

## THEORETICAL MECHANICS FOR STUDENTS OF ENGINEERING PROFILE

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**Abstract.** The paper summarizes the experience of the Institute of Mechanics in teaching programs that prepare students in Mechanical Engineering, Manufacturing Technology and Transport where Theoretical Mechanics is a fundamental discipline. The paper analyzed the following main methods and tools used for training students in Mechanical Engineering: lecture materials, including multimedia presentation, the system, which generates a large number of engineering problems for individual work; application of the system for students' individual work; application of E-learning system ORTUS; individualization of the exchange of information between students and teachers using modern technologies.

**Keywords:** Theoretical Mechanics, training methods, lecture materials.

### Introduction

Experience of teaching of Theoretical Mechanics in the Riga Technical University (RTU) is considered: creation and application of materials of lectures in the Multimedia presentation programs format, use of animation, the Internet resources and the MathCad programs; individualization of tasks for students' independent work; development of the system of control of knowledge on the basis of the results of long-term work of the staff of the department; use of a portal of e-training of RTU ORTUS; realization of opportunities of the Skype™ technologies for remote and individual training and contacts.

The Theoretical Mechanics as one of fundamental sciences is important for understanding and assimilation of many disciplines of a mechanical cycle and formation of engineering thinking as a whole.

### Materials and Methods

The study of the main methods and tools used for training students in Mechanics is based on personal experience of teaching Theoretical Mechanics for the last twenty years. The aim of the article is to develop a modern study process in teaching students in the Riga Technical University.

The research is based on the following methodological materials developed and mastered at the department: printed textbooks, using the Internet information resources, presented in both, video and animation materials, using the e-learning portal RTU ORTUS, control of knowledge and distance learning using Skype™. Responses of students have been reflected as well.

### Results and Discussion

#### *Problems of higher technical education in Latvia*

Unfortunately, for the last twenty years, training of engineers in higher educational institutions of Latvia has been significantly reduced, and in a number of programs where the theoretical mechanics were always present, it has been excluded completely, or the course was reduced to 2, 3, or 5 credit points (1 credit point corresponds to one hour of classroom loading per week during a semester). One example, which has had negative consequences, is the situation where coursework essential to the profession, such as Theoretical Mechanics and Resistance of Materials has been eliminated from the Bachelor program. Consequences of this decision are extremely negative - all branches of construction lack for qualified personnel.

Reduction of classroom hours to study theoretical mechanics was a reason to look for opportunities to intensify lectures, assign independent work and give control of knowledge to the students.

Gradually technical means were introduced with which the considerable part of the faculty is equipped, and also modern information technologies became a basis for the direction of methodical work. The task was thus set with very limited material resources, including the salary of the teachers, to present classic content in a new form. It is necessary to pay attention to the questions which have

not been directly connected with the technique of teaching of theoretical mechanics, but the common problems of training in state universities of Latvia:

- reception on 1 course is carried out guided by the results of the final centralized examinations among which obligatory examination in mathematics appeared only in 2009 and its introduction lowered the level of complexity of examination tasks – that at all graduates including provincial schools there was an opportunity to receive a positive assessment. Respectively, the level of knowledge of mathematics for the first-year students is significantly lower than twenty years ago;
- for some specialties occurring in the first course at the RTU there is a high percentage of native Russian speakers. For these students, language becomes an obstacle when attempting to learn the large volume of new terminology that is more complex. This contributes to a high failure rate and the elimination of students at the end of the first course.

Therefore, during lectures, it is vital to provide technologies to support them so that students not only orally perceive new names of subjects of lectures, terms and definitions, but also see the corresponding records and are able to analyze the abstract of lectures competently. It gives students the chance to understand the information provided in the corresponding literature and more deeply study the lecture subject.

Besides, as it became clear from questioning the students, an obstacle for normal perception of lectures is that a number of classrooms were moved to very long and narrow rooms where chalkboards were replaced with modern white boards on which the faculty write with felt-tip pens. The size of these boards is smaller, making it difficult and insufficient to see the records and schemes from a distance of ten or more meters.

#### *Introduction of modern equipment and programs in the educational process*

At the same time some departments were equipped with modern computer equipment, continuous access to the INTERNET and with a big screen nearby or over a board across the entire length of the classroom. The additional screens allowed students to easily view the lectures and materials presented by the faculty. The funds for this refurbishment came from the European Union.

