UDC 378

# Role and Place of the Course "Theoretical Mechanics" in Training of a Contemporary Mechanical Engineer

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**The article deals with organizational-methodical problems concerned with teaching the course of Theoretical Mechanics for engineering students in modern conditions. Attention is paid to fundamental significance of this course. The methods and forms of lectures and practical classes are discussed.**

***Key words:*** *National Doctrine of engineering education, theoretical mechanics, teaching methods, educational testing, web-technology.*

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One of the principles of the National Doctrine in Engineering Education [1], developed by the Association of Engineering Education in Russia, is transition to the new educational methods in engineering training. In the broad sense this principle implies: "…search for and development of original engineering, social, and pedagogical solutions, application of ideas and crucially new "high", providing multiple increase in efficient teaching and academic labour techniques, creation of mass "talent production" methods, using distant learning" [1].

The present article deals with organizational-methodical problems concerned with teaching the course "Theoretical Mechanics" for engineering students in modern conditions.

In addition to "Theoretical Mechanics" course "Engineering Mechanics" curricula include a number of engineering disciplines: "Strength of Material", "Theory of Mechanisms and Machines", "Details of Units and Devices". In the context of transition to credit training system there appeared a tendency to unite these disciplines under some common names: "Engineering Mechanics", "Applied Mechanics" etc. What are the drawbacks of such an approach? The matter is that "Theoretical Mechanics", in contrast to all applied courses, is a fundamental discipline. It means that it develops not only knowledge, skills and competences, but also scientific outlook of a future engineer. It is this important component that is usually «washed away» when uniting the disciplines of engineering profile, as the major attention is paid to learning some particular methods of equilibrium or object motion calculations.

On the pages of "Engineering Education" journal different aspects of engineering education modernization under the condition of transition to the two-stage higher education system are discussed. In V.I. Livshitz's article [2] it is fairly pointed out to the gap between university education and conditions of real production, it is emphatically offered "to replace the concept of fundamentalization to professionalization in engineering education". However, such an extreme opinion appears to be dangerous. From our point of view one should support a balanced approach of S.A. Podlesniy [3] who stands for optimal combination of fundamental and professional training. Complete "replacement of education fundamentalization into professionalization" could result in training of

specialists who only possess competencies in a focused professional sphere, but do not have any scientific outlook orientation. The gaps in fundamental training can lead to serious errors in the development of definite engineering projects.

Students' materialist conception is developed at studying fundamental laws of nature and its properties. In this case it is impossible to avoid historical aspects of development of basic scientific ideas: "long-range" and "short-range" potential, "discontinuous" and "continuous" concepts. Without them it is impossible to understand the essence of mechanics – mechanical motion and material bodies' interaction. It is just these concepts about motion and bodies' interaction that make possible to understand material properties and material world arrangement.

Special attention should be paid to awareness of mechanical laws. Usually, students keep in mind only the second Newton's law out of all dynamics laws that is expressed in a simple formula applied in problem solutions. In this case no attention is paid to methodological significance of the first mechanics law – law of inertia. As a result, the conditions of dynamics basic law application are ignored and there appear the problems in comprehension of essence of inertia forces. Methodological significance of the third Newton's law also often remains "outside the parentheses".

Let us pay attention to the inextricable and integral connection of theoretical mechanics and mathematics. It is mechanical parameters that allow for gaining deeper insight into the essence of differential quantities. Theoretical mechanics is, perhaps, the only course of engineering curriculum that uses the theory of differential equations to the full extent as the most important tool for dynamic systems analysis. Unfortunately, at present in engineering practice there is often the situation when a specialist cannot take the first step in research of a definite mechanism – perform mathematical modeling and compose differential motion equations. In this case the second stage of engineering analysis becomes impossible, i.e. determination of motion characteristics. In this situation there is no sense in possession of modern calculation means and software as the mechanical problem itself has not been formulated.

Usually mechanics teachers justify such a result by complete lack of classroom hours. However, application of modern educational techniques allows for making "Theoretical mechanics" course limited in time, but of rich content. First of all, what it involves is multimedia resources. A modern lecture is unconceivable without application of software, for example, slides of Power Point. In this case one should use a definite technique. Training material should not be presented in poster form. Every slide should be filled in gradually. For this purpose it is relevant to use pop-ups, staged construction of complex views, motion simulation by means of animation etc. Students should have at their disposal soft copies of slide lectures developed by the lecturer. It is even better if there is a possibility to develop and offer students soft multimedia lectures with sound. Such a set of lectures developed by the author in each of the basic parts of theoretical mechanics: "Statics", "Kinematics", "Dynamics" [4]. This resource is used by the students in independent work. It does not replace traditional textbooks, but helps students to be easily oriented in learning material. In particular, by means of it one can compensate the information from the classes missed. Besides, modern web-techniques allow lecturer to apply efficiently the potential of university educational portal, posting on a personal website all necessary training materials.

