

**Syllabus**  
**selective component**  
**Theoretical mechanics**

Subjects:	<b>Theoretical mechanics</b>
Level of higher education:	<b>First (undergraduate)</b>
Course page in Moodle:	<a href="https://dl2022.khadi-kh.com/course/view.php?id=3494">https://dl2022.khadi-kh.com/course/view.php?id=3494</a>
The scope of the educational component	<b>4 credits (120 hours)</b>
Final control form	<b>Test</b>
Consultations:	<b>on schedule</b>
Name of the department:	<b>Machine Components and Theory of Machines and Mechanisms</b>
Teaching language:	<b>English</b>
Course leader:	<b>Alexey Voropay, Doctor of Engineering Sciences, professor</b>
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**Brief content of the educational component:**

The "Theoretical Mechanics" course is part of the disciplines related to general professional activity. The structure of professional activity in the field of mechanics is related to the operation and maintenance of technically complex mechanical structures, devices and devices.

The goal is the formation of students' knowledge of the laws of motion and balance of material bodies and the resulting interactions between bodies, the formation of a theoretical basis for further study of special engineering disciplines. Namely, the study of basic equations according to the sections "statics", "kinematics", "dynamics". From "statics", students must solve problems on equilibrium and the position of the center of gravity of a solid body. From "kinematics", students must find the parameters of movement without taking into account external forces. From "dynamics", students should know general theorems and energy equations of motion. Also, students should be able to calculate forces, work of force, kinetic and potential energy of a material point and system of material bodies.

Subject: general laws of mechanical motion, equilibrium of material systems and interaction of material bodies.

**The main tasks of studying an academic discipline are:**

use the acquired knowledge when solving the problems of theoretical mechanics in accordance with its sections:

"Statics" - to draw up equations of equilibrium of various systems of forces, to reduce any system of forces to the simplest form, to determine forces in truss rods, to find the center of gravity of bodies;

"Kinematics" - to determine the speed and acceleration of a separate point and points of a solid body in various cases of their movement by analytical and graphical methods;

"Dynamics" - to compile and investigate the differential equations of motion of a material point and a solid body, to determine the dynamic characteristics of moving objects using general theorems of dynamics and methods of analytical mechanics.

**Prerequisites for studying the educational component:**

Physics

Higher mathematics

## **Competences acquired by the acquirer:**

### **General competences:**

Ability to communicate in a foreign language (English).

The ability to communicate with the scientific community in order to present the results of scientific research and make them public in English.

Ability to think critically, generate new complex ideas, analyze and synthesize holistic knowledge.

Ability to organize and conduct original scientific research.

Knowledge and understanding of the subject area and professional engineering activities.

### **Special (professional) competences:**

Ability to use professional terminology in a foreign language.

Ability to search, process and analyze and summarize information for conducting independent scientific research.

Ability to formulate and perform tasks of design and analysis of existing models

Ability to design machine parts.

Ability to perform analysis of various parts and products, evaluate their operational, technical and economic, technological functions

Ability to apply typical analytical methods and computer programs for solving engineering problems of mechanical engineering, effective quantitative methods of mathematics, physics, engineering sciences, as well as appropriate computer software for solving engineering problems of mechanical engineering

Ability to apply fundamental scientific facts, concepts, theories, principles to solve professional problems and practical problems of mechanical engineering.

The ability to use conceptual scientific and practical knowledge of mathematics, chemistry and physics to solve complex practical problems in the field of construction and civil engineering and involve modern specialized software, computer modeling for their solution.

The ability to evaluate and ensure the quality of the work performed.

### **Learning outcomes according to the educational program:**

Critically evaluate scientific values and achievements of society in the development of technologies.

Apply, use modern information and communication technologies to solve practical tasks and design.

Set and solve both theoretical and applied problems according to the specialty on the basis of physical laws and regularities.

Find and master the basic skills of creating new mechanisms and machine parts.

Knowledge and understanding of mechanics and mechanical engineering and their development prospects.

Carry out engineering calculations to solve complex problems and practical problems in mechanical engineering.

Analyze engineering objects, processes and methods.

Apply basic theories, methods and principles of mathematical and natural sciences, modern models, methods and software tools to solve complex problems of construction and civil engineering.

Participate in research and development in the field of architecture and construction. Design construction structures, buildings, structures, engineering networks and technological processes of construction production, taking into account engineering and technical measures.

