Mechanics and Machines, Lecture 1

Introduction

Computer Aided Design (CAD)

Engineering Drawings

Innopolis University

Lecturers/Instructors

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Course Goal

To understand engineers:

their problems and

their terminology

*by doing **their** job*

*using **their** tools*

Course puprose 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	Project Selection		07.09
3	Type of drives	CAD, assembly 1	**Defence selection**	Kinematics, analytical solution	14.09
4	Synthesis of planar mechanisms	CAD, assembly 2			21.09
5	Motor sizing (selection)	CAE, motion simulation 1	**Defence Kinematics, analytical solution**	Dynamics, analytical solution	28.09
6	Friction	CAE, motion simulation 2			05.10
7	Links, Joints, Connections, Bearings	CAE, motion simulation 3	**Defence Dynamics, analytical solution**	Dynamics, simulation	12.10
8	Connections: Detachable, Permanent	Render			19.10
9	Overview of materials used in mechanical engineering 1	Overview of materials used in mechanical engineering 2	**Defence Dynamics, simulation**	CAD modeling	26.10
10	Overview of manufacturing methods	Basics of FDM Printing			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**	Durability analysis	16.11
13		CAE, durability analysis 2	**Defence Durability analysis**	Implement a mech in hardware, Render CAD	23.11
14					30.11
15				**Defence the comlete project**	15.12

Grading criteria

CP: Course project: 40%

HWs: Homework assignments: 15% Lab tasks + 15% HWs

Mid: Midterm: 10%

FE: Final Exam: 20%

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

Scale:

A: 85 — 100%

B: 70 — 84.99%

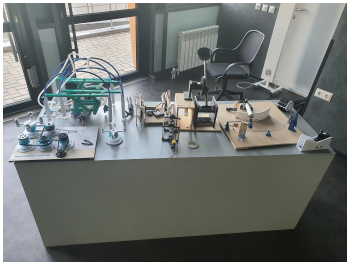
C: 50 — 69.99%

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) e-ISSN: 2395-0056
Volume: 06 Issue: 03 | Mar 2019 www.irjet.net p-ISSN: 2395-0072

Design and Fabrication of Multi Legged Robot

S.N. Teli[1], Rohan Agarwal[2], Devang Bagul[3], Pushkar Badawane[4], Riddhesh Bandre[5]

[1]*Professor, 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 octopedal 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

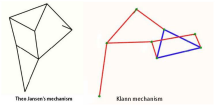
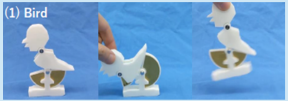


Fig 1. Jansen & Klann Mechanism

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

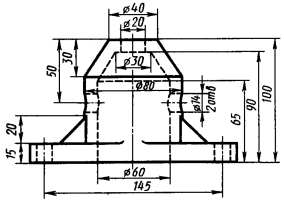


Information about project

In «Project» slides

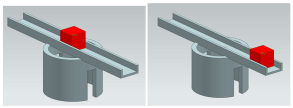
Final Exam (Previous Year)

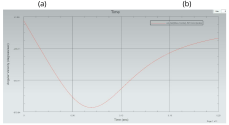
1. (10 score) Make a CAD model of the blueprint, which provided below.
2. (2 extra score) Make the same blueprints (without dimensions), based on your CAD model.
3. (3 extra score) Perform the stress analysis of the detail. All forces and fix supports are on the picture. Material — Steel. You have to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

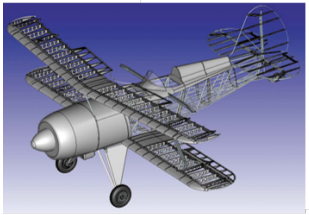
1. What the key aspects should we consider during the motor chosing? The general guide-line of the motor selection.
2. Screw types. Multisided screws, prof and cons. Type of drills. Type of holes. How to distinguish them on a blueprints?

