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On Some Engineering Mathematics and its Applications to Engineering Students by Overpass the Understanding Gap of Subject

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ABSTRACT:
The study of mathematics and its applications is taught in a wide range of university programmes, including those in engineering, economics, administration, computing, and many other scientific fields. Due to its application in the creation of mathematical models mathematics is a crucial subject for undergraduate engineering students to learn. As a result, a substantial portion of the engineering courses taken by students in all programmes require mathematics. To finish their engineering degrees, many students, however, struggle to connect and apply their mathematics understanding to the engineering concepts and issues that they must comprehend. There seems to be a substantial knowledge gap or disconnection between mathematics and engineering that has to be addressed in order for students to become proficient in applying and integrating mathematics in their engineering courses. From the perspective of a teacher who teaches engineering courses, this paper addresses these knowledge gaps between mathematics and engineering students with numerous examples and their solutions may find these instances and solutions helpful.

KEYWORDS. Engineering Mathematics, Application of Mathematics in Engineering Branches

INTRODUCTION

In Babylonia, mathematics was developed early, and the Greeks began to independently develop mathematics, building on the foundations laid forth by the Babylonians. After that, Iran, Syria, and India were among the nations where mathematics flourished. The well-known names generally made the most notable and significant advancements. Galileo, for example, transformed the application of mathematics to the study of the universe, and Newton is only one example of how this happened with his many new discoveries showing how astronomy, physics, and mathematics interact. The applied mathematics has been effectively employed in the advancement of science and technology. Engineers have easy access to the fundamental tools they need to solve problems by using mathematics applications. We shall go over a few instances of mathematical applications in engineering field throughout this paper. We conclude that mathematics ought to be a fundamental consideration in engineering design and practice. In engineering, the direct use of mathematical models is necessary for the interpretation and resolution of specific problems. It is frequently required to apply concepts from differential, integral calculus and linear algebra in order to comprehend and analyze these mathematical models.

Numerous authors, such as Murakami (1988), have suggested that mathematics should be taught to engineering students by mathematicians with help from engineers in order to create a learning environment more in line with students' professional realities. In an effort to better understand the mathematical applications utilised by engineering students, Cardella (2006) set out to identify the kind of mathematics that ought to be taught in engineering colleges and provided examples of the various ways in which engineering students apply mathematical thinking to problem-solving throughout the project design process. Drawing on the work of Schoenfeld (1992) and Doeer (2007) regarding the teaching of mathematics through applications and modelling in the context of engineering education, Cardella recognised the need for mathematics teachers in engineering programmes to have a better understanding of how mathematics and mathematical thinking are used in engineering. Educators should understand the mathematical material required for engineering and should take into account the value of problem solving techniques, resources, practices, attitudes, and the learning environment. Thus, we are interested in identifying and debating the attitudes and beliefs of these teachers in order to ascertain how these ideas affect the way that teachers from varied academic backgrounds teach mathematical topics in engineering programmes. She emphasized the significance of these different approaches to mathematical reasoning, emphasizing that in order to make sure students get the material being taught, teachers must closely monitor their mistakes as they are made. Studying mathematics has always been difficult, and students at esteemed engineering colleges struggle with a continual fear of the subject. Most students find mathematics to be too difficult. In both core and new engineering courses, mathematics is required as a main subject. There are many study sets for each branch that center on the importance of mathematics. Alexander (2011) found that, like science itself, mathematics is viewed as a dynamic, historically changing field unto itself rather than as the static framework of science. Lynch (2012) pointed out that scientific fields including agriculture, chemistry, biology, medicine, business, and engineering are prioritized in this day and age of research and technology. In the numerous engineering areas, several forms of arithmetic may be applied to arrive at a particular solution.

MATHEMATICS AND ENGINEERING. Specifically in electrical engineering, differential equations are crucial for resolving circuit problems. Electrical engineers frequently use linear algebra to build electrical circuits. Electromagnetic theory is connected to another topic in electrical engineering. Furthermore, it establishes a strong basis in the comprehension of triple integrals and integration over a closed surface by using mathematical concepts related to calculus. Linear algebra is a mathematical concept that is related to electrical engineering concepts such as circuit theory and signal processing. Students studying engineering are taught to use Laplace and Fourier transform equations extensively. In signal processing and circuit theory, it also has further ties to linear algebra. The most common use of mathematical complex number algebra is in solving equations related to power system load flow and sinusoidal stimulation circuits (AC).

