

**MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE  
NATIONAL TECHNICAL UNIVERSITY  
«DNIPRO UNIVERSITY OF TECHNOLOGY»**

**STRUCTURAL, THEORETICAL AND APPLIED MECHANICS  
DEPARTMENT**

**«APPROVED»**

**Head of Department**

**Kolosov D.L.**

**31.08.2021**

**WORKING PROGRAM  
«Technical Mechanics»**

Field of knowledge.....	14 Electrical engineering
Specialty .....	141 Electric Power Engineering, Electrical Engineering and Electromechanics
Educational level .....	First (bachelor)
Educational program ....	Electric Power Engineering, Electrical Engineering and Electromechanics
Status .....	compulsory
Total volume .....	4 ECTS (120 hours)
Teaching time .....	4th semester (7,8 quarters)
Form of final control ...	exam
Teaching language .....	English

Professor: Alexander M. Dolgov

The program of the discipline «Technical Mechanics» for applicants of higher education in the field of knowledge 14 Electrical Engineering, specialty 141 Electric Power Engineering, Electrical Engineering and Electromechanics / A.M. Dolgov; Nat. Tech. University, Dept. construction, theoretical and applied mechanics. - D .: NTU «Dnipro University of Technology», 2021. - 13 p.

Author – A.M. Dolgov

The work program regulates:

- The purpose of the discipline;
- Disciplinary learning outcomes formed on the basis of the transformation of the expected learning outcomes of the educational program;
- Basic disciplines;
- Volume and distribution by forms of organization of the educational process and types of training sessions;
- Program of the discipline (thematic plan by types of classes);
- Algorithm for assessing the level of achievement of disciplinary learning outcomes (scales, tools, procedures and evaluation criteria);
- Tools, equipment and software;
- Recommended sources of information.

The work program is designed to implement a competency-based approach to planning the educational process, teaching the discipline, preparing students for control activities, monitoring the implementation of educational activities, internal and external quality control of higher education, accreditation of educational programs within the specialty.

The work program will be useful for the formation of the content of bachelor's training in the specialty 141 Electric power, electrical engineering and electro mechanics

Agreed by the decision of the scientific-methodical commission of the specialty 141 Electric Power Engineering, Electrical Engineering and Electromechanics (protocol № 21/22-01 from 30.08.2021).

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## 1 PURPOSE OF THE COURSE

In the educational and professional program of the National Technical University «Dnipro University of Technology» for applicants of higher education on the specialty 141 Electric Power Engineering, Electrical Engineering and Electromechanics is represented the distribution of the program learning outcomes (PLO) by organizational forms of the educational process. In particular, the discipline Ф6 «Technical Mechanics» includes the following learning outcomes:

PLO code	Content
ПР07	To carry out the analysis of processes in the electric power, electrotechnical and electromechanical equipment and the corresponding complexes and systems

**The discipline goal** is to form knowledge of general methods of using the basic laws and principles of Mechanics necessary for the analysis of physical phenomena, modeling of various processes and finding optimal solutions to problems arising in the development, technical implementation and operation of electromechanical and power equipment.

Achieving the goal requires the transformation of program learning outcomes into disciplinary ones, and the selection of the content of the discipline according to this criterion.

## 2 EXPECTED DISCIPLINARY LEARNING OUTCOMES

Дисциплінарні результати навчання (ДРН)		
Шифр ПРН	Шифр ДРН	Зміст ДРН
ПР07	ПР07.1-Ф6	compose and resolve equilibrium equations for systems of forces, determine force factors and build their diagrams
	ПР07.2-Ф6	compose and solve the equation of motion of material bodies
	ПР07.3-Ф6	find the kinematic characteristics of the motion of solids
	ПР07.4-Ф6	use general theorems and principles of dynamics for analysis, mechanical processes in machines and devices of electromechanical equipment
	ПР07.5-Ф6	perform engineering calculations for strength, rigidity and stability in tension, compression, torsion and bending
	ПР07.6-Ф6	apply the acquired knowledge for diagnostics and modeling of standard structures of machinery and mechanisms of electromechanical and power equipment.

