Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Aircraft and Rocket Engineering

DYNAMICS OF MECHANICAL STRUCTURES OF AIRPLANE, HELICOPTERS, SATELLITES

Work program of the discipline (Syllabus)

Details of the discipline

Реквізити навчальної дисципліни

Level of higher education	*Second (master's)*
Field of knowledge	*13 Mechanical engineering*
Specialty	*134 Aviation and aerospace technologies*
Educational program	*Aviation and aerospace technologies*
Status of the discipline	*Cycle of professional training*
Form of study	*Full-time form of study*
Year of preparation, semester	*1 course, fall srmester*
Scope of the discipline	*120 hours*
Semester control/ control measures	*Exam*
Lessons schedule	*http://rozklad.kpi.ua*
Language of teaching	*Ukrainian/English*
Information about the teacher course leader	*Lecturer: Associate Professor P.V. Lukianov,lvptvl@ukr.net* *Laboratory: Associate Professor Lukyanov P.V., lvptvl@ukr.net*
Placement course	*https://campus.kpi.ua*

Program of educational discipline

1. ***Description of the educational discipline, its purpose, subject of study and learning outcomes***

This discipline is designed to provide masters with theoretical and practical knowledge and skills necessary for independent calculation and design of aircraft and their components and construction of their mathematical models. In particular, students learn to independently develop algorithms for forming mathematical models of the dynamics of mechanical objects and systems.

The knowledge and skills that students acquire in the course of studying the credit module "Dynamics of Mechanical Structures" allow them to independently analyse and calculate the dynamics of mechanical objects and systems in the process of creating a master's thesis.

- **The aim of the discipline is to develop students' competencies:**

- PC 5. Ability to create, improve and apply mathematical and numerical methods of modelling properties, phenomena and processes in systems and elements of aviation and rocket and space technology.

- PC 8. Ability to determine the optimal designs of samples of aviation and rocket and space technology, and to optimise the parameters of structural elements and systems.:

And also:

- develop physical and mathematical models of dynamic systems;
- apply numerical methods to describe arbitrary mechanical structures in the form of systems of mathematical functions;
- develop methods and algorithms for optimising mechanical structures and parameters of their elements;
- implement physical and mathematical models of dynamic systems using methods and tools of modern information technology;
- to develop mathematical models of elastic mechanical structures and use them to determine the frequencies and forms of vibrations of aircraft structures.

In accordance with the requirements of the educational and professional programme, students must demonstrate the following learning outcomes after completing the discipline:

knowledge:

- theoretical methods of studying complex mechanical structures;
- methods of analytical mechanics, their interrelation;
- basic parameters of mechanical structures and methods of parametric modelling of mechanical systems and study of their dynamic behaviour;

Programme learning outcomes:

PLO 2. To know and understand the work processes in the systems and elements of aviation and/or rocket and space technology necessary to understand, describe, improve and optimise their parameters.

PLO 9. Reasonably assign a class of materials for elements and systems of aviation and rocket and space technology, select and apply effective methods of modifying their properties.

PLO 16. Calculate the stress-strain state, determine the load-bearing capacity of structural elements and the reliability of aerospace engineering systems using specialised software used in the industry.

PLO 17. Apply in practice modern methods and means of design, production, testing, repair and (or) certification of aviation and rocket and space technology systems.
PLO 21. Ability to evaluate the dynamics of objects of aviation and rocket and space technology.

And also:

- create and analyse a mathematical model of a mechanical structure;
- analyse its behaviour and dynamic characteristics;
- apply numerical methods of analysis to study mechanical systems using modern information technologies;

1.Prerequisites and post-requisites of the discipline (place in the structural and logical scheme of study for the relevant educational programme)

The study of this discipline requires students to have skills in the basics of theoretical mechanics,

knowledge of the theory and methods of solving differential equations, systems of differential equations, the ability to solve the Cauchy problem for differential equations and systems of differential equations. To do this, they must use personal computers at the level of an experienced user, as well as have the level of knowledge and skills that they acquire when studying the disciplines of the first (bachelor's) level of training in the specialty "134 Aviation and Rocket and Space Engineering".

1. Content of the discipline

Chapter and topic titles	Number of hours				
	Total	including			
		Lectures	Practice works	Laboratory`s works	IWS
Topic 1.1. Basic concepts of analytical mechanics.	60	8	-	8	44
Modular test	10	2	-	-	8
Topic 2.1. Free (natural) oscillations of a mechanical system with one degree of freedom.	60	10	–	10	40
Total hours:	**120**	18	-	18	84

2.Training materials and resources .

Literatures:

2.1. Basic.

1.1. Pavlovskyi M.A. Teoretychna mekhanika. – Kyiv, Tekhnika, 2002. – 510.s

1.2. Pavlovskyi M.A., Zaplatnyi V.I. Analitychna mekhanika. - K.: NMK VO, 1990. - 144 s.

1.3 Bahniuk H.A., Halanzovska M.R., Nakonechnyi V.V., Serilko L.S. Praktykum z teoretychnoi mekhaniky. – Rivne: NUVHP, 2014. – 162 s.