These new opportunities imposed new requirements for the teachers to deliver the courses and their content in the format of PowerPoint with use of animation and the INTERNET resources.

Initially, the creation of the slides including drawings, settlement schemes and mathematical formulas is a very labor-intensive process, but the result justifies the means. The faculty took about half a year to prepare an initial set of 120 slides. During this time, materials are corrected and updated to reflect the most current information.

At the creation of a presentation, it is very important to apply animation allowing the shown material to appear on the screen gradually, at the speed similar to the speed of record on a board. It is especially important that new terminology, definitions and formulations are reproduced in the state language and if necessary are explained in more detail.

We emphasize that it is a question not only of the abstract of lectures, but also of the material supplementing an oral component and traditional record on the board.

The benefit of creating multimedia presentations is that it allows the faculty an opportunity to return to the previous slides and there is an opportunity to identify the most important elements by the corresponding graphic illustrations that are very important for the best understanding of the material for the students (Figure 1).

What was once impossible is now possible with the advancement of modern technologies. Using multimedia, photographs, videos and diagrams to model real world problems, especially as it relates to MathCad is essential in order to activate the attention of the listeners. During practical training, materials from the lecture slides are opened and serve as the basic reference material for the solution of tasks.

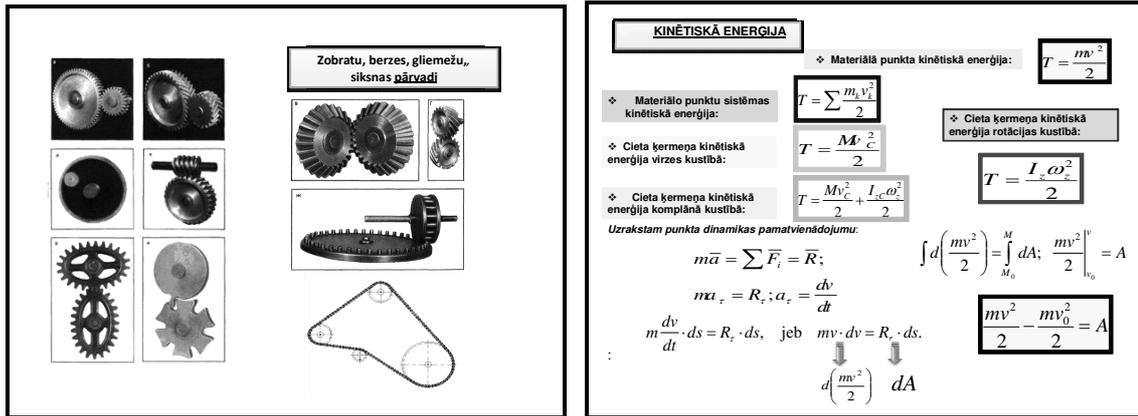


Fig. 1. Examples of slides

Existence of materials of lectures in an electronic format allows the faculty and students to use them for distance learning, which we will now discuss below.

*Use of the INTERNET information resources*

Huge opportunities exist for increasing the students' interest and understanding when utilizing the INTERNET. Free access to information is presented in both, video and the animation materials which clearly demonstrate the objects and the phenomena about which there is speech when reading a course (Figure 2). On the average for each lecture on kinematics and dynamics, four - five materials are picked up.

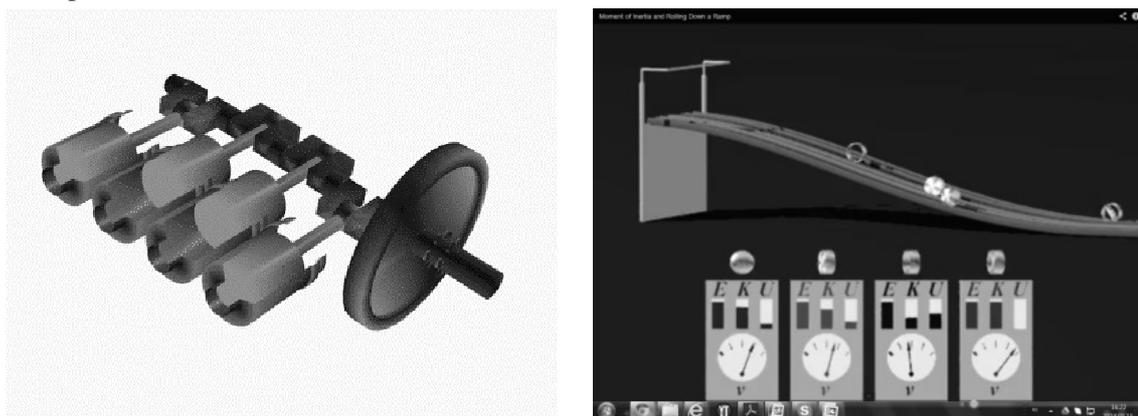


Fig. 2. Examples of animation [1; 2]

A strong impression is made on students when demonstrating real emergencies and accidents (Figure 3). This allows the instructors to emphasize the importance of the knowledge of the theory as, for example, at the beginning of the FLUCTUATION section.