### 3 BASIC DISCIPLINES

Course title	Learning outcomes obtained
B3 Computer science	PIP06 Use application software to solve practical problems in professional activities
B2 General Physics	PIP07.1-B2 Know: basic laws and concepts of classical (including relativistic) and quantum mechanics, thermodynamics and statistical physics, electrodynamics, theory of oscillations and waves, physics of atoms, molecules, atomic nucleus and condensed state. PIP08.2-B2 Formulate physical ideas, solve problems, estimate quantities, operate with physical models and understand the limits of their applications
B1 Higher Mathematics	PIP07 Carry out analysis of processes in electrical, electrical and electromechanical equipment, relevant complexes and systems. PIP08 Select and apply suitable methods for analysis and synthesis of electromechanical and electrical systems with specified parameters

### 4 SCOPES AND DISTRIBUTION BY FORMS OF EDUCATIONAL PROCESS ORGANIZATION AND TYPES OF TRAINING SESSIONS

Type	Scope, hours	Distribution by forms of study, hours					
		Full time		Part time education		Education by correspondence	
		classroom	individual work	classroom	individual work	classroom	classroom
lectures	60	34	36	-	-	-	-
classes	60	25	35	-	-	-	-
lab	-	-	-	-	-	-	-
<b>TOTAL</b>	120	59	61	-	-	-	-

### 5 DISCIPLINE PROGRAM BY TYPES OF TRAINING SESSIONS

	Types and Topics of Training Sessions	The volume of components, hours
	<b>Lectures</b>	<b>60</b>
PIP07.1-Φ6	<b>1. Basic concepts and axioms of statics</b> 1.1. Subject of statics. Basic concepts and axioms 1.2. Constraints, their classification 1.3. Moment of a force relative to the pole and axis	2
PIP07.1-Φ6	<b>2. Equilibrium conditions of force systems</b> 2.1. Equivalent systems of forces 2.2. Reduction of an arbitrary system of forces to the simplest form 2.3. Center of parallel forces. Center of gravity. Methods of finding the center of gravity 2.4. Equilibrium conditions of particular cases of force systems	6

ΠΡ07.2-Φ6 ΠΡ07.3-Φ6	<b>3. Kinematics of the point</b> 3.1. The subject of kinematics. Space and time in classical mechanics 3.2. Determining the motion of a point, path 3.3. Determining velocity and acceleration of a point	<b>2</b>
ΠΡ07.2-Φ6 ΠΡ07.3-Φ6	<b>4. The simplest movements of a rigid body</b> 4.1. Translational motion of a rigid body 4.2. Rotation of a rigid body around a fixed axis. Angular velocity and angular acceleration of the body 4.3. Velocity and acceleration of points of a rotating solid	<b>2</b>
ΠΡ07.2-Φ6 ΠΡ07.3-Φ6	<b>5. Plane motion of a rigid body</b> 5.1. Equation of plane motion. Distribution of velocities of points of a plane figure. Velocity projection theorem 5.2. Determining velocities and accelerations of body points in plane motion 5.3. Instantaneous center of velocities and ways to find it. ICV as a pole. Methods for determining the angular velocity and angular acceleration of a plane figure	<b>6</b>
ΠΡ07.4-Φ6	<b>6. Dynamics of the point</b> 6.1. The subject of dynamics. Laws of dynamics 6.2. Problems of point dynamics 6.3. Differential equations of the motion of a point	<b>4</b>
ΠΡ07.4-Φ6 ΠΡ07.5-Φ6	<b>7. General theorems of dynamics</b> 7.1. The concept of mechanical systems. Mass and geometric characteristics of systems and solids 7.2. Measures of mechanical motion of the system 7.3. Measures of mechanical interaction 7.4. Theorem of the center of mass motion of a mechanical system. The law of motion of the center of mass of the material system 7.5. Theorem of the change in the momentum and kinetic momentum of mechanical system. Equation of motion of a rigid body around a fixed axis 7.6. Theorem of the change in of kinetic energy	<b>8</b>
ΠΡ07.4-Φ6 ΠΡ07.5-Φ6	<b>8. Fundamentals of the theory of oscillations</b> 8.1. Types of point oscillations. Differential equations of point oscillations 8.2. Free oscillations 8.3. Forced oscillations Decrement oscillations. Resonance	<b>6</b>
ΠΡ07.4-Φ6 ΠΡ07.5-Φ6	<b>9. Introduction to Strength of Materials</b> 9.1. Basic hypotheses. Types of beam deformation 9.2. Stress and strain	<b>2</b>
ΠΡ07.4-Φ6 ΠΡ07.5-Φ6	<b>10. Axial tension and compression</b> 10.1 Deformation of tension and compression. Longitudinal forces and drawing their diagrams 10.2. Tension. Longitudinal and transverse deformations. Hooke's law 10.3. Mechanical characteristics of materials. Tension and compression diagrams. Dangerous stresses. Strength and working stress. Strength condition	<b>6</b>
ΠΡ07.4-Φ6	<b>11. Torsion</b>	<b>4</b>

