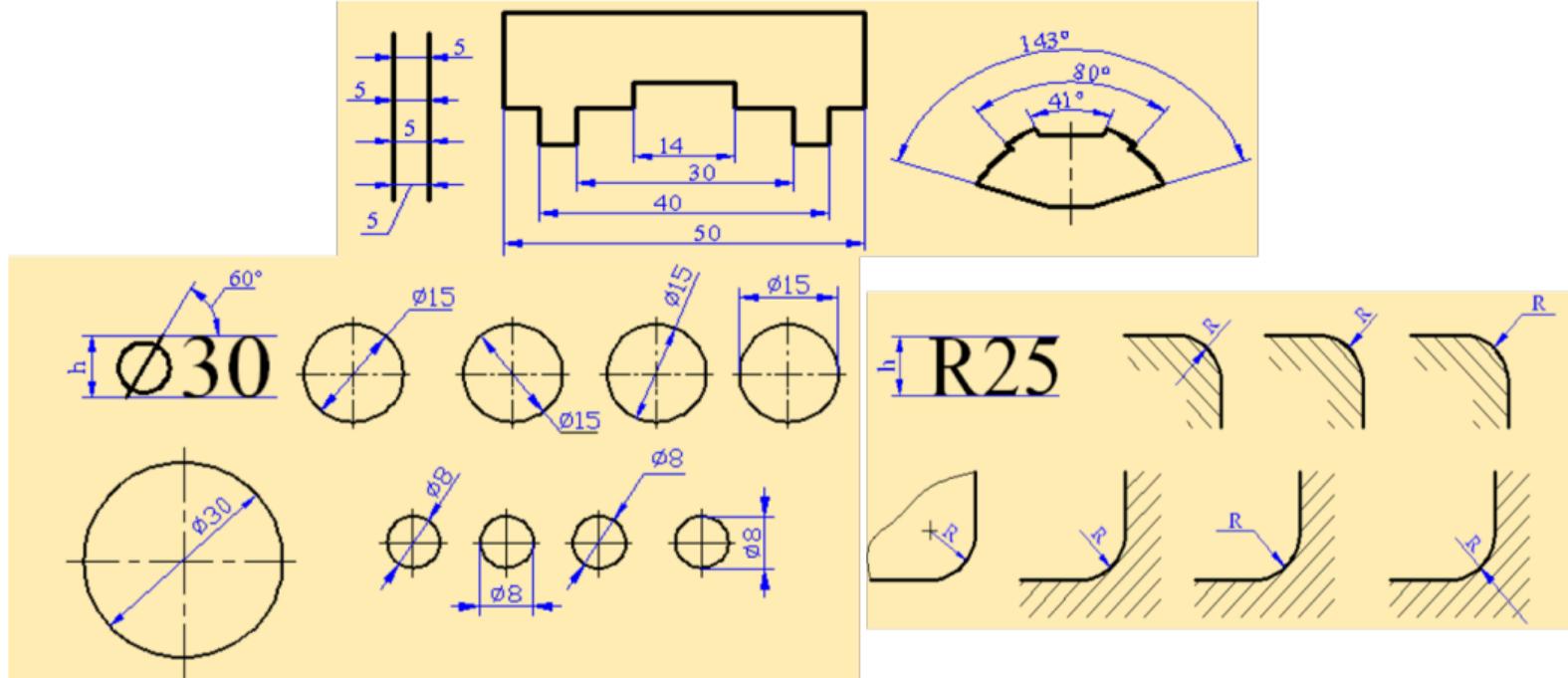


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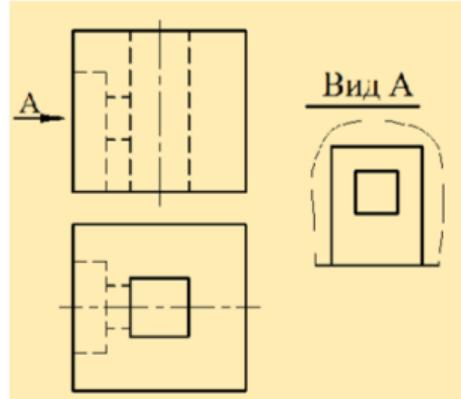
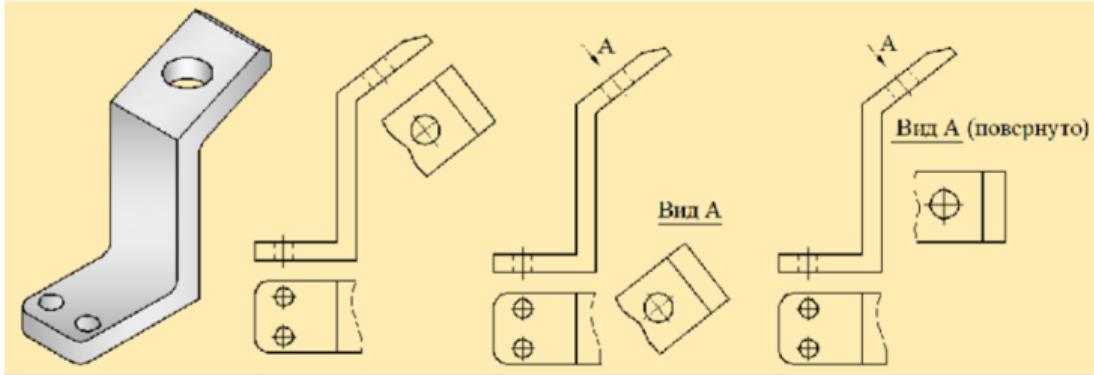