Theory part

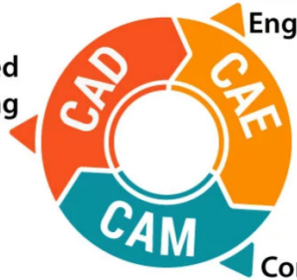
Lab Goals

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

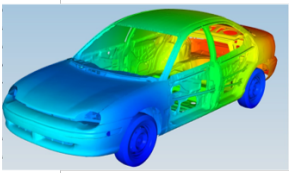
Computer Aided Design



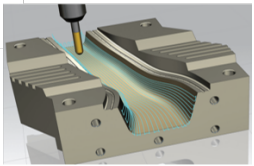
Computer-Aided Drafting



Computer-Aided Engineering

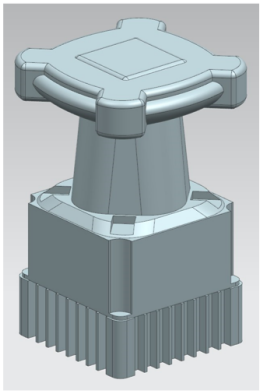


Computer-Aided Manufacturing



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

CAD

Inventor

CAD/CAM/CAE/PDM

SolidWorks

CAD

Компас 3D

CAD/CAM/CAE/PDM

Siemens NX

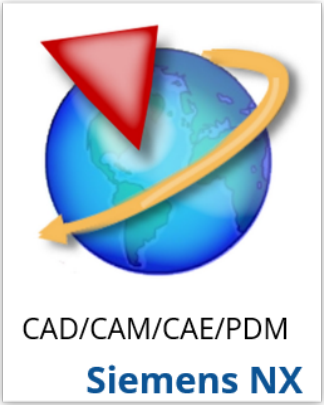
CAD

AutoCAD

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

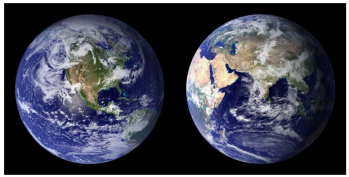
Video

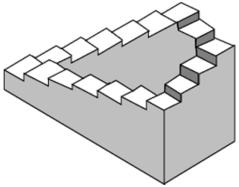
We work with 3D-objects which must be shown in a flat drawing. This is a problem.

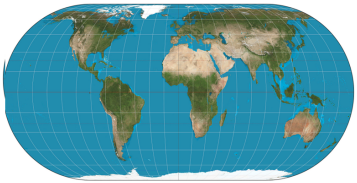
Projections

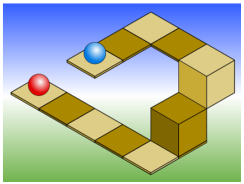
On the one hand, we cannot accurately show curved surfaces.