Mathematics in Electronics Engineering. Engineering systems that are non-linear can be solved using numerical techniques. However, Matrix algebra and contemporary simulation software algorithms are intimately related to mathematics in engineering concepts. The demand to comprehend common concepts and broaden knowledge is offered by top colleges for electronics engineering. Additionally, they are able to comprehend a wide range of complex number, differential, and integral calculus-based mathematical concepts. Therefore, advanced calculus and partial differentiation are prerequisites for students. They must have a solid understanding of complex concepts related to differential equations, matrices, vectors, and statistics in order to do this. When applied to engineering, the concept of mathematics enables one to solve problems with the greatest efficiency and to think logically.

Mathematics in Civil Engineering. In civil engineering, geometry is used to design structures and ensure their safe and practical operation. Civil engineers can use differential equations to determine how big the supporting piers needed to build a bridge should be. In order to estimate how long the construction will take to build, they might also employ intricate mathematical models. The civil engineers use differential equations just for their daily work in calculus, statistics, and engineering mathematics. The chemistry of materials is studied by civil engineers through mathematical equations. In addition, the structural survey was conducted using mathematical trigonometry. Where the structure's varied angles and ground elevation were taken into consideration. In the field of civil engineering, bridges are built. Where decisions are made regarding the number, thickness, and size of the steel columns that support the bridge, as well as their installation. The project's cost estimate is also crucial and involves fundamental statistics and accounting concepts. The project's planning stage and the financial budget's distribution are entirely determined by mathematical calculations.

Mathematics in Mechanical Engineering. In mechanical engineering, mathematics plays a special role and is strategically important for the advancement of technology. We go into detail on a few subjects in this paper, including partial differential equations for mechanical engineering, Laplace transform, and matrices. Vibrational mechanics, which uses calculus to determine the acceleration and velocity of the vibrating item, is taught in mechanical engineering colleges. Furthermore, a simultaneous linear equation and differential equation were used to derive the precise equation for the displacement of nodes in vibrations. Algebraic concepts, multi-degree equation solving, and graph analysis are used in engineering mechanics to compare different parameters. Heat waves and gradients are concepts that are distinct in engineering thermodynamics and heat transfer for the students in the list of engineering colleges. Logarithmic ideas, together with ratios and proportions for ideal gas laws, are utilised in the computation of heat and temperature. Colleges of engineering have used logarithmic equations for real stresses, engineering stress equations in production engineering in the mechanical stream, and geometry, angles, and trigonometry for calculations on forces and velocities. In addition, multivariable equations for solutions on states and calculus flow variables are employed in fluid mechanics.

Mathematics in Computer Science Engineering. Working on CSS websites and handling all complicated algorithmic database queries require equal amounts of algebra and mathematical models. Digital logic design, which is essential to the construction of computers, is based on Boolean algebra. Programmers in computer science fields such as machine learning and artificial intelligence need possess a strong foundation in mathematical topics including probability, calculus, and statistics as well as engineering mathematics theory. Basic mathematical ideas like algebra, set theory, graph theory, probability, and number theory all of which are taught in discrete mathematics curricula are the foundation of programming and computer science. Mathematics and logic are the foundations of cryptography programming, and number theory is used extensively in cryptography. This top engineering college in India offers specializations in Computer Science and Engineering, Electronics and Communication Engineering, Mechanical Engineering, Electrical Engineering, and Civil Engineering. Advanced facilities, highly qualified faculty, employability enhancement, real-world industry projects, guest lectures, and industrial visits are all features of this top engineering college. No matter what their line of work, most people in today's highly developed and sophisticated world depend on mathematics as a vital tool. Clearly, mathematics is essential to many aspects of daily life, including business, clerical labor, and architecture. Math is even used by us to monitor our savings accounts, pay our bills, and balance our budget.