As additional sources in "Theoretical mechanics" course it is recommended to use, for example, a very instructive methodical aid by A.M. Pavlov [5]. It describes the history of emergence and development of the basic concepts in mechanics: "velocity", "mass", "force", "impulse" and others. How the idea of inertia and momentum conservation was developed; what debates took place regarding the first and second Newton's laws; how the science came to the concepts of motion and rest relativity – the principle of relativity; how gradually mechanics was arriving to the law of universal gravitation; whether the gravitation constant is constant; what we know about the nature of gravitation; argument about measurement of motion; how gradually

scientists found the meaning of concepts of work and energy, the law of energy conservation; how the ideas of force moment and impulse moment emerged; connection of the conservation laws and properties of space and time properties – all these are closely interrelated with academic material treatment and accompanied by the examples.

The following aspect is concerned with the arrangement of practical classes. The method at which a student is solving a problem at the board (often at teacher's dictation), the others are just coping the solution, under current conditions is absolutely unacceptable. One needs to apply the active forms of practical classes' arrangement.

Credit training technique requires shifting the gravity center to students' independent work. It is possible only at the individual approach. But having practical classes with the group of 20 students and more it is not an easy task. Nevertheless, there is a way out, it is well known – every student is to make individual task including definite set of problems on every theme. For this purpose it is convenient to use, for example, "The book of short problems" edited by O.E. Kepe [6]. A key element of such a technique is a credit test of students' solved problems. A lecturer has to briefly discuss with every student checking his/her understanding the essence of the problem and method of its solution. By the way, such an approach enables the development of oral expressions of students' ideas.

Another necessary form of control in the current conditions is testing. Its primary advantage is high technology permitting for checking many students' knowledge simultaneously and defining the outcome quickly. However, testing involves the professional approach: one should know and meet a great deal of methodical requirements and organization conditions. In leading universities lecturers have the opportunity to attend training seminars on methods of test design, there is a system of expertise and certification of testing resources, the necessary adequate software is developed permitting for organization of computer testing for groups of students. At such an approach one can evaluate students' competencies without lecturer's participation. If there is a system of independent testing in a university and all necessary organizational requirements are met, the results obtained in examination period can be used for objective evaluation of quality performance of every lecturer [7]. In this case the basic demand for IOS quality standard is complied [8] – objective measurement of service quality in the process of its performance (internal quality monitoring).

Particular attention should be paid to students' research work organization in the course of theoretical mechanics. It is students' participation in research and methodical work that contribute to the development of creative approach and formation of impendent skills in scientific search. Theoretical mechanics provides a wide choice for students' research topics. Of particular interest for students are those concerned with controversial issues, paradox phenomena, or historical casus. For example, in the Internet there are a lot of video-films presenting self-moving mechanisms – eternal engine. Attempts to explain the operation principle in each case are sure to promote deep understanding the nature of different physical interactions and mechanical laws.

In recent time the development of distant educational techniques takes place at a quick rate. It implies application of specific teaching methods and specific training materials for different sections of mechanics. In our opinion it is multimedia training materials with sound that could replace a lecturer in the students' independent work to the full extent using distant techniques. In this connection the problem becomes to teach lecturers to develop relevant training materials. The technical support of this work should be performed by workers of special multimedia laboratory. Only professional approach to this task provides development of multimedia materials.

In conclusion one should say that in two-level system of higher education it is very important to differentiate fundamental and applied disciplines. Of particular significance is fundamental training for Bachelor's Degree. Without fundamental knowledge of mathematics, physics, and mechanics it is impossible to train engineer capable of keeping up with the times, com-

prehending, and developing innovations in engineering and technology. A university course of "Theoretical mechanics" plays a special role in formation of scientific outlook of modern mechanical engineer and implies great opportunities in training creative specialist. Without deep and sound knowledge in the sphere of mechanics bases it is impossible to lay the foundation for learning all subsequent disciplines of mechanical engineering. To solve this problem it is necessary to raise the level of current requirements for teaching methods and develop the adequate resources.



## REFERENCES


1. Basic principles of the National Engineering Education Doctrine [Electronic resource] // Association of Engineering Education in Russia: [official site]. Moscow, 2003–2012. – URL: http://aeer.cctpu.edu.ru/winn/doctrine/doctrine_1.phtml, free. Title from the screen (Date of reference: 12.12.2012) (All in Russian).
2. Livshitz V.I. Development of Creativity at Engineers' Training of Mass Professions // Engineering Education. 2012. № 9. PP. 26–37 (All in Russian).
3. Podlesny S.A. How to Develop Creativity in Engineering Training // Engineering Education. PP. 38–39 (All in Russian).
4. Tomilin A.K. et al. Courese of Video-lectures «Theoretical Mechanics. Statics. Kinematics. Dynemics» [Electronic resource] // http://lms.tpu.ru/course/category.php?id=1922&perpage=15&page=4, free. Title from the screen (Date of reference: 12.11.2012) (All in Russian).
5. Pavlov A.M. Course of General Physics. Mechanics / A.M. Pavlov. Moscow; Izhevsk, 2008. 412 p (All in Russian).
6. The Problem Book on Theoretical Mechanics / O.E. Kepe et al; ed. by O.E. Kepe. Moscow, 1989. 368 p. (All in Russian).
7. Tomilin A.K. Inner University Management in University // Engineering Education. 2012. № 9. PP. 56–61 (All in Russian).