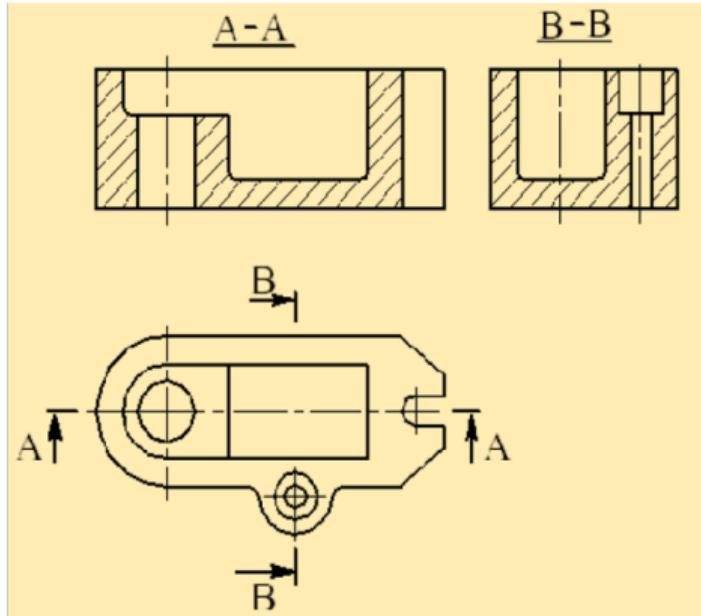
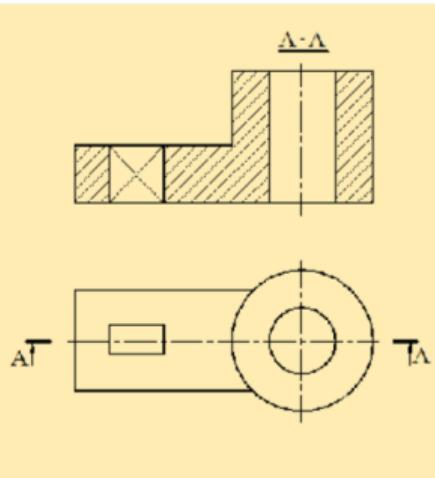
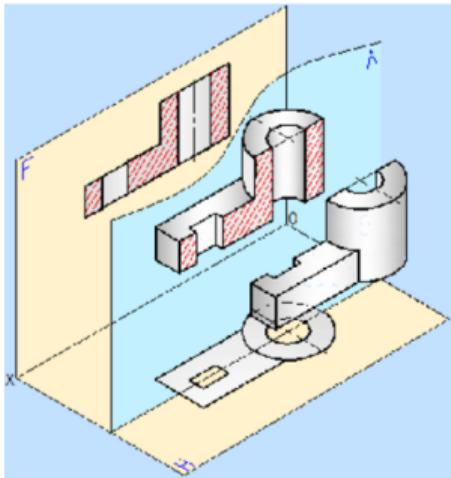
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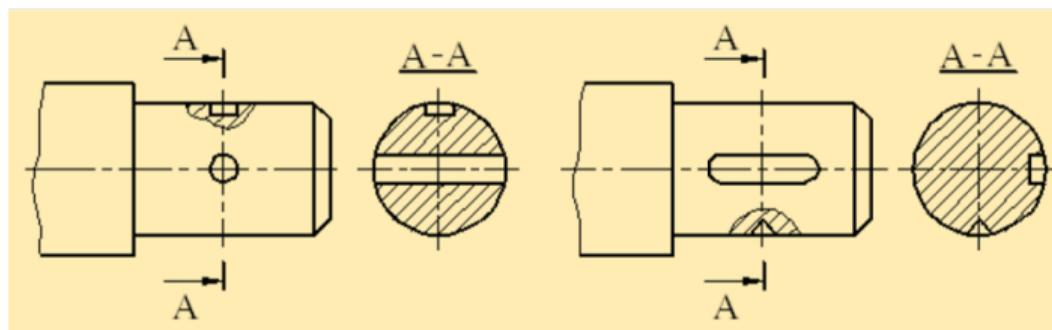