### Thematic plan

Topic No	Name of topics (LK, LR, PR, SZ, SR)	Number of hours	
		ocular	extramural
1	2	3	4
1	<b>LL.</b> Introduction . Structural Analysis of Mechanisms .	4	1
	<b>PL.</b> Basic Terms . Determining The Number of Degrees of Freedom.	2	
	<b>IW.</b> Basic Terms. Classification of Kinematic Pairs.	9	14
2	<b>LL.</b> Kinematic analysis of mechanisms. Kinematics of Lever Mechanisms .	4	1
	<b>PL.</b> Vector Diagrams for Velocities and Accelerations. Velocity and acceleration plans.	2	2
	<b>IW.</b> Analytical Kinematics of Lever Mechanisms	9	14
3	<b>LL.</b> Dynamics of mechanisms. Reducing of Forces and Masses. Kinetostatics of Lever Mechanisms.	4	1
	<b>PL.</b> Determination of Reduced Force and Mass.	4	
	<b>IW.</b> Dynamic Analysis of the Crank-and-slider Mechanism.	9	14
4	<b>LL.</b> Machine Elements Classification. Engineering Materials.	4	1
	<b>PL.</b> Basic Requirements to Machines and their Elements	2	
	<b>IW.</b> Modern Construction Materials.	9	14
5	<b>LL.</b> Power Transmissions.	4	1
	<b>PL.</b> Kinematic Analysis of Gear Mechanisms.	2	
	<b>IW.</b> Transmissions by Friction.	9	14
6	<b>LL.</b> Gear mechanisms. Gearings	4	1
	<b>PL.</b> Basic Parameters of Mechanical Transmissions.	2	
	<b>IW.</b> Planetary Gears .	9	
7	<b>LL.</b> Elements for Revolving Motion	4	1
	<b>PL.</b> Calculation of shafts. Calculation of Shafts.	2	
	<b>IW.</b> Sliding and Rolling Bearings.	9	14
8	<b>LL.</b> Permanent and Detachable Joints.	4	1
	<b>PL.</b> Calculation of Joints.	2	2
	<b>IW.</b> Connection with tension. Expanding and Interference Fit	9	14
<b>Toge-ther</b>	<b>LL.</b>	32	8
	<b>PL.</b>	16	4
	<b>IW.</b>	72	108

## Teaching methods :

- 1) verbal:
  - 1.1 traditional: lectures, explanations, stories, etc.;
  - 1.2 interactive (non-traditional): problem lectures, discussions, etc.;
- 2) visual: method of illustrations, method of demonstrations
- 3) practical:
  - 3.1 traditional: practical classes, seminars;

## Evaluation system and requirements:

### Current performance

1 The current success of applicants for the performance of educational types of work in training sessions and for the performance of independent work tasks is evaluated using a four-point rating scale with subsequent transfer to a 100-point scale. During the evaluation of the current academic performance, all types of work provided by the educational program are taken into account.

1.1 Lecture classes are evaluated by determining the quality of performance of specified tasks.

1.2 Practical classes are evaluated by the quality of performance of a control or individual task, performance and design of practical work.

2 The current performance of higher education applicants is assessed at each practical session (laboratory or seminar) on a four-point scale ("5", "4", "3", "2") and entered in the journal of academic performance.

– **"Excellent"**: the winner mastered the theoretical material flawlessly, demonstrates deep knowledge of the relevant topic or academic discipline, the main provisions;

– **"Good"**: the applicant has mastered the theoretical material well, has the main aspects from primary sources and recommended literature, presents it in a reasoned way; has practical skills, expresses his thoughts on certain problems, but certain inaccuracies and errors are assumed in the logic of the presentation of theoretical content or in the analysis of practical ones;

– **"Satisfactorily"**: the applicant has basically mastered the theoretical knowledge of the educational topic or discipline, orients himself in primary sources and recommended literature, but answers unconvincingly, confuses concepts, answers additional questions uncertainly, does not have stable knowledge; when answering questions of a practical nature, reveals inaccuracy in knowledge, does not know how to evaluate facts and phenomena, connect them with the future profession;

– **"Unsatisfactorily"**: the applicant has not mastered the educational material of the topic (discipline), does not know scientific facts, definitions, hardly orients himself in primary sources and recommended literature, lacks scientific thinking, practical skills are not formed.

3 The final score for the current activity is recognized as the arithmetic mean sum of points for each lesson, for individual work, current control works according to the formula:

$$K^{current} = \frac{K1 + K2 + \dots + Kn}{n},$$

where  $K^{current}$  is the final assessment of success based on the results of current control;

$K1, K2, \dots, Kn$  – evaluation of the success  $n$  of the current control measure;

$n$  - the number of measures of current control.

Assessments are converted into points according to the calculation scale (table 1).