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



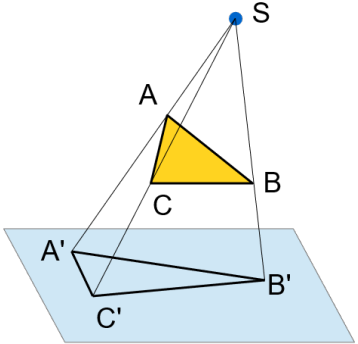






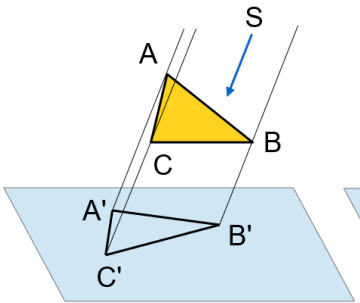
Parallel and perspective projections

Central (perspective) projection

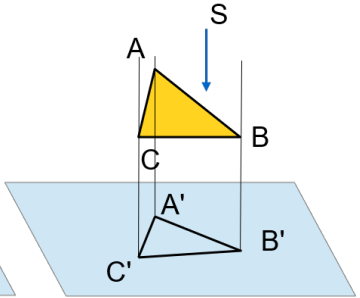


Parallel projections

General (oblique) case

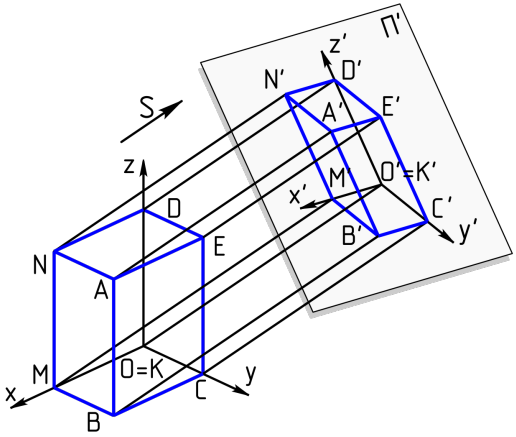


Orthografic projection

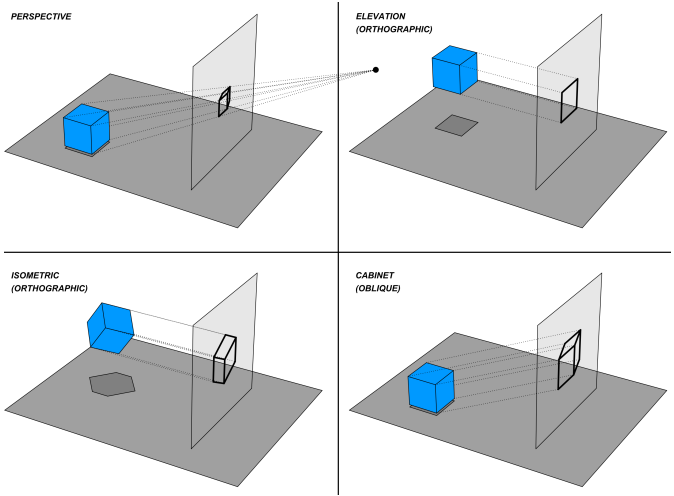


Axonometric projections

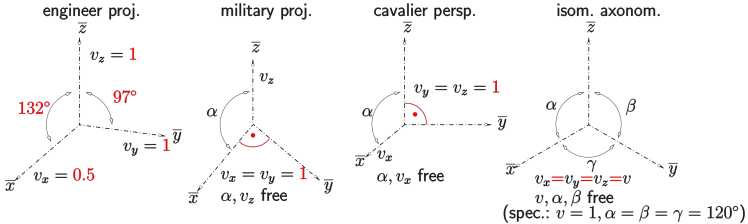
General

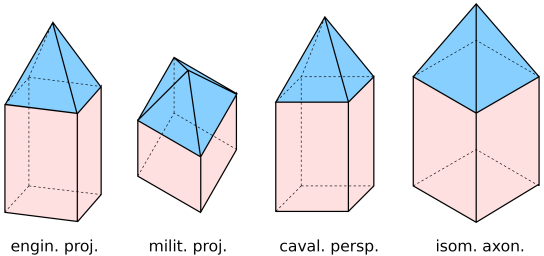


Axonometric projections