Mathematics in Industrial Engineering. Industrial engineers utilise calculus to estimate the rate at which certain variables will change throughout a given process. In industrial engineering, it is common practice to make safe estimations and assumptions in order to ensure that all activities are appropriately regulated. One or more mathematical principles are used in these approximations and predictions. It is well recognised that engineers need to be knowledgeable in a variety of mathematical areas, such as differential equations, linear algebra, and numerical methods, in order to address and solve real-world engineering challenges in their line of work. As a result, engineers are required to finish several mathematics courses early in their engineering curriculum. There are three Calculus and Analytic Geometry classes, one Linear Algebra class, and one Differential Equations class. In addition, before graduating from their senior year, students must complete one statistics course. Teachers from the Department of Mathematics instruct all courses in mathematics with the exception of the statistics course.

Students majoring in engineering begin studying engineering courses including fluid mechanics, system dynamics, and heat transfer after their sophomore year. Most junior students have struggled to relate and apply the mathematical knowledge they have learned in their engineering lectures, despite the fact that all of them have completed these courses and obtained passing grades. In order for students to become proficient in using and integrating mathematics in their engineering courses, there appears to be a significant knowledge gap or disconnect between mathematics and engineering that has to be addressed. From the perspective of a faculty member teaching engineering courses, this paper addresses these knowledge gaps between mathematics and engineering with several examples and suggestions for improvement.

EXAMPLES OF KNOWLEDGE GAP. An illustration will make the problem of knowledge gaps, which are common in engineering courses, very evident. Determine the change in a substance's attribute, such enthalpy, in an engineering thermodynamics class. Since enthalpy is a property, the journey between the two states has no bearing on how its value changes; rather, it is solely dependent on the two end states. Though many did not see its relevance in their thermodynamic lesson, every engineering student had studied the concept of precise differential in their math subject. There will be more instances provided, similar to those in standard engineering courses.

STATICS AND DYNAMICS IN ENGINEERING. Students take engineering mechanics classes as their first engineering courses. Finding the centroid or center of mass of various physical bodies is one of the first applications of analytical geometry that this subject will cover. While many students struggle to select the appropriate differential element, apply the proper limits, and compute the integral for complicated bodies all of which are prevalent in engineering mechanics they are nonetheless able to calculate these computations for basic shapes. When students are asked to calculate the area or mass moment of inertia of complicated bodies, these challenges become more apparent. One of the possible causes could be the student’s incapacity to see the 3-dimensional bodies. The graphical relationship between the integration and differentiation processes is another area where students struggled to make the connection between engineering and mathematics. Dynamics characteristics can occasionally be shown graphically, including displacement, velocity, and acceleration of particle motion. For instance, it may be necessary to ascertain the particle's displacement over a specific time period from a graph of the particle's acceleration. In this instance, many students find that even though they can complete the process if an equation for the acceleration is provided, they are unable to do graphical integration correctly. The true issue for the students in both cases is that they are unable to relate the analytic geometry class taught mathematical ideas and solution techniques to the engineering problems.

Fluid Mechanics in Engineering. The main challenge that students face in this subject is with differential equations or multivariate calculus. Equations for mass, momentum, and energy conservation are obtained mathematically and solved for certain basic flows in fluid mechanics. This subject covers the governing differential equation analytically for simple flows, like the flow between parallel plates. The Navier-Stokes equations and the conservation of mass equation, however, are a challenge for nearly all students. The involved problem solving techniques are quite straightforward, but students struggle when it comes to translating physical boundaries into mathematical equations or comprehending how the analytical answer relates to the physical problem. This is not unique to this course; it occurs in many other courses as well. The main issue here is that many students view differential equations as equations to solve rather than as a representation of a real world flow, like the flow of water in a circular pipe. This makes it difficult to relate mathematics and physical understanding. Students' inability to perceive and comprehend what the analytical answer in the real world problem signifies is a result of this deficiency.