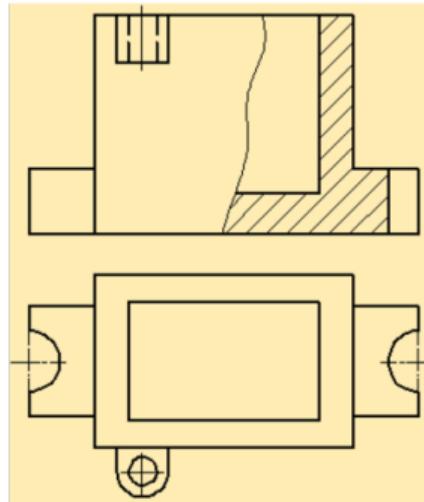
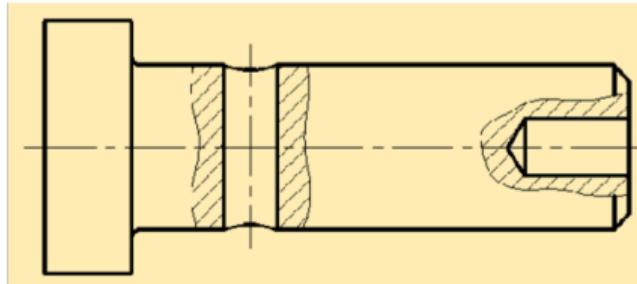
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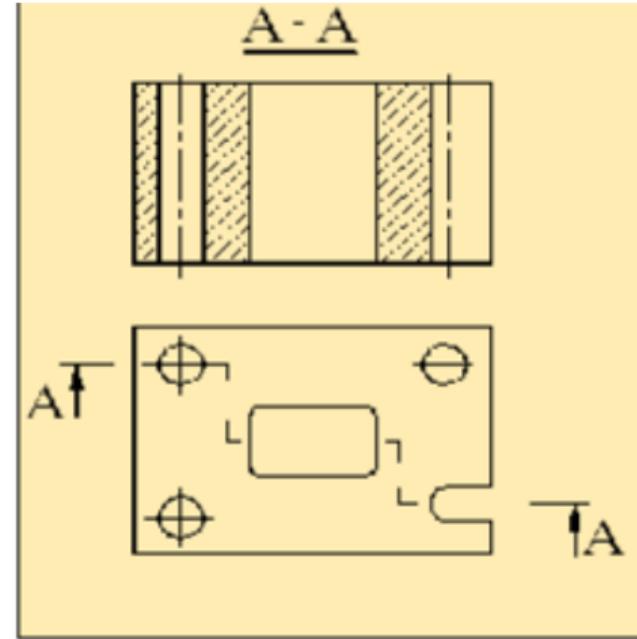