ΠΡ07.5-Φ6	11.1. Determining torques and drawing their diagrams 11.2. Stress and strain at torsion of round cross section rods 11.3. Calculation of strength and rigidity	
ΠΡ07.4-Φ6 ΠΡ07.5-Φ6	<b>12. Straight transverse bending</b> 12.1. Types of bent beams. Internal efforts at direct transverse bending and drawing their diagrams 12.2. Differential dependences at bending. Differential equation of the elastic line of the beam 12.3. Normal stress at pure bending. Calculation of beams on strength by normal stresses	<b>6</b>
ΠΡ07.4-Φ6 ΠΡ07.6-Φ6	<b>13. Basics of machine parts</b> 13.1. Belt and chain transmissions 13.2. Gears and worm gears 13.3. Shafts and axles 13.4. Bearings 13.5. Detachable and non-detachable connections 13.6. Couplings	<b>6</b>
	<b>Practical Classes</b>	<b>60</b>
ΠΡ07.1-Φ6	Equilibrium of concurrent force system	<b>3</b>
ΠΡ07.1-Φ6 ΠΡ07.2-Φ6	Equilibrium of coplanar force system	<b>4</b>
ΠΡ07.3-Φ6	Point kinematics: determining path, velocity and acceleration of a point	<b>3</b>
ΠΡ07.3-Φ6	Rotational motion of a rigid body around a fixed axis. Determining the speed and acceleration of the body points	<b>3</b>
ΠΡ07.3-Φ6	Plane motion of a rigid body: determining velocities and acceleration points of the body	<b>6</b>
ΠΡ07.4-Φ6	Solution of the first and second problems of point dynamics	<b>4</b>
ΠΡ07.4-Φ6	Using the theorem of the center of mass motion of a mechanical system	<b>3</b>
ΠΡ07.4-Φ6	Using the kinetic moment theorem of a point and a system	<b>3</b>
ΠΡ07.4-Φ6	Using the theorem of the change in kinetic energy of a point and a system	<b>6</b>
ΠΡ07.4-Φ6	Oscillatory motion of a material point: free, damping and forced oscillations	<b>3</b>
ΠΡ07.5-Φ6	Calculation of tensile and compressive strength and rigidity	<b>4</b>
ΠΡ07.5-Φ6	Calculations for torsional strength and rigidity	<b>4</b>
ΠΡ07.5-Φ6	Diagrams of internal efforts for beams at bending	<b>4</b>
ΠΡ07.5-Φ6	Calculations for the strength of transverse bending by normal stress	<b>3</b>
ΠΡ07.5-Φ6 ΠΡ07.6-Φ6	Fundamentals of calculation of mechanical gears	<b>4</b>
ΠΡ07.1-Φ6	Shaft calculation and bearing selection	<b>3</b>
	<b>TOTAL</b>	<b>120</b>

## 6 ASSESSMENT OF LEARNING OUTCOMES

Certification of student achievement is carried out through transparent procedures based on objective criteria in accordance with the Regulations of the University «On the evaluation of learning outcomes of higher education».