**Table 1** – Recalculation of the average grade for the current activity into a multi-point scale

4-point scale	100 points scale	4-ball scale	100 points scale	4-ball scale	100 points scale	4-ball scale	100 points scale
5	100	4.45	89	3.90	78	3.35	67
4.95	99	4.4	88	3.85	77	3.3	66
4.9	98	4.35	87	3.80	76	3.25	65
4.85	97	4.3	86	3.75	75	3.2	64
4.8	96	4.25	85	3.7	74	3.15	63
4.75	95	4.20	84	3.65	73	3.1	62
4.7	94	4.15	83	3.60	72	3.05	61
4.65	93	4.10	82	3.55	71	3	60
4.6	92	4.05	81	3.5	70	from 1.78 to 2.99	from 35 to 59
						reassembly	
4.55	91	4.00	80	3.45	69	from 0 to 1.77	from 0 to 34
4.5	90	3.95	79	3,4	68	repeated study	

### Final assessment

1 A student of higher education receives a credit in the last lesson in the discipline based on the results of the current assessment. The average score for the current activity is converted into points on a 100-point scale, according to the conversion table (table 1).

Applicants for higher education who have a current grade point average in the discipline lower than "3" (60 points) can increase their current grade by taking tests in the discipline in the last session.

Assessment of the knowledge of applicants through testing is carried out according to the following scale:

- "Excellent": at least 90% of correct answers;
- "Very good": from 82% to 89% of correct answers;
- "Good": from 74% to 81% of correct answers;
- "Satisfactory": from 67% to 73% of correct answers;
- "Satisfactory enough": from 60% to 66% of correct answers;
- "Unsatisfactory": less than 60% of correct answers.

2 The condition for obtaining credit is:

- making up for all missed classes;
- the average current grade in the discipline is not lower than "3" (60 points).

3 For performing individual independent work and participation in scientific events, additional points are awarded to the winners.

3.1 Additional points are added to the sum of points scored by the student of higher education for the current educational activity (for disciplines for which the final form of control is a credit), or to the final grade in the discipline for which the final form of control is an exam.

3.2 The number of additional points awarded for different types of individual tasks depends on their volume and importance:

- prizes in the discipline at the international / all-Ukrainian competition of scientific student works - 20 points;
- prize places in the discipline at the All-Ukrainian Olympiads - 20 points;
- participation in the international / all-Ukrainian competition of scientific student works - 15 points

- participation in international / all-Ukrainian scientific conferences of students and young scientists - 12 points;
- participation in all-Ukrainian Olympiads in the discipline - 10 points
- participation in Olympiads and scientific conferences of the Khnadu in the discipline - 5 points;
- performance of individual scientific and research (educational and research) tasks of increased complexity - 5 points.

3.3 The number of additional points cannot exceed 20 points.

4 The learning outcome is evaluated:

– on a 100-point scale (for differentiated assessment) according to table 2.

The final grade together with additional points cannot exceed 100 points.

**Table 2** – The scale for evaluating the knowledge of students based on the results of the final control of the academic discipline

Score in points	Evaluation on a national scale		Evaluation according to the ECTS scale	
	examination	test	Rating	Criteria
<b>90-100</b>	<b>Excellent</b>	<b>Enrolled</b>	<b>A</b>	The theoretical content of the course has been mastered in its entirety, without gaps, the necessary practical skills for working with the mastered material have been formed, all educational tasks provided for in the training program have been completed, the quality of their performance has been assessed with a number of points close to the maximum
<b>80–89</b>	<b>Good</b>	<b>Enrolled</b>	<b>B</b>	The theoretical content of the course has been mastered in its entirety, without gaps, the necessary practical skills for working with the mastered material have mainly been formed, all educational tasks provided for by the training program have been completed, the quality of most of them has been assessed with a number of points close to the maximum
<b>75-79</b>			<b>C</b>	The theoretical content of the course has been mastered in its entirety, without gaps, some practical skills of working with the mastered material have not been formed enough, all educational tasks provided for by the training program have been completed, the quality of none of them has been assessed with a minimum number of points, some types of tasks have been completed with errors
<b>67-74</b>	<b>Satisfactorily</b>		<b>D</b>	The theoretical content of the course is partially mastered, but the gaps are not of a significant nature, the necessary practical skills for working with the mastered material are basically formed, most of the educational tasks provided by the training program have been completed, some of the completed tasks may contain errors

Score in points	Evaluation on a national scale		Evaluation according to the ECTS scale	
	examination	test	Rating	Criteria
<b>60–66</b>			<b>E</b>	The theoretical content of the course has been partially mastered, some practical work skills have not been formed, many educational tasks provided by the training program have not been completed, or the quality of some of them has been assessed with a number of points close to the minimum.
<b>35–59</b>	<b>Unsatisfactorily</b>	<b>Not counted</b>	<b>FX</b>	The theoretical content of the course has been partially mastered, the necessary practical work skills have not been formed, most of the prescribed training programs of educational tasks have not been completed, or the quality of their implementation has been assessed with a number of points close to the minimum; with additional independent work on the course material, it is possible to improve the quality of the performance of educational tasks (with the possibility of retaking)
<b>0–34</b>	<b>Unacceptable</b>		<b>F</b>	The theoretical content of the course has not been mastered, the necessary practical work skills have not been formed, all completed educational tasks contain gross errors, additional independent work on the course material will not lead to any significant improvement in the quality of the performance of educational tasks (with a mandatory repeat course)