Heat Transfer in Engineering. Like fluid mechanics, heat transport is a subject that greatly depends on mathematical proficiency, particularly with differential equations. The differential equation for the particular situation must be solved in order to find the answers for heat conduction issues. The challenges are comparable to those in fluid mechanics: using appropriate boundary conditions and solving techniques, as well as interpreting and visualizing the differential equations solution. For instance, in an unstable heat conduction problem, the solution usually has an exponential decaying term in time since the solution tends to equilibrium or zero when the duration is long. Students cannot understand that the solution decays exponentially, though, if you ask them to sketch the solution for an endless amount of time without using the analytical exact solution. Therefore, to overcome this challenge, it is imperative that students grasp various mathematical functions and their features in class. Numerical solutions to the governing differential equations present a new area of challenge in the field of heat transfer. Numerical solutions to heat transfer problems are provided in a lot of heat transfer textbooks. Students are expected to solve a series of algebraic equations numerically using the finite difference approach for solving problems numerically. Both direct techniques, like Gauss Elimination, and indirect techniques, such the Gauss-Seidel iterative method, are typically included in textbooks. As was previously said, students must pass a linear algebra course that covers algebraic equation solutions. Nevertheless, a lot of students attempt to solve algebraic equations using calculators or mathematical software programs like MATLAB since they don't comprehend the nature of the equations they are solving. There is no unique solution to this set of equations because, as is evident from a close examination of the equations, the first and second equations are identical. The mathematical software programs will nevertheless solve problems and generate results, but clearly differing from one solution to another. The lesson here is that when working with numerical solutions to engineering problems, students need to comprehend concepts like convergence and numerical mistakes. Additionally, the students must be able to defend the numerical solution's validity and convergence as well as the fact that it is an approximation of the solution.

SYSTEM DYNAMICS IN ENGINEERING. A course on system dynamics, which covers mathematical modelling and response analysis of dynamic systems, is required for the majority of engineering programmes. The course covers a wide range of systems in its analysis and design approaches, including mechanical, electrical, hydraulic, pneumatic, and thermal systems. Despite being in distinct domains, all systems may be reduced analytically and represented by ordinary differential equations. For this reason, understanding ordinary differential equations (ODEs) is crucial to succeeding in this course. It is anticipated that students would have a good grasp of the fundamentals of Laplace transforms and solutions to differential equations of both first and second order. In actuality, though, since these courses were completed a year or more ago, the students just do not recall much of the prior content. Additionally, students become even more confused by new terms and ideas like stability, poles, zeros, transfer functions, and others. Teachers need to take the Dynamic Systems course multiple lecture periods to cover the principles of the Laplace Transform and solutions to ordinary differential equations in order to help students in understanding.

SOME SOLUTION TO OVERPASS THE KNOWLEDGE GAP. For college students, there are likely more mathematics related issues than those in the aforementioned cases. Similar issues can arise in graduate courses and might be connected to the growing reliance on software and computer technologies, even in undergraduate courses, to solve engineering difficulties. Below are some recommendations for solutions:

- Review the mathematical concepts that are pertinent to the course at the start of the semester, give the necessary resources, and administer a quick test. This will enable the teacher to identify the students' areas of weakness and give extra attention when necessary during the semester.
- Stress the use of graphs to illustrate mathematical problems and functions. For comparison's sake, offer both graphical and analytical solutions. Request that students, if at all possible, include graphs of the analytical solutions.
- Describe the concepts of individual differential and integral equation terms as well as the physical interpretations of distinct mathematical functions. When defining these equations, give a mathematical translation of the physical parameters and boundaries.
- Approach the same problem by combining analytical and numerical solution techniques. To gain a deeper comprehension of engineering problems, analytical solutions are necessary. Numerical techniques can aid in visualizing the physics and outcomes underlying the equations. Students are motivated to learn about the parallels and contrasts that arise when the same problem is approached using both analytical and numerical methodologies.
- Explain to students the limitations of solution algorithms and the numerical errors related to various numerical methods when using numerical solution techniques. Talk about problems like unique solutions, convergence conditions, and error propagation.

CONCLUSION. This research concludes that the foundation of technical subjects in engineering sciences is mathematics. Numerous engineering fields, including fluid dynamics, material strength, machine design, etc., use mathematics. This is how problems in the aforementioned topic are solved using mathematical concepts and methods. This paper presents some of the typical issues that undergraduate students in various engineering courses run into when attempting to apply mathematics to engineering disciplines. Additionally, some recommendations for fixing these issues are given. These solutions are being used in multiple courses, and when this semester is through, the whole findings will be accessible. Faculty members who run into the same or related issues when instructing engineering courses may find these instances and solutions helpful.

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