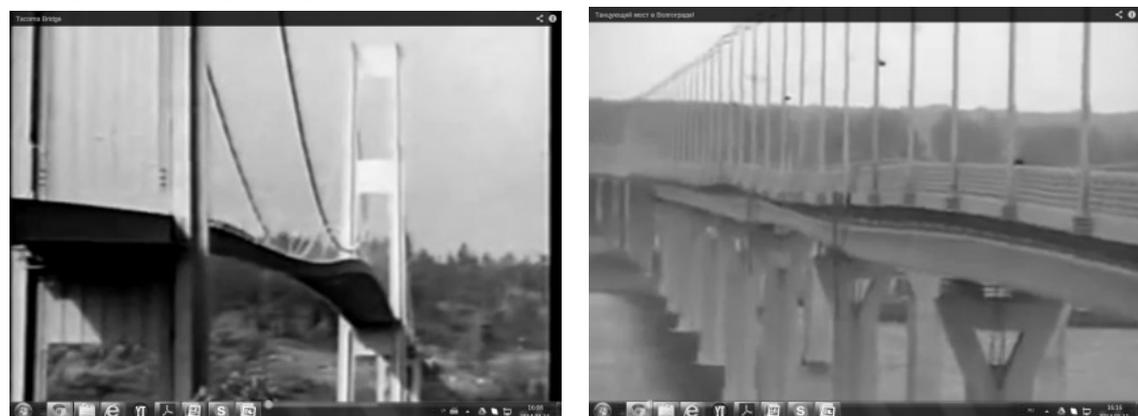


Fig. 3. Examples of demonstration of movies [3; 4]

The first year students are trained to use the MathCad program in order to demonstrate how FLUCTUATION occurs over time. By utilizing the MathCad programme, we have many opportunities to show how each separate parameter of the system is influenced (Figure 4).

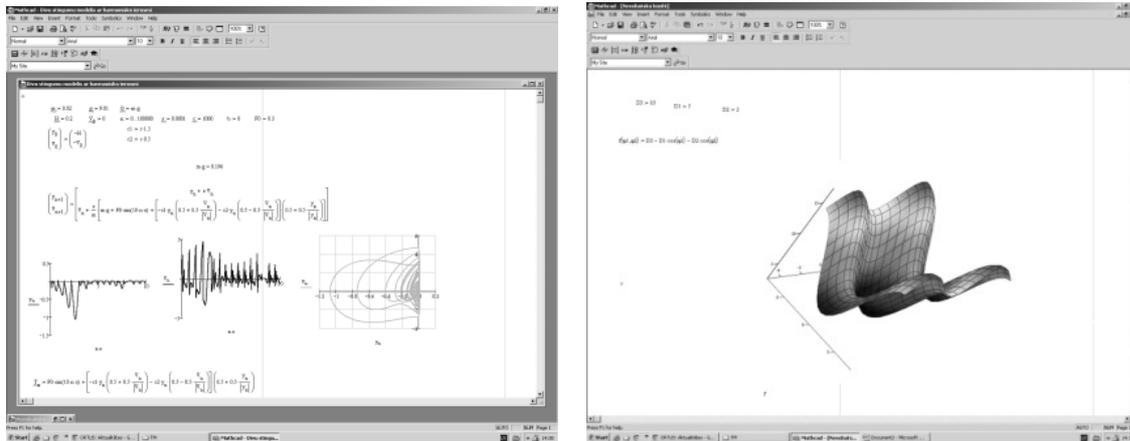


Fig. 4. Examples of solving problems in the program MathCad

*Using the e- learning portal RTU ORTUS*

Six years ago we began to operate the RTU portal ORTUS (translated from Latin - “rise, a new beginning”), which concentrated all information and communication functions. When using the portal, each teacher has the ability to post the training materials and tests in addition to being able to receive the students’ work. This circumstance produces jobs as computerization individual design work also for students’ work. Students in their first year can design work using Microsoft Office, create drawings, build design diagrams and write equations.