The achieved level of competencies in relation to the expected ones, which is identified during the control activities, reflects the real result of the student's study in

the discipline.

## 6.1 Scales

Assessment of academic achievements of students of NTU «DP» is carried out on a rating (100-point) and institutional scales. The latter is necessary (in the official absence of a national scale) for the conversion (translation) of mobile students' grades.

*Scales for assessing the academic achievements of students of NTU«DP»*

<b>Rating</b>	<b>Institutional</b>
90...100	Excellent
74...89	Good
60...73	Satisfactory
0...59	Fail

The discipline is credited if the student got a final mark of at least 60 points. The lower mark is considered to be an academic debt that is subject to liquidation in accordance with the Regulations on the organization of the educational process of NTU «DP».

## 6.2 Means and Procedures

The content of diagnostic tools is aimed at controlling the level of knowledge, skills, communication, autonomy and responsibility of the student according to the requirements of the NRC to the 6-th qualification level during the demonstration of learning outcomes regulated by the work program.

The student in the control activities must perform tasks focused solely on the demonstration of disciplinary learning outcomes (Section 2).

Diagnostic tools provided to students at control activities in the form of tasks for current and final control, are formed by specifying the initial data and the method of demonstrating disciplinary learning outcomes.

Diagnostic tools (control tasks) for the current and final control of the discipline are approved by the department.

The types of diagnostic tools and assessment procedures for the current and final control of the discipline are given below.



### *Diagnostic means and assessment procedures*

CURRENT CONTROL			FINAL CONTROL	
training session	diagnostic tools	procedures	diagnostic tools	procedures
lectures	control tasks for each topic	poll	exam	determining the weighted average result of current controls
classes	control tasks for each topic	performing tasks during practical classes		performing complex control task (CCT) during the exam at the request of the student
	individual task	performing tasks during individual work		

If the content of a certain type of classes is subject to several descriptors, the integral value of the assessment can be determined taking into account the weights set by the teacher.

If there is a level of results of current controls in all types of classes at least 60 points, the final control is carried out without the participation of the student by determining the weighted average of current grades.

Regardless of the results of the current control, each student during the exam has the right to perform the CCT, which contains tasks covering key disciplinary learning outcomes.

The number of specified tasks of the CCT should correspond to the allotted time for execution. The number of the CCT options should provide individualization of the task.

The value of the assessment for the implementation of the CCT is determined by the average assessment of the components (specified tasks) and is final.

The integral value of the assessment of the implementation of the RCC can be determined taking into account the weights set by the department for each descriptor of the NRC.

### **6.3 Criteria**

Actual student learning outcomes are identified and measured relative to what is expected during the follow-up activities using criteria that describe the student's actions to demonstrate the achievement of learning outcomes.

To assess the performance of control tasks during the current control of lectures and practical classes as a criterion is used the coefficient of mastering, which automatically adapts the assessment indicator to the rating scale:

$$O_i = 100 a/m,$$

where  $a$  is the number of correct answers or significant operations performed in accordance with the decision standard;  $m$  is the total number of questions or significant operations of the standard.

Individual tasks and complex tests are evaluated expertly using criteria that characterize the ratio of requirements to the level of competencies and indicators of

assessment on a rating scale.

The content of the criteria is based on the competency characteristics defined by the NQF for the master's level of higher education (below).

