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Original Paper

The Merits of Teaching Basic Courses in Engineering Curriculum

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Abstract

This paper tries to answer the question frequently asked by engineering students, why we are studying basic subjects such as Mathematics, Mechanics and Physics. Engineering students study these basic subjects in addition to some other courses such as computer programming, production, chemistry and some humanity courses during their first year of study as a preparatory year for all engineering disciplines. Students are expecting to study their major subjects in the first year of study when they enroll in faculty of engineering around the world. It is almost impossible to teach advanced subjects such as fluid mechanics, mechanical vibration, automatic control, modeling and simulation and robotics without prior knowledge of the basic courses. The students could not recognize in their first year of study that understanding basic mathematics and mechanics skills help them a lot in getting the knowledge of advanced courses easily and effectively. For example, all automatic control courses need some modelling techniques which the students can gain by studying engineering mechanics and calculus during their first level of study. Basic knowledge of Newton's second law of motion and basic rules of calculus are very important in achieving satisfactory understanding of the advanced topics in all disciplines. Some of the advanced topics for example robot Jacobian is based on partial derivatives and the equations of motion of a multi-joints robot manipulator are based on Lagrange's equation. The students cannot understand subjects such as heat transfer and thermal power stations and fluid mechanics without basic knowledge of physics.

Keywords

engineering, education, curriculum, mechnics, basic, merits, learning

1. Introduction

Teaching engineering mechanics with its two components statics and dynamics is very important for all engineering disciplines. It is almost impossible to find an engineering curriculum without mechanics subject. Some universities teach mechanics for one semester, others are teaching mechanics for the first two semesters. Alexandria University in Egypt teaches mechanics for three semester statics, dynamics of particle and rigid body dynamics respectively. It should be noted that the engineering mechanics course is one of the basic courses in civil engineering as well. It is a bridge between public courses, professional basic courses and professional engineering courses (Lin, 2021).

Due to the importance of mechanics in engineering curriculum, some universities offer the course in the form of lectures and tutorials while others offer the course as lectures and laboratory sessions. Bernhard (2000) presented the efforts in establishing Microcomputer Based Laboratory MBL for mechanics course at Linkoping University in Sweden. The main objective of the Laboratory is to promote conceptual change in mechanics. In MBL students perform real experimental, not simulated experiments using various types of sensors (motion, force, torque, light, temperature, sound, proximity) connected to a computer via an interface. The results and graphs are displayed in real-time to bridge the gap between real experiments and the theoretical information. Huang et al. (2020) presented a new strategy in teaching engineering mechanics by integrating the subject of optimization theory into mechanics modelling using normal modelling techniques. The main objective of this integration is to promote the students' structural optimization modelling skills to enhance their understanding of the basic concepts in mechanics and mathematics and master a general method for practical problem solving. The effectiveness of the proposed strategy is demonstrated by the "six principles" for designing thought-revealing activities and the feedback from all participants in the course. Montes et al. (2023) demonstrated how the propaedeutic subjects, such as mathematics and/or physics in degrees that combine the need for technical knowledge with creative skills, can promote creative processes of an architectural project. They developed the concept of equilibrium challenge and adapted it to Physics subject and create an interaction with other subjects as well. They presented challenges that include experiments with physical concepts and some other learning outcome from different subjects such as mathematics, introduction to architecture, drawing, or history of art.

This paper will elaborate on this idea and focuses on the importance of teaching basic engineering subjects such as engineering mechanics in understanding advanced subjects in engineering curriculum in all disciplines. The material of the paper is based on the long experience of teaching basic engineering subjects such as engineering mechanics and mathematics for undergraduate students and advanced subjects such as robotics and modelling and simulation for postgraduate students. Some problems faced and possible solutions related to this matter will also be highlighted.

2. Discussion

Engineering students learn statics during their first semester to enhance their understanding about equilibrium and how engineers can achieve it in all engineering applications. Newton's first and third laws furnish the basis for action and reaction and how to stabilize engineering structures in every application. This course will expand the students' knowledge about the conditions for equilibrium for what they can see around them in our daily life. The concept of action and reaction will help them in understanding higher subjects in advanced semesters and to be ready to study dynamics in their next semester.

