

THEORETICAL MECHANICS AND GENERAL ENGINEERING DISCIPLINES

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Abstract. *This article examines the characteristics of the academic discipline “Theoretical Mechanics” and its significance in the study of general professional subjects. It further specifies the fundamental sections and topics of theoretical mechanics that students are required to master in order to ensure the effective study of general engineering sciences, as well as the concepts, theorems, equations, and inequalities of the course that are applied in this process.*

Keywords: *theoretical mechanics, statics, kinematics, dynamics, mechanics, theory of machines and mechanisms, machine parts, hydraulics, strength of materials, velocity, acceleration, moment of force.*

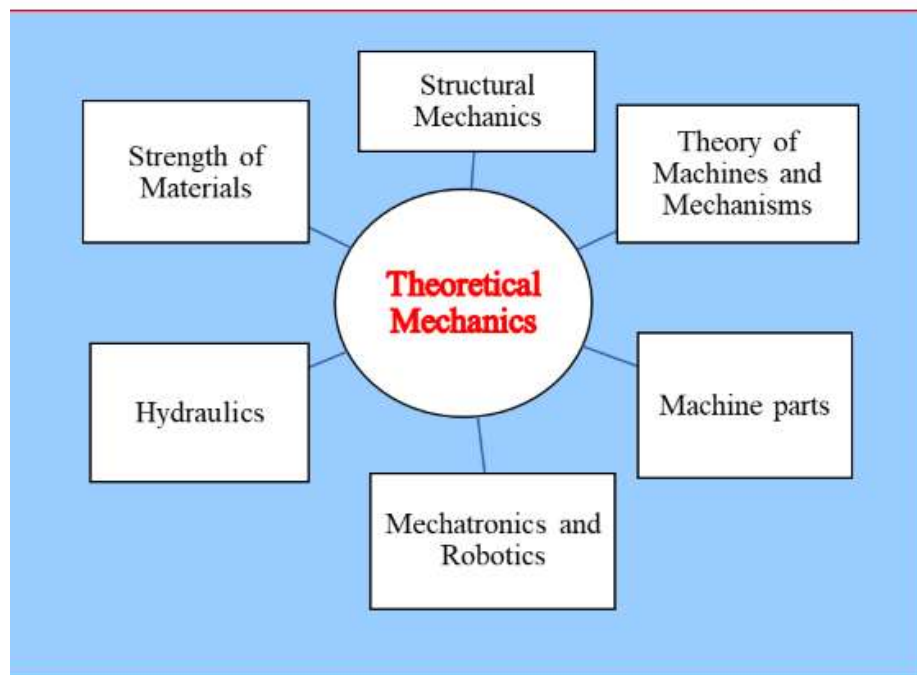
Introduction. Theoretical mechanics contributes to the development of theoretical thinking, understanding of a wide range of phenomena related to mechanical motion, and to the formation of a dialectical-materialistic worldview among students. The laws of theoretical mechanics serve as a basis for solving practical problems in modern engineering fields. This discipline was formed on the basis of specific problems that emerged during technological progress and continues to develop actively to this day.

Main Part. The discipline “Theoretical Mechanics” is fundamental for all sciences related to mechanics and machines as a scientific foundation for many fields of technology. Mastering the course

“Theoretical Mechanics” can provide the basics for studying the following disciplines: “Strength of Materials”, “Theory of Machines and Mechanisms”, “Machine Parts”, “Hydraulics”, “Structural Mechanics”, “Control of Technical Systems”, “Mechatronics and Robotics”, “Automation and Telemechanic” as well as a number of specialized engineering sciences related to the dynamics and control of machines and various types of transport, the calculation, construction, and operation of buildings, bridges, roads, irrigation structures, and pipeline transport. In other words, the laws, principles, and equations of theoretical mechanics are used in many sciences and various fields [1].

The following examples demonstrate the importance of theoretical mechanics in the practical work of engineers engaged in mining, engineering, and mechanical engineering technologies. Solving practical applied problems—such as underground operations, quarry issues, the motion of machines and mechanisms used in the mining industry, the construction of bridges, roads, and tunnels, determining support reactions, and calculating stresses and forces in truss members - requires knowledge of this discipline.

It is important for every student who has studied the course of theoretical mechanics to understand the relationship between theoretical mechanics and the general engineering disciplines of their specialty. Therefore, in the following diagram, we will present the general engineering disciplines for which “Theoretical Mechanics” serves as a foundation and analyze them individually.

Theoretical mechanics and general engineering disciplines

In studying the disciplines presented in the above diagram, we indicate the relevant sections and topics of the course Theoretical Mechanics for each discipline, as well as which concepts, theorems, equations, and inequalities of this course are applied.