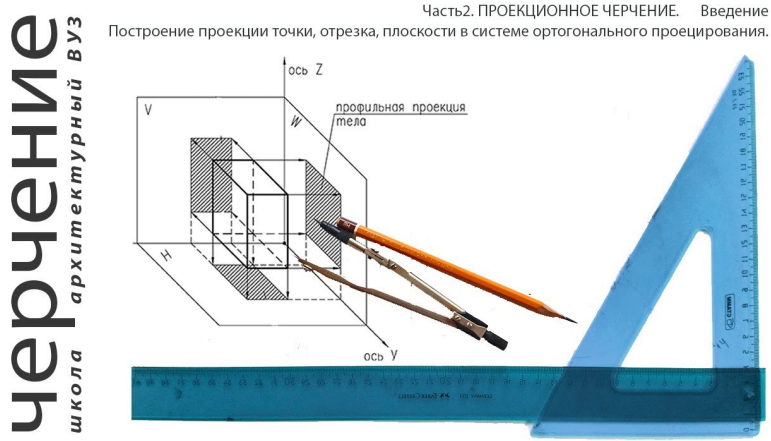
Axonometric projections



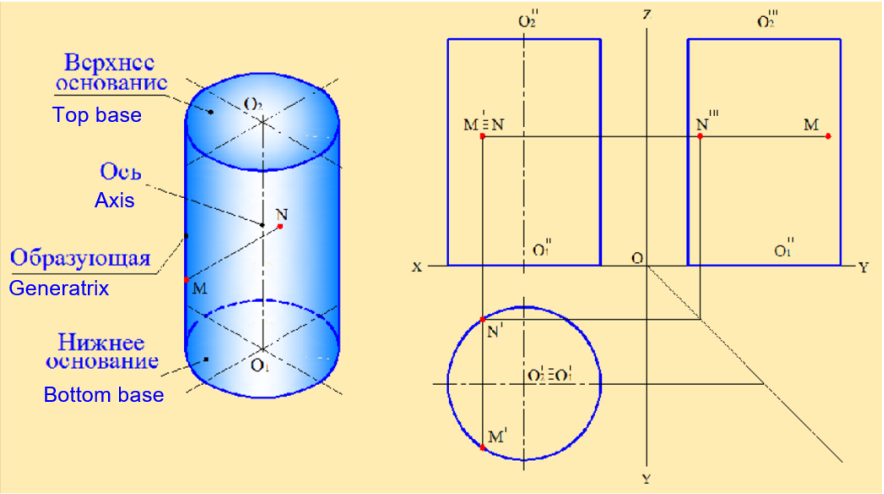


Make a line projection

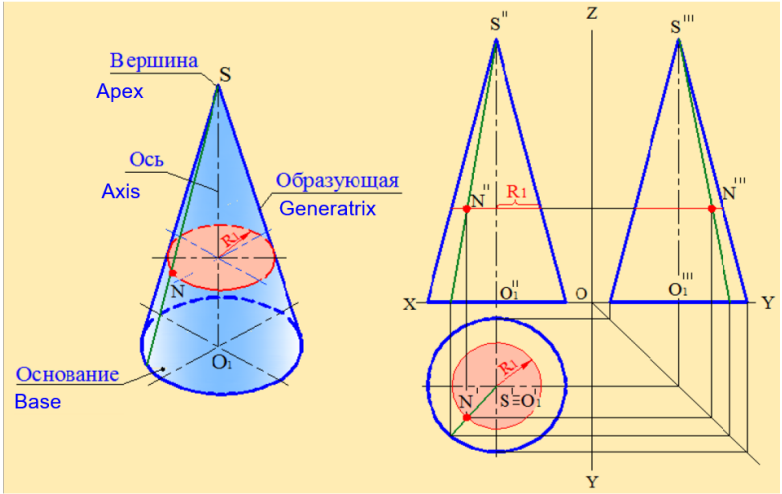
Video



Orthographic Multiview projections



Orthographic Multiview projections



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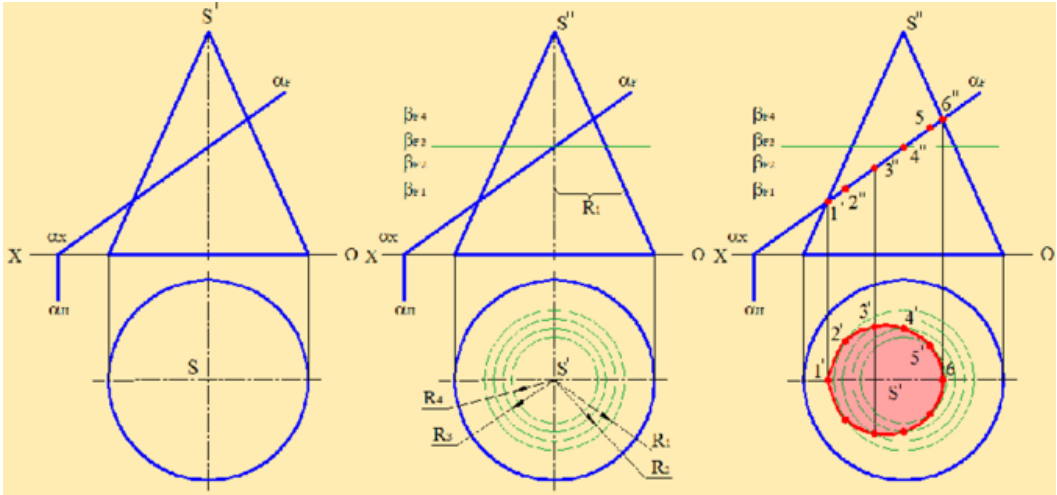

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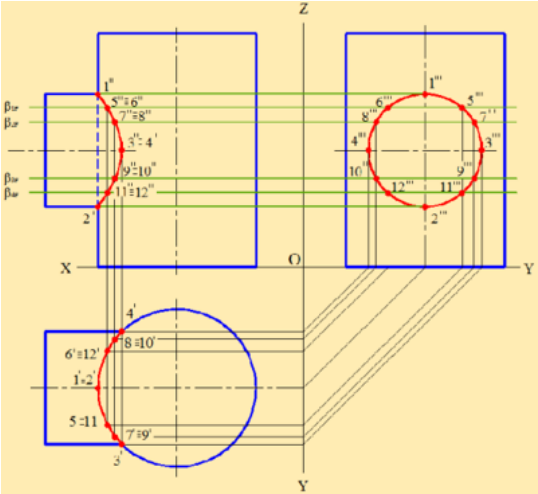
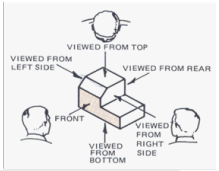
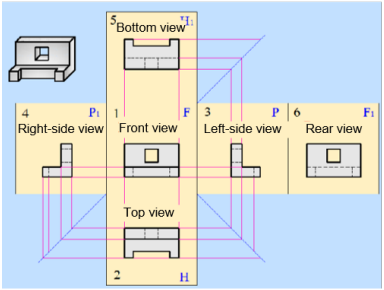
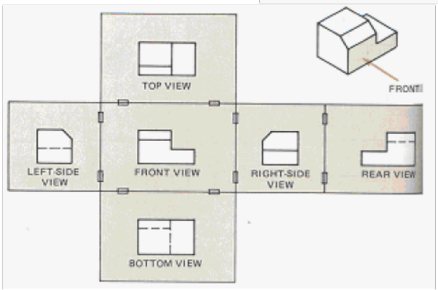