#### Course policy:

- the course involves working in a team, the environment in the classroom is friendly, creative, open to constructive criticism;
- mastering the discipline involves mandatory attendance of lectures, as well as independent work;
- independent work involves the study of individual topics of the academic discipline, which are presented in accordance with the program for independent study, or were considered briefly;
- all tasks provided by the program must be completed within the set time;
- if the student of higher education is absent from classes for a good reason, he presents the completed tasks during independent preparation and consultation of the teacher;
- while studying the course, students of higher education must comply with the rules of academic integrity set forth in the following documents: "Rules of academic integrity of participants in the educational process of the KhNAHU" ([https://www.khadi.kharkov.ua/fileadmin/P\\_Standart/pologeniya/stvnz\\_67\\_01\\_dobroch\\_1.pdf](https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_67_01_dobroch_1.pdf)), "Academic integrity. Checking the text of academic, scientific and qualification papers for plagiarism" ( [https://www.khadi.kharkov.ua/fileadmin/P\\_Standart/pologeniya/stvnz\\_85\\_1\\_01.pdf](https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_85_1_01.pdf) ), "Moral and ethical code of participants in the educational process of the KhNAHU ( [https://www.khadi.kharkov.ua/fileadmin/P\\_Standart/pologeniya/stvnz\\_67\\_01\\_MEK\\_1.pdf](https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_67_01_MEK_1.pdf) ).
- in case of detection of plagiarism, the applicant receives 0 points for the task and must repeat the tasks provided for in the syllabus;
- writing off during tests and exams is prohibited (including using mobile devices). Mobile devices are allowed to be used only during online testing.

## Recommended Books:

### Basic literature

1. Distance course:

<https://dl2022.khadi-kh.com/course/view.php?id=3494>

2. Solodov V.G., Romanenko L.G. Theoretical mechanics: Education. manual for students universities; Hark. national automobil.-dor. Univ. Kh., 2014. 270 c.

3. Solodov V.G., Avershin A.G., Starodubtsev Yu.V., Khandrymailov A.A., Shipenko O.N. Theoretical mechanics: Theory and problems. Education manual for students universities, Hark. national automobil.-dor. Univ. Kh., 2010. 214 c.

3. Kyrychenko I.G., Sayenko N.V., Sharapata A.S. Study guide "Mechanical Engineering" with Grif MES Publishing House of the Kharkiv National Automobile and Road University, 2007. 324 p.

4. Sayenko N. V. Study guide "Science and Technology" Publishing House of the Kharkiv National Automobile and Road University, 2016. 180 p.

### Supporting literature

1 .Design of Machine Elements Department of Mechanical Engineering Indian Institute of Technology Kharagpur. Prof. SK Roy-Chowdhury Prof. B. Maiti Prof. G. Chakraborty Kharagpur 721302. Web-course <https://nptel.ac.in/courses/112/105/112105125>

2 .Zakhovaiko O. P. Theory of mechanisms and machines. Part 1: Classification and analysis of mechanisms <https://ela.kpi.ua/handle/123456789/40261>

3 .Zakhovaiko O. P. Theory of mechanisms and machines. Part 2: Synthesis of mechanisms, friction, vibration protection <https://ela.kpi.ua/handle/123456789/40262>

4. Voropay, A., Yehorov, P., Gnatenko, G., Povaliyev, S. & Sharapata, A. (2022). OPTIMIZATION OF MACHINE PARTS MODELS FOR 3D PRINTING. International Journal of 3D Printing Technologies and Digital Industry, 6 (3), 511-520. DOI: 10.46519/ij3dptdi.1187111

5. Voropay O. V., Sharapata A. S. Technical Mechanics: Outline of lectures. Kharkiv: Khnadu, 2022. 124 p.

6. Voropay O. V., Sharapata A. S., Egorov P. A. Methodological instructions for RGR, SRS and practical classes for full-time and part-time students of the discipline "Technical Mechanics" from the specialty 275.03 Transport technologies (on road transport ). Kharkov, Khnadu. 2022. 64 p. (electronic version)

### Additional sources:

1. distance course:

<https://dl2022.khadi-kh.com/course/view.php?id=1473>

2. distance course:

<https://dl2022.khadi-kh.com/course/view.php?id=2522>

3 . Outline of lectures:

[https://static.uni-graz.at/fileadmin/ Persoenliche Webseite/maas\\_axel/tm2016-17.pdf](https://static.uni-graz.at/fileadmin/ Persoenliche Webseite/maas_axel/tm2016-17.pdf)

Developer


of the syllabus of the educational discipline



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