There is no doubt that dynamics of particle and rigid body is essential for all engineering students. The fruit of the dynamics course is the determination of the equation of motion for any dynamical systems either in translation or rotation motion. Equation of motion is a relation between mass, force and acceleration in translation motion and inertia, torque and angular acceleration in rotation motion. In deriving equation of motion students learn the concept of momentum and energy principle and the difference between them and how to apply each concept to find the equation of motion in any moving object. Once the equation of motion is determined, student can compromise between different parameters to properly select the best values for the optimal performance. During this course the engineering students learn how to apply Newton's second law of motion, D'Alembert principle of dynamic equilibrium and Lagrange's Equation as tools in higher engineering subjects.

Dynamics course is the secret word in understanding many engineering subjects in higher semesters. These subjects include but not limited to fluid mechanics, machine design, mechanical vibration, theory of machines, automatic control, modelling and simulation, sensors and actuators theory of structures and final year's projects. In subjects such as automatic control, mechanical vibration and robotics, finding the equations of motion is very crucial in designing control strategy for the moving objects. Without mathematical model, of objects either in translation or rotation motion, it is very hard to design the controller using linear control theory. In the absence of mathematical models, some other control strategies such as Neural Networks, Fuzzy Logic and Genetic Algorithms can be applied. In the subject of modelling and simulation of dynamical systems, the modelling techniques such as Newton's second law of motion, Lagrange equation and Hamilton's principle have great contribution in understanding the subject.

For the final year's project, students are required to integrate their knowledge and come up with some innovative ideas as a working project. In most of the cases, students need to do a force analysis for their structure to make sure that their project structure is stable and will not collapse under the prescribed loads. They can apply their conceptual understanding and knowledge of equilibrium of frames and machines to design their platform. If the project contains moving objects, deriving the equations of motion is essential to select the proper parameters of the project to satisfy the required needs such as velocity, wheels dimensions and actuator sizes. Also, the equations of motions of the moving objects is

very important to draw the block diagram and apply linear control theory to control the motion of the moving object. It should be noted that it is difficult to start teaching design early in the curriculum, because a context in which design can be taught is not available. A degree of student dissatisfaction was apparent due to the absence of engineering in the first two years (Belytschko, Bayliss, Brinson, Carr, Kath, Krishnaswamy, Moran, Nocedal, & Peshkin, 1997).

As a concluding remark, engineering mechanics helps in most of the engineering curricula for different engineering courses and applications. Table 1 shows some of the engineering courses that depend on the understanding of engineering mechanics in getting full benefits by students.

Table 1. Some of the Courses that Depend on Engineering Mechanics in Different Engineering Disciplines

Courses	Mechanical Engineering	Electrical Engineering	Civil Engineering	Mechatronic Engineering	Marine Engineering
Fluid Mechanics	√	√	√	√	√
Theory of Machines	√			√	√
Machine Design	√			√	√
Mechanical Vibration	√	√		√	√
Modelling and Simulation	√	√	√	√	√
Automatic Control	√	√	√	√	√
Sensors and Actuators		√		√	
Theory of Structures	√	√	√	√	√
Final Year's Project	√	√	√	√	√

One of the merits of teaching engineering mechanics is increasing the student's awareness of how the application of the theoretical information can lead to an interesting advanced technological projects. This makes the students anxious to learn more basic knowledge to apply and answer the frequently asked question why we are studying these basic subjects. For instance, the basic knowledge of a two-force member, equilibrium of particle and equilibrium of rigid body, wonderful structures and trusses such as bridges, hanging bridges, communication towers, electric distribution towers, factory

and house roofs, advertisement panels, etc. can be designed and implemented. In order to design a moving object ranging from baby toys to a complicated industrial manipulator, the equation of motion should be derived using either Newton's second law of motion or Lagrange's equation. The instructors can always refer to these great applications as a results when teaching the basic knowledge to enhance the students' desire to appreciate what they are studying.

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