Mastery of “**Strength of Materials**” relies significantly on the statics section of Theoretical Mechanics, which provides the foundational principles for analysis. Equilibrium equations derived from statics are employed in tension and compression problems to develop diagrams of longitudinal and normal forces. The determination of geometric characteristics of planar shapes relies on statics principles, including the center of gravity, static moments, and moments of inertia. Furthermore, in analyzing bending deformation and constructing bending moment diagrams, the established rules for calculating force moments are systematically applied [2].

The analysis and synthesis of problems in the “**Theory of Machines and Mechanisms**” rely on the sections of Theoretical

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Mechanics—Statics, Kinematics, and Dynamics—together with the fundamental equations used to determine angular velocity, linear velocity, and acceleration. In particular, during the kinematic analysis of mechanisms, when determining the velocities and accelerations of mechanism links, the polar method is applied for rigid bodies in planar parallel motion. In addition, in the dynamics of mechanisms, both static and dynamic loads are considered when calculating the forces acting on the mechanisms. In non-uniform motion of mechanism links, inertial forces are also taken into account. To calculate the work performed in the motion regimes of machines and mechanisms, the theorem of kinetic energy change is applied.

The study of “**Machine Parts**” employs the equations and relationships of Theoretical Mechanics in the design and kinematic analysis of transmissions, encompassing the determination of velocities, the calculation of transmission ratios, and the evaluation of stresses arising within them [3].

The course “**Hydraulics**” consists of the sections *Hydromechanics* (mechanics of fluids) and *Aeromechanics* (mechanics of gases).

Hydromechanics is a branch of mechanics that studies the equilibrium and motion of fluids. In this field, fluid equilibrium is studied in *hydrostatics*, while their motion is studied in *hydrodynamics*.

Aeromechanics is a branch of mechanics that studies the equilibrium and motion of gases. In this field, gas equilibrium is studied in *aerostatics*, while their motion is studied in *aerodynamics*.

When checking the equilibrium of a rigid body in the statics section, the geometric sum of the forces acting on it is set to zero. In hydrostatics, instead of forces, *hydrostatic pressures* are considered, and

their projections on the axes are set to zero. This is because, in a state of equilibrium, the influence of one part of the fluid on other parts, on the container walls, and on any immersed bodies is transmitted through pressure.

Even for ideal fluids, when deriving a generalized equation, in addition to pressure forces, inertial forces must also be considered because the fluid is in motion. Therefore, when applying the equilibrium conditions in hydrostatics, D'Alembert's principle is used, leading to the derivation of the differential (Euler) equation of motion for an ideal fluid.

The fundamental equation of fluid motion, known as Bernoulli's equation, is also derived using the law of change of kinetic energy, which is one of the general theorems of theoretical mechanics. In other words, the theorem of kinetic energy change is applied to an elementary part of the flow in motion. According to this law, during the motion of a body, the change in its kinetic energy equals the total work done by the forces acting on it.

In hydraulics problems, for example, for a fluid in a rotating container, it is affected by centrifugal force and gravity, and to determine its equation of motion, the fundamental equation of dynamics is applied [4].

“Structural Mechanics” is a science that deals with studying, verifying, and calculating the strength, rigidity, stability, and vibration properties of structures. In structural mechanics, theoretical calculations are based on disciplines such as theoretical mechanics, strength of materials, elasticity theory, plasticity theory, and others.

To solve the problems of this science, a deep understanding of the statics section of the course “Theoretical Mechanics” is required. A student must thoroughly master concepts such as types of supports,

acting forces and operations on them, equilibrium equations, methods of truss analysis, techniques for solving statically determinate and indeterminate problems, as well as the rules for calculating moments of forces.

Mechatronics is the practical embodiment of theoretical mechanics, a discipline that emerged as a result of combining mechanical systems with elements of electronics, automation, and control.

“Theoretical Mechanics” is the foundation of the *mechatronics* course. A mechatronic system is created based on knowledge of forces, moments, equations of motion, differential equations of motion, and mechanical systems. Without knowledge of theoretical mechanics, it is impossible to create a mechatronic system [5].

Overall, the connection between mechatronics and theoretical mechanics is of great importance in fields such as robotics, medical engineering, automotive engineering, aviation, drones, and industrial automation.

In conclusion, this article has highlighted the interrelations between the discipline “Theoretical Mechanics” and the general engineering sciences. It has also examined which sections, concepts, and laws of “Theoretical Mechanics” students need to master in depth in order to understand general engineering subjects and solve their practical problems. In addition, the article provided an answer to students’ question about why the discipline “Theoretical Mechanics” is essential for us, engineers.

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