**General criteria for achieving learning outcomes for the 6-th qualification level for NRC**

NRC descriptors	Requirements for knowledge, skills, communication, autonomy and responsibility	Grade
<b>Knowledge</b>		
specialized conceptual knowledge acquired in the process of learning and / or professional activity at the level of the latest achievements, which are the basis for original thinking and innovation, in particular in the context of research work; critical understanding of problems in teaching and / or professional activities and at the border of subject areas	The answer is excellent - correct, reasonable, meaningful. Characterizes the presence of: - specialized conceptual knowledge at the level of the latest achievements; - critical understanding of problems in teaching and / or professional activities and at the border of subject areas	95-100
	The answer contains minor errors or omissions	90-94
	The answer is correct, but has some inaccuracies	85-89
	The answer is correct, but has some inaccuracies and is insufficiently substantiated	80-84
	The answer is correct, but has some inaccuracies, insufficiently substantiated and meaningful	74-79
	The answer is fragmentary	70-73
	The answer shows the student's vague ideas about the object of study	65-69
	The level of knowledge is minimally satisfactory	60-64
	The level of knowledge is unsatisfactory	<60
<b>Skills</b>		
<ul style="list-style-type: none"> <li>• solving complex problems and problems that require updating and integration of knowledge, often in conditions of incomplete / insufficient information and conflicting requirements;</li> <li>• conducting research and / or innovation activities</li> </ul>	The answer characterizes the ability to: - identify problems; - formulate hypotheses; - solve problems; - update knowledge; - integrate knowledge; - to carry out innovative activity; - to carry out scientific activity	95-100
	The answer characterizes the ability to apply knowledge in practice with minor errors	90-94
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of one requirement	85-89
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the two requirements	80-84
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation of the three requirements	74-79
	The answer characterizes the ability to apply knowledge in practice, but has some inaccuracies in the implementation	70-73

NRC descriptors	Requirements for knowledge, skills, communication, autonomy and responsibility	Grade
	of the four requirements	
	The answer characterizes the ability to apply knowledge in practice when performing tasks on the model	65-69
	The answer characterizes the ability to apply knowledge in performing tasks on the model, but with inaccuracies	60-64
	The level of skills is unsatisfactory	<60
<b>Communication</b>		
<ul style="list-style-type: none"> <li>• clear and unambiguous communication of own conclusions, as well as knowledge and explanations that substantiate them, to specialists and non-specialists, in particular to students;</li> <li>• use of foreign languages in professional activities</li> </ul>	Clarity of the answer (report). Language: <ul style="list-style-type: none"> <li>- correct;</li> <li>- clean;</li> <li>- clear;</li> <li>- accurate;</li> <li>- logical;</li> <li>- expressive;</li> <li>- concise.</li> </ul> Communication strategy: <ul style="list-style-type: none"> <li>- consistent and consistent development of thought;</li> <li>- the presence of logical own judgments;</li> <li>- appropriate reasoning and its compliance with the defended provisions;</li> <li>- correct structure of the answer (report);</li> <li>- correct answers to questions;</li> <li>- appropriate technique for answering questions;</li> <li>- ability to draw conclusions and formulate proposals;</li> <li>- use of foreign languages in professional activities</li> </ul>	95-100
	Sufficient clarity of the answer (report) and appropriate communication strategy with minor flaws	90-94
	Good clarity of the answer (report) and appropriate communication strategy (three requirements in total are not realized)	85-89
	Good clarity of response (report) and appropriate communication strategy (four requirements not implemented in total)	80-84
	Good comprehensibility of the answer (report) and appropriate communication strategy (five requirements in total are not fulfilled)	74-79
	Satisfactory clarity of response (report) and appropriate communication strategy (seven requirements not implemented in total)	70-73
	Satisfactory comprehensibility of the answer (report) and communication strategy with errors (a total of nine requirements are not implemented)	65-69
	Satisfactory comprehensibility of the answer (report) and communication strategy with errors (a total of 10 requirements are not implemented)	60-64
	The level of communication is unsatisfactory	<60
<b>Autonomy and responsibility</b>		
• responsibility for	Excellent competence:	95-100