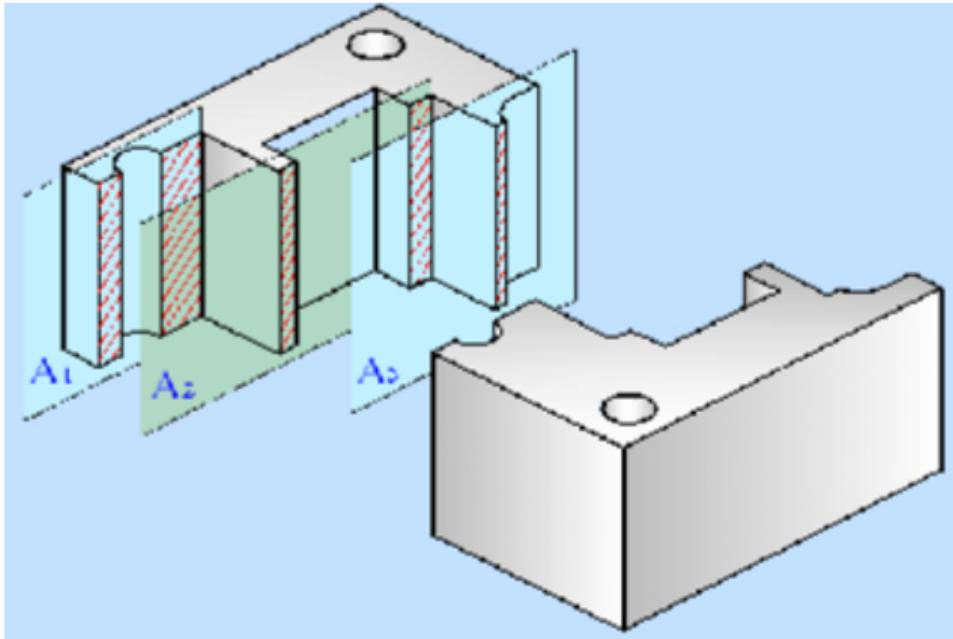
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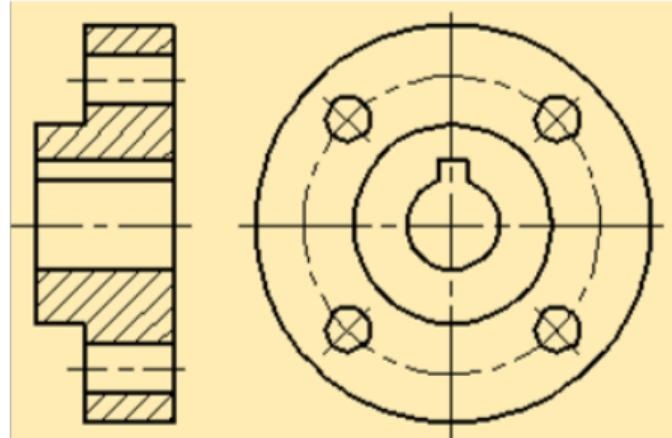
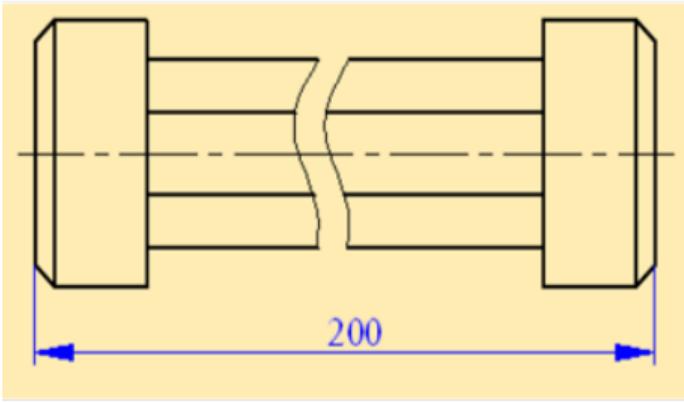
# GOST Standard