Orthographic Multiview projections

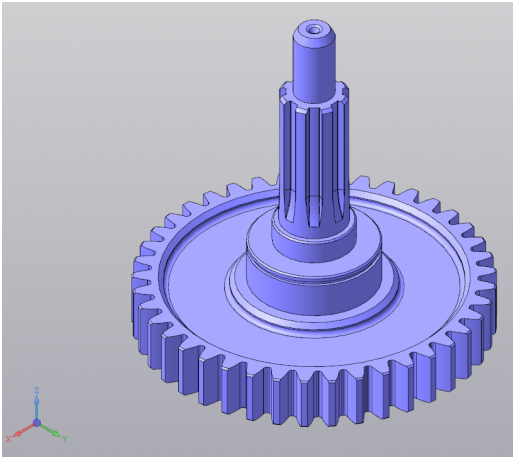
The difference between European and American standards



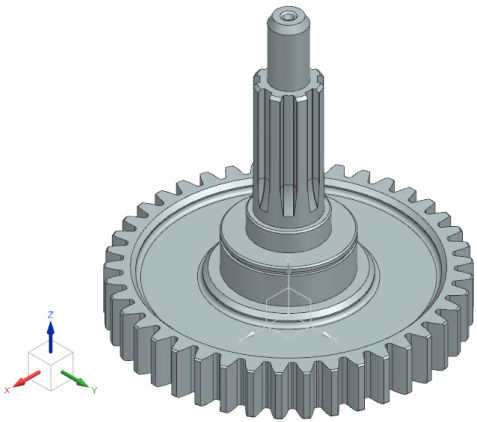




Orthographic Multiview projections

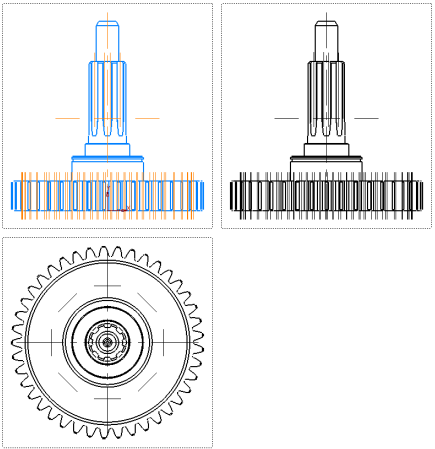


Kompas 3D

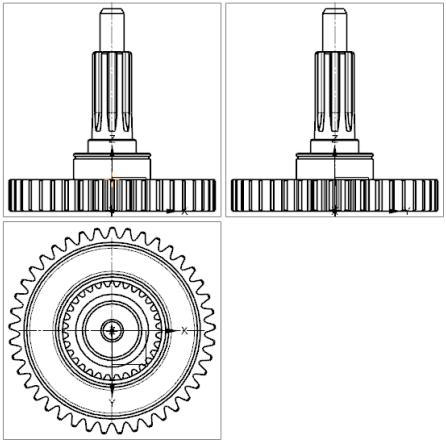


Siemens NX

Orthographic Multiview projections

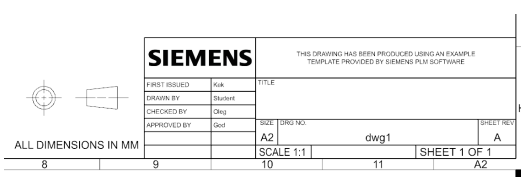


Kompas 3D (European system)



Siemens NX (American system)