<b>NRC descriptors</b>	<b>Requirements for knowledge, skills, communication, autonomy and responsibility</b>	<b>Grade</b>
the development of professional knowledge and practices, assessment of the strategic development of the team; • ability to further study, which is largely autonomous and independent	<ul style="list-style-type: none"> <li>- use of principles and methods of organizing team activities;</li> <li>- effective distribution of powers in the team structure;</li> <li>- maintaining a balanced relationship with team members (responsibility for the relationship);</li> <li>- stress resistance;</li> <li>- self-regulation;</li> <li>- work activity in extreme situations;</li> <li>- high level of personal attitude to the case;</li> <li>- mastery of all types of educational activities;</li> <li>- appropriate level of fundamental knowledge;</li> <li>- the appropriate level of formation of general educational skills and abilities</li> </ul>	
	Confident mastery of the competencies of autonomy and responsibility with minor flaws	90-94
	Good mastery of autonomy and responsibility competencies (two requirements not met)	85-89
	Good mastery of autonomy and responsibility competencies (three requirements not met)	80-84
	Good mastery of autonomy and responsibility competencies (four requirements not met)	74-79
	Good mastery of autonomy and responsibility competencies (five requirements not met)	70-73
	Good mastery of autonomy and responsibility competencies (six requirements not met)	65-69
	Satisfactory mastery of autonomy and responsibility competencies (fragmentary level)	60-64
	The level of autonomy and responsibility is unsatisfactory	<60

## **7 TOOLS, EQUIPMENT AND SOFTWARE**

Technical teaching aids (laboratory equipment, personal computers, multimedia equipment).

Remote platform (Teams, Zoom).

## **8 RECOMMENDED SOURCES OF INFORMATION**

1. S. Targ. Theoretical Mechanics. A Short Course. – Moscow: Foreign Languages Publishing House, 1974. – 421 p.
2. N.M. Belyaev. Strength of Materials. – Moscow: Mir Publisher, 1979. – 647 p.
3. Theoretical mechanics. Kinematics [Text]: Summary of lectures/ A.M.Dolgov. - D.: National Mining institute, 1992. - 39 p.
4. Elements of Strength of Materials. [Text]: Summary of lectures, Part 1/ Blokhin S.E., A.M. Dolgov. - D.: National Mining university, 1998. - 35 p.
5. Theoretical Mechanics. Statics [Text]: Summary of lectures/ A.M.Dolgov. - D.: National Mining university, 1998. - 37 p.
6. Theoretical Mechanics. Dynamics [Text]: Summary of lectures/ A.M.Dolgov. - D.: National Mining university, 2000. - 49 p.

7. Theoretical Mechanics. Dynamics [Text]: tutorial/ A.M.Dolgov. - D.: National Mining university, 2012. - 160 p.
8. Dolgov, A.M. Theoretical mechanics [electronic resource] : electronic textbook / A.M.Dolgov ; Ministry of Education and Science of Ukraine, National Mining University. – Dnipropetrovs'k : NMU, 2015. – 124 p.
9. A.M. Dolgov, D.L.Kolosoov. Mechanics of Machines [Text]: Study Guide / A.M. Dolgov. – D.: NTU «Dnipro university of technology», 2020. – 64 p.

Information Resources:

<https://do.nmu.org.ua/course/view.php?id=2592>  
<https://do.nmu.org.ua/course/view.php?id=2425>  
<https://do.nmu.org.ua/course/view.php?id=2070>  
<https://btpm.nmu.org.ua/ua/vydav/metodichka.php>  
<https://btpm.nmu.org.ua/ua/selfstudy/och.php>

Educational Edition

**WORKING PROGRAM**

«Technical Mechanics»

for bachelors majoring in 141 Electric Power Engineering, Electrical Engineering and Electromechanics

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