# GOST Standard

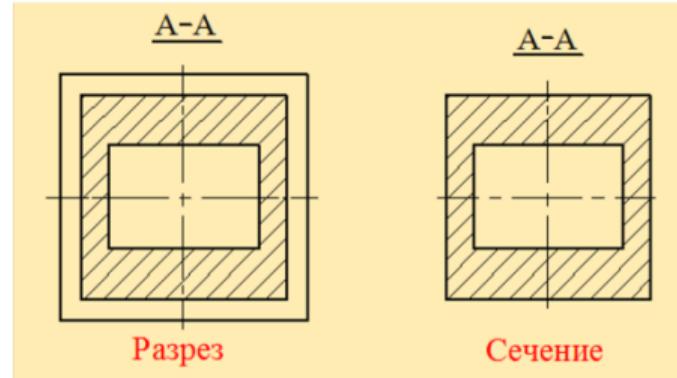
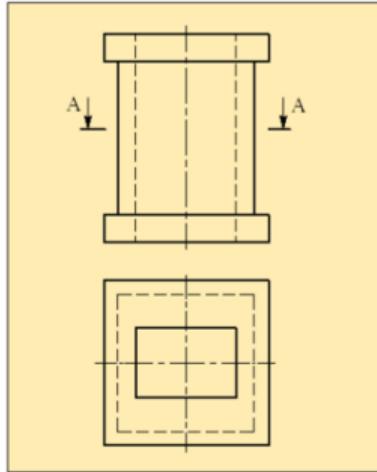
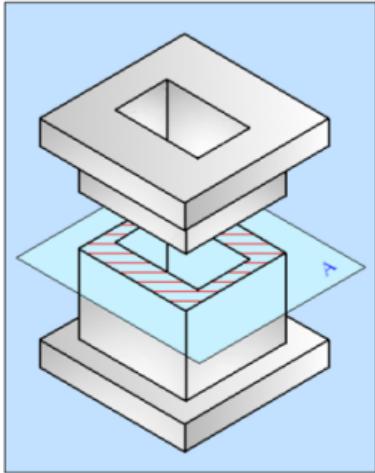


# GOST Standard





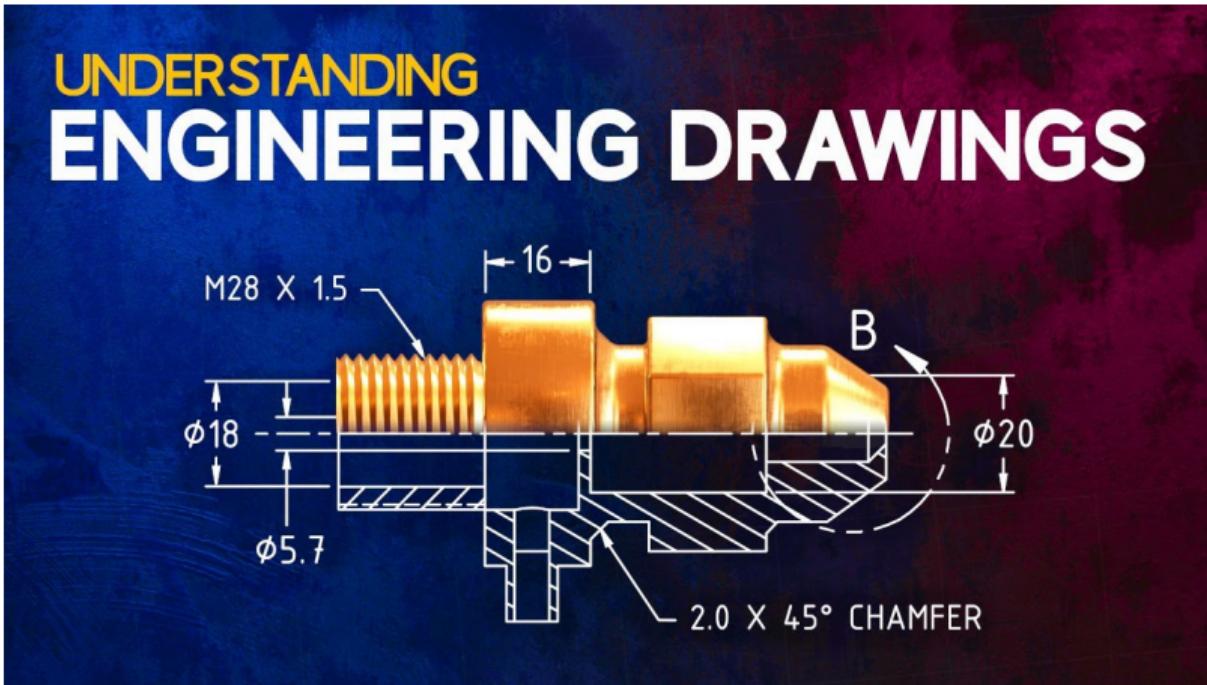
# GOST Standard





# Understanding Engineering Drawings

Video





# Reference Materials

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

# Deserve “A” grade!

– Oleg Bulichev

✉ o.bulichev@innopolis.ru

↗ @Lupasic

🚪 Room 105 (Underground robotics lab)