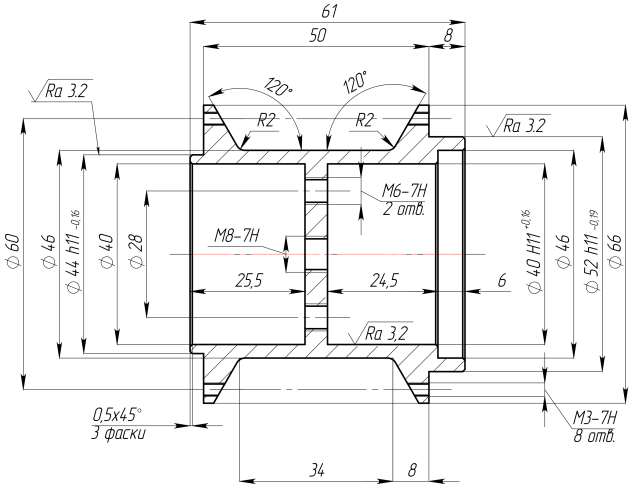
Drawing standards



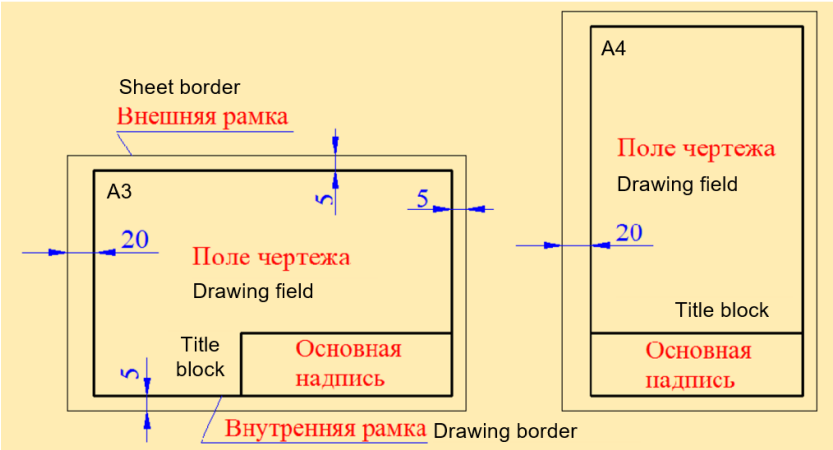
ANSI standard Title Block

GOST standard Title Block

GOST Drawing Example



GOST Drawings



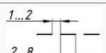
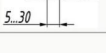
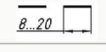
GOST Drawing Title Block

Scale

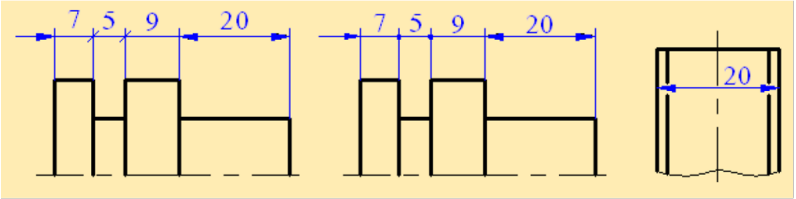
Drawings may be made actual size, or they may be made smaller or larger than the actual size of the object. A drawing that is twice the actual size of the part would show a scale of 2 = 1 or 2:1. A drawing made half the actual size of a part would be in a scale of 1/2 = 1 or simply 1:2.

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



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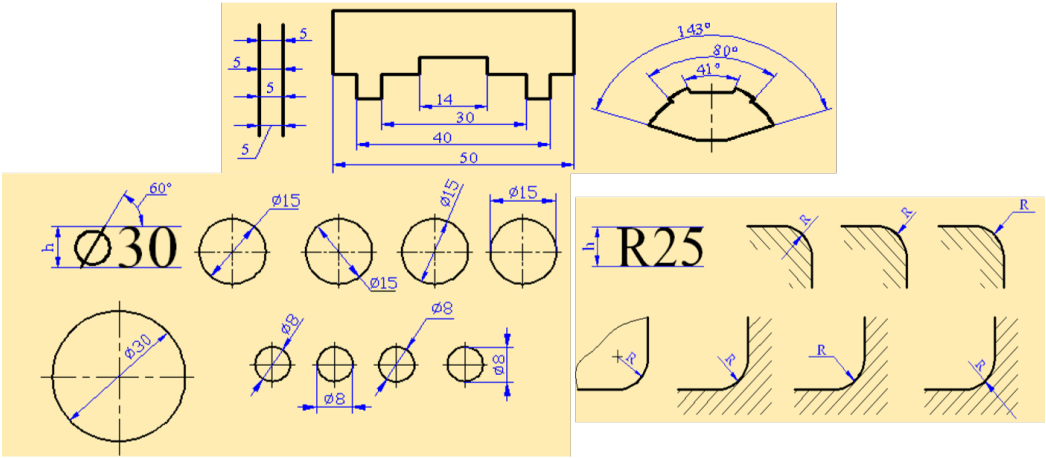