These skills are required during the entire training and are improved upon in practice. Therefore, once the students master the use of technology, the rate of the work carried out by the computer becomes faster than the traditional methods.



Fig. 5. Examples of the interface of a portal ORTUS

*Individualization of tasks*

The tasks to individual students' work on each subject consist of at least one hundred options that are quite enough for the existing groups and provide individualization of tasks for independent work of the students.

The tasks are traditional, but the quantity for each student in a semester was reduced to four. The teacher is required to transfer these tasks to an electronic form and to place them in the corresponding directory of ORTUS where they are available to each student who is training on the appropriate program.

There are also examples offered of execution of tasks for each topic. This is especially important for the first-year students who have no experience to design work in the official language.

We have developed software that allows the professors to create tests on definite subjects within a course to be placed on the ORTUS portal. These tests may be used by students for self-checking.

### *Control of knowledge*

In order to give control of knowledge to students at the Department of Theoretical Mechanics of the Riga Technical University, a group of highly skilled authors was organized to create a special collection of tasks [5].

This book, judging by the number of links in the INTERNET network, was widely adopted in higher education institutions of Russia and other countries where training is done in Russian. In recent years, this book had been published several times.

Assimilation of theoretical mechanics is complicated because of the important role it plays drawing up the schemes and mathematical representation of processes. Therefore, at the solution of specific engineering objectives students have difficulties as the objectives are more complicated.

Two decades have passed since the first edition of the collection. When put into practice it has demonstrated its effectiveness among all types of control of knowledge. Moreover, this collection is utilized by students and professionals from multiple countries whose first language is not Russian. Their understanding is enhanced through translation of the text and illustrations.

The purpose of the present collection is to supply the teachers and students with 1757 short tasks the schemes of which are rather simple and clear. All tasks are supplied with answers. It is not necessary for their solution to carry out the difficult mathematical transformations and calculations, but it is necessary to understand their physical sense.

The tasks of the collection are widely used for various educational and control purposes, namely: for exercises in practical training, for students' independent work and taking examinations.

Experience shows that in recent years examinations are carried out most often in writing and in big streams that require the teachers to check a large number of individual tasks. The collection gives the teacher a chance to pack a large number of individual tickets with answers provided for the teacher.

Experience in the use of the offered tasks in the educational process showed their simplicity, close connection with separate sections of the theory and a large number of tasks in each section of a course.

### *Distance learning using Skype™*

By utilizing Skype™, institutions are able to carry out all types of distance learning, which is practical for small groups (4-5 students) in branches, such as the city of Ventspils (about 200 km from Riga). The materials used for this class structure include lectures on Multimedia presentation programs, a large number of individual tasks for students, control of knowledge and examination cards in the computerized form.

When this method of collaborative communication is used, the students are able to hear the teacher's explanation, and have the ability to instantly receive the forwarded teacher resources. Naturally, the teacher is able to receive feedback to the same extent.

Practice has shown that such studying significantly reduces the transportation expenses of students, and the expense of business trips by teachers. This form is modern and close to students, but, naturally, demands from teachers that they master new technologies.

### *Responses of students*

For a number of years, the RTU has delivered a survey to the students at the end of each semester. This is an anonymous survey that allows the students to provide feedback of the teaching of each course in 14 separate parameters. They are able to state remarks or emphasize the positive side of a technique of teaching. The generalized results are brought to the attention of the responsible teachers and heads of divisions. The analysis of responses allows the RTU to note that all receptions listed in this article that are applied in the course of teaching theoretical mechanics at the RTU are estimated by the students positively. Modern youth are connected with information technologies since childhood

and are able to grasp the difficult, fundamental disciplines required in the instruction of Theoretical Mechanics using the technologies available today.

### Conclusions

1. Theoretical Mechanics is important for understanding not only mechanics, but also for engineering thinking as whole.
2. On the bases of long-term experience of teaching Theoretical Mechanics in the Riga Technical University successful application of modern means and methods in the educational process is stated.
3. Professors and lecturers should be open for innovations in order to develop modern study materials and use them during the learning process.
4. Visualization of materials of lectures and practical training make the traditionally difficult course of Theoretical Mechanics more attractive and clear for students, increase interest in studying the subject and improve progress that is the main goal of education.

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