1.4 Kilchevskyi M.O. Kurs teoretychnoi mekhaniky: U dvokh tomakh. : pidruchnyk : u dvokh tomakh / M.O. Kilchevskyi. – Kyiv : Kyivskyi universytet. T.1 : Kinematyka, statyka, dynamika tochky. – 2009.,- 499s.

1.5 Kilchevskyi M.O. Kurs teoretychnoi mekhaniky: U dvokh tomakh. : pidruchnyk : u dvokh tomakh / M.O. Kilchevskyi – Kyiv : Kyivskyi universytet T.2 : Dynamika system. – 2009.,-462s.

Допоміжна.

2.1 Nivaldo A. Lemos. Analytical mechanics.- Cambridge University Press.-2018.,470p.

2.2 Valter Moretti. Analytical Mechanics.-Springer,2023.,-540p.

2.3. O.M.Chernysh,M.H.Berezovyi M.H.,V.V.Yaremenko, I.V.Holovach. Teoretychna mekhanika.-TsUL,2020.-760s.

2.4 P.K.Shtanko, V.H.Shevchenko, O.S.Omelchenko, L.F.Dziuba, V.R.Pasika,O.M.Poliakov, Teoretychna mekhanika.-STATUS,2021.- 464s.

Online resources:

1. http://iat.kpi.ua

2. http://kpi.ua
3. NACA Library, USA, www.nasa.gov

Educational content

5. Methods of mastering the discipline (educational component**)**

Lecture classes.

Таблиця 2

№	Title of the lecture topic and a list of key questions
	Topic 1.1. Fundamentals of mechanics of material systems
1	**Lecture 1: Basic concepts of analytical mechanics.** Definition of the terms "mechanics" and "theoretical mechanics". Basic concepts of theoretical mechanics. Basic laws of classical mechanics. Differential equations of motion of a free material point. Two main problems of dynamics of a free material point. The assignment for the SRS is to study the use of the basic laws of classical mechanics and two basic problems of the dynamics of a free material point in engineering. Literature: [1.1] p. 5-8, 172-175.
2	**Lecture 2. Motion of an unfree material point.** Equation of motion of a non-free material point. Motion of a point on a smooth fixed surface. Motion of a point along a smooth fixed curve. IWS task: study the motion of a non-free material point. Literature: [1.1] c. 182-188.
3	**Lecture 3: Dynamics of relative motion of a material point.** The basic equation of the dynamics of relative motion of a material point. Special cases of relative motion of a point. Conditions of relative rest. The principle of relative classical dynamics. Theorem on the change of kinetic energy in the relative motion of a point. IWS task: study of the application of the equation of dynamics of relative motion of a material point in engineering. Literature: [1.1] p. 271-276.
4	**Lecture 4. Basic concepts of analytical mechanics.** Brief historical information. The subject of analytical mechanics. Relations and their reactions. Axioms about connections. Types of connections and their reactions. Natural axes and natural triangles. Real and possible displacements IWS task: study of the types of connections found in technology. Literature: [1.1] p. 333-339.
	Fundamentals of analytical mechanics **Topic 2.1. Free and forced oscillations**
5	**Lecture 5. Free (natural) oscillations of a mechanical system with one degree of freedom.** Definition of free oscillations of a mechanical system. Equations of natural oscillations of a system with one degree of freedom. Differential equations of motion of mathematical, physical, gyroscopic pendulums, a body on a stiffening spring and a body suspended on a string or torsion. The effect of a resistance force that depends linearly on the speed on the oscillations of a mechanical system with one degree of freedom. IWS task: study of the motion of a mathematical pendulum, a physical pendulum, a gyroscopic pendulum, a body on a spring, a body on a string or torsion.

	Literature: [1.1] p. 416-420.
6	**Lecture 6. Forced oscillations of a system without taking into account resistance forces.** The law of change of a disturbing force. Differential equation of motion of a system with one degree of freedom. General solution of a non-homogeneous differential equation. Partial solution in the case of resonance. Forced oscillations of a mechanical system with one degree of freedom with consideration of the medium resistance forces proportional to the first power of the velocity. Amplitude-frequency and phase-frequency characteristics. : study of factors influencing forced oscillations of a mechanical system with one degree of freedom. Literature: [1.1] c. 420-427.
7	**Lecture 7. Fundamentals of vibration protection and vibration isolation.** The problem of vibration protection and vibration isolation of the simplest applied systems. Formulation of equations of motion using the kinetostatics method. Solving problems of vibration protection and vibration isolation. Free (natural) oscillations of a mechanical system with two degrees of freedom. Rayleigh's theorem. Forms of oscillations. IWS task: study of factors affecting vibration protection and vibration isolation Literature: [1.1] p. 427-429.
8	**Lecture 8. D'Alembert-Lagrange principle (general equation of dynamics).** D'Alembert's principle for a material point. D'Alembert's principle for a system of material points. The principle of possible displacements. D'Alembert-Lagrange principle. IWS task: studying the application of D'Alembert and D'Alembert-Lagrange principles in engineering. Literature:: [1.1] p. 340-342.
9	**Lecture 9. Generalised coordinates, velocities, accelerations and generalised forces.** Conditions of equilibrium of the system in generalised coordinates. Generalised coordinates, velocities and accelerations. Generalised forces and methods of their calculation. Conditions of equilibrium of the system in generalised coordinate**s.** IWS task: studying the conditions of equilibrium of technical systems. Literature: [1.1] p. 343-350.