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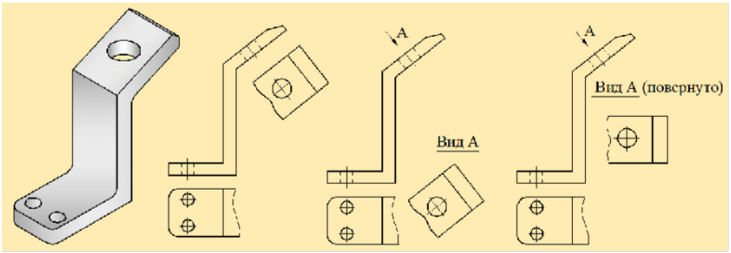

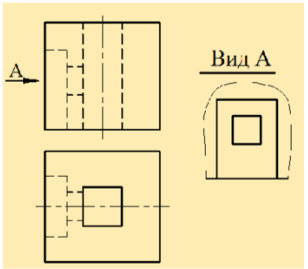

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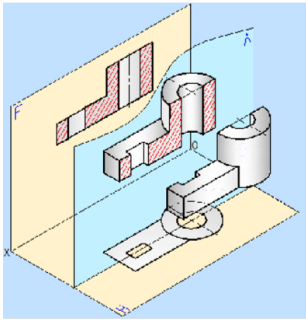

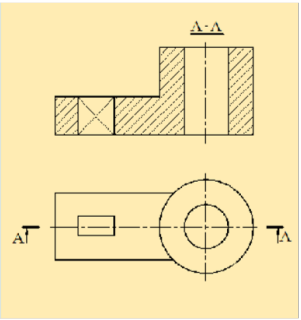

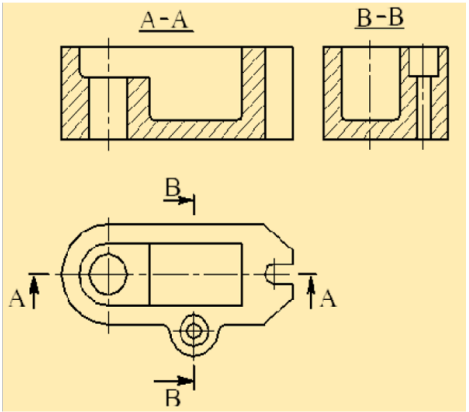

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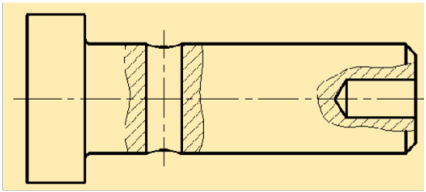

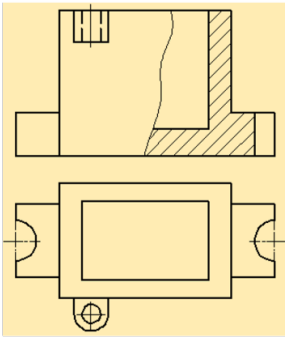

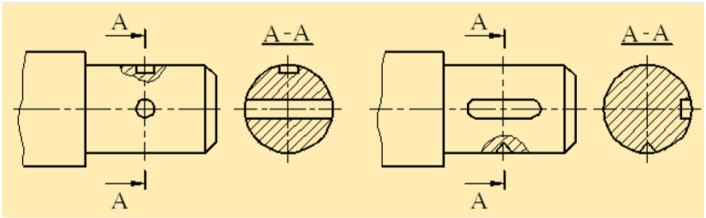

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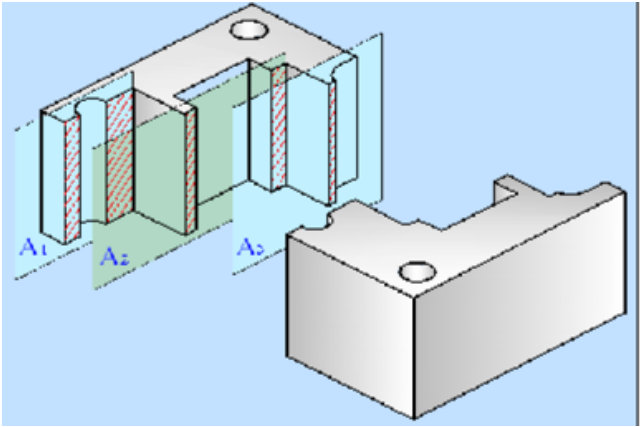

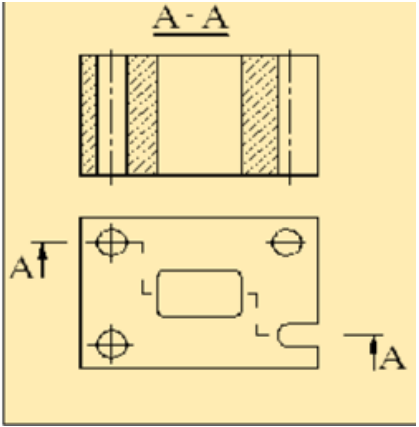

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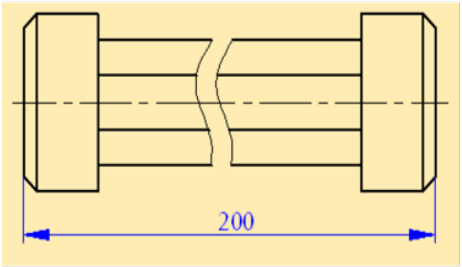

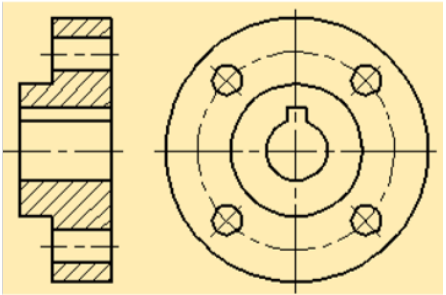

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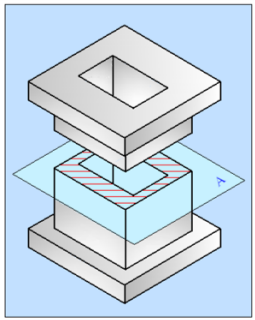
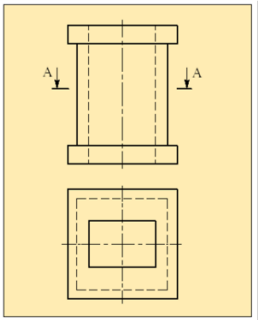
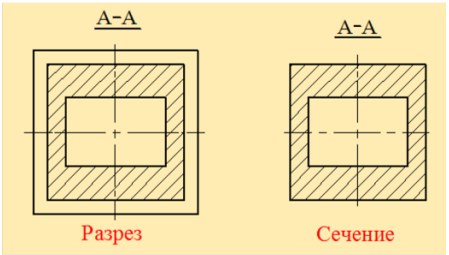
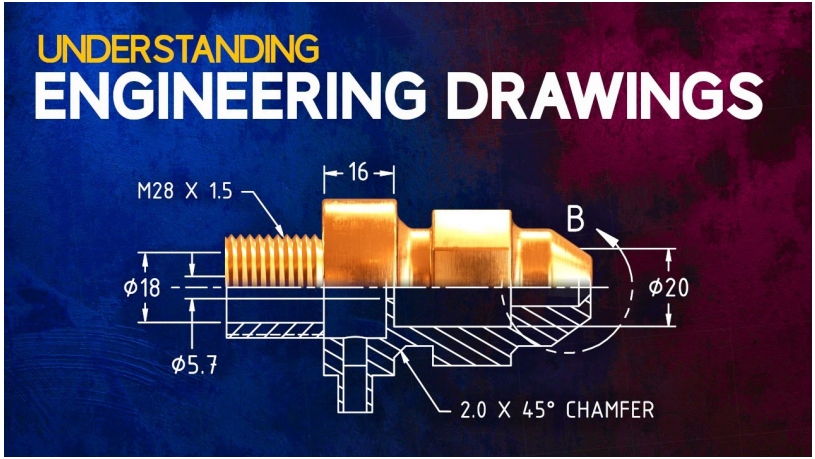






Understanding Engineering Drawings

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)