Laboratory classes.

The main purpose of laboratory classes is to study the peculiarities of applying analytical mechanics methods to solve problems of analysing the dynamics of mechanical objects and systems.

№ p/w	Name of practice work	Number of hrs
1	Problems on balancing bodies rotating about a fixed axis (Theme 1.1).	4
2	Determination of angular speeds of rotation of centripetal control mechanisms (Theme 1.1).	4
3	Drawing up a differential equation of forced oscillations of a mechanical system (Theme 1.1).	4
4	Determination of amplitude and phase-frequency characteristics of the system (Theme 1.1)	2
5	Free oscillations of a system with two degrees of freedom (Theme	2

	2.1)	
6	Forced oscillations of a system with two degrees of freedom (Theme 2.1)	2

Independent work of students

The student's independent work consists in preparing for classroom classes, familiarization with thematic literature, performing calculation work.

Calculation and graphic work is issued at the semeste beginning individually to each student and is defended in form of a written work containing calculations and necessary graphic material (drawings, graphs, etc.) individually according to separate schedule **.**

Policy and control

5. Policy of academic discipline (educational component)

Grading policy (missed classes, making up for absences): each grade is assigned in accordance with the criteria developed by teacher and announced to students in advance, as well as motivated individually at the student request; if student does not complete all prescribed classes, he will not be admitted to credit; missed classes must be made up. The form and time of practice are mutually agreed upon by student and teacher..

Academic integrity

The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code https://kpi.ua/code.

Norms of ethical behavior

Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute". More details: https://kpi.ua/code.

8. Types of control and rating system of evaluation of learning outcomes (RSO)

In the first lesson, students get acquainted with the rating system of the discipline, which is built on the basis of the Regulation on the system of evaluation of learning results https://document.kpi.ua/files/2020_1-273.pdf

Current control is carried out at each practical lesson in accordance with the specific goals of the topic in order to check the degree and quality of material learning. In all classes, objective control of theoretical training and learning of practical skills is used to check the readiness of student for the class. In the process of current control, the student's independent work is evaluated in terms of the completeness of tasks, level of assimilation of educational materials, mastering of practical skills of analytical and research work, etc. The results of current control are entered into the Ihor Sikorsky KPI Campus System.

Calendar control: is carried out twice a semester as a monitoring of current state of fulfillment of the syllabus requirements. In order to receive "credited" from the first intermediate certification (8th week), student will have at least 9 points (provided that at the beginning of the 8th week, according to the calendar of control activities, the "ideal" student must receive 15 points). To receive "credited" from the second intermediate certification (14th week), the student will have at least 21 points (provided that at the beginning of the 14th week, according to the calendar plan of control activities, the "ideal" student should receive 30 points).

Student who scored less than 38 points in the academic discipline during the semester is not admitted to the exam.

The student's rating in the discipline consists of the points he receives for the following:

- practical work;
- calculation and graphic work;
- modular control work.

1. Practical work

Weight score – 5.

The maximum number of points is equal to 6 points x8 = 48 points.

Evaluation criteria:

- full completion of the task - 5;
- implementation, but theoretical knowledge is insufficient - 3...4;
- not prepared - 0.

2. Calculation and graphic work

Weight score – 8.

The maximum number of points is equal to 8 points x1 = 8 points.

Evaluation criteria:

- complete completion of the task - 8;
- implementation, but theoretical knowledge is insufficient — 5 ... 6;
- execution, but no report - 3;
- work was not performed - 0.

3. Modular control work

Weight score – 47.

The maximum number of points is equal to 47 points x 1 = 47 points.

Evaluation criteria:

- complete completion of the task - 47;
- incomplete completion of the task - 25...40;
- work was not performed - 0.

Penalty and incentive points:

- creative approach to work, active participation in discussion of topics, independent **search for topics: +1...3 points;**
- **absence of missing lectures without valid reasons: +1...3 points;**
- **absence from class without a valid reason: –1...–5 points.**

The maximum number of incentive points is 5.

Calculation of the rating scale (R):

Thus, the rating scale for the discipline is:

R = 48 + 8 + 44 = 100 points.

Table of correspondence of rating points to grades on the university scale:

Scores Rating

100-95 Excellent

94-85 Very good

84-75 Good

74-65 Satisfactory

64-60 Enough

Less than 60 Unsatisfactory

Admission conditions are not met Not allowed

9. Additional information on the discipline (educational component)

If a graduate student is transferred from another university is recalculated only if the curriculum is consistent.

Work program of the discipline (syllabus):

Compiled by Associate Professor of the Department of Aircraft and Rocket Engineering, PhD , Lukianov P.V.

Approved by the Department of Aircraft and Rocket Engineering (Minutes № 10 of 16.06.2023)

Approvedby the Methodological Commission of the IAT (Minutes № 6 of 22 .06.2023)