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What mathematical knowledge must be achieved in an engineering career?

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KEYWORDS

- Educational mathematics;
- Applied mathematical modeling;
- Interdisciplinary engineering problems;

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CiTi Keywords **–OMS (Optimization, Modelling, Simulation) Data Fractional calculation and applications, Evolutionary algorithms, Evolutionary aspects in game theory, Mathematical Statistics, Data Analysis and information security in electronic format, New security technologies based on hardware devices and post-quantum cryptography, Control Theory, Monitoring the structural health of some material and environmental area, The concept of Smart Bio-City**

CiTi strategy **– Aplicability and Interdisciplinarity: Research, design and training**

Personal Research directions on APPLIED MATHEMATICS

- **Applied Mathematics in mechanics (**Continuous modeling - from micro to macro scale - of advanced materials in virtual manufacturing, Microstructure of micro and nano-metric systems, Limit problems in the study of some fluid flows. Complex movements for non-Newtonian fluids)
- **Applied Mathematics in Urbanism** (demographic models)
- **Applied Mathematics in Robotics (**Embedded systems, computing and control. Simulation devices, visualization, interaction and combined environments, Bio-inspired techniques to ensure robot group security)
- **Applied Mathematics by statistics(**Hazard based models and covariates, Applications in Economy for Utility Functions Involving Risk Theory)
- **Nonlinear analysis with optimization and control applications**

As part of CiTi

- **Evolutionary algorithms and applications (Genetic programming); Data Analysis and Risk theory; Quantum in cryptography;**

Aplicability and Interdisciplinarity: Research, design and training

TOPIC OF THE PRESENTATION

INTRODUCTION

CORE MATHEMATICS CONTEXT

What means Core Zero and Core Level 1

TYPES OF ENGINEERING PROBLEMS vs. MATHEMATICAL MODELING

Answering to: why, what, where, when, and how core mathematics is useful, important, or fundamental for a budding engineer to obtain the necessary professional abilities and competencies.

APPLIED MATHEMATICS vs. INTERDISCIPLINARY MATHEMATICS IN ENGINEERING

STUDENT COMMUNICATION SESSIONS PLACE FOR CREATIVITY-

Research, design and training core mathematics level 1

FINAL COMMENTS

ABSTRACT

Mathematics in engineering education is the art of applying maths to complex real- world problems, combining mathematical theory, practical engineering, and scientifc computing to address today's technological challenges.

Core exercises for a human body are those which construct the strength and sustain an equilibrium to the whole system, put it in an initial state for healthy and good immunity. Likewise, what core mathematics should be studied by engineering students and how should it be defned?

The key to technical skill for training engineering students to be mathematicians is mathematical modeling. Problem-solving of this kind is best-learned through practical experience, and how engineering students learn, e.g., using case-study applications which include engineering, life sciences, medicine, climate science, energy, data science, robotics, and more. Therefore, different mathematical modeling units feature in all technical degree programs where the students often work in teams to tackle challenging, open-ended issues, putting theory into practice.

In this paper, we analyze and answer some essential questions, such as why, what, where, when, and how core mathematics is useful, important, or fundamental for a budding engineer to obtain the necessary professional abilities and competencies.

At the end of the paper are presented some ideas related to applied mathematicsvs. interdisciplinary mathematics in engineering.

I. INTRODUCTION

The approach of a subject entitled "**WHAT MATHEMATICAL KNOWLEDGE MUST BE ACHIEVED IN AN ENGINEERING CAREER?"** is somewhat similar to grabbing with one hand a sphere with a diameter larger than the palm. I mean, you don't know where to start. The first question you ask yourself is "**what's it for**?"

The technology and mathematics it requires, they went intertwined for years, decades, and centuries, developing each other.

The next question, of course, is "**which engineers**?"

This exposition will focus on engineers who use physics, as students at the technical faculties, considering that they are still the majority among future engineers, and we'll try to name the part of mathematics that we believe is necessary for them.

We will also assume that **students** - those who are students at a college that ends with an engineer's license - **arrive with some knowledge from previous schools**.

The engineers who will use physics are also very **diverse**.

II. CORE MATHEMATICS CONTEXT

Central core = **The essential mathematics material for all engineering graduates**

Central Core	***Core Zero*** (Basic)	+	***Core level 1***
	Realistic pre-requisite knowledge		Mathematics used by engineers in the understanding and developing of theory and in the sensible selection of tools for analysis of engineering problems
Mathematics	**Algebra, Analysis &Calculus** **Discrete Mathematics** **Geometry & Trigonometry** **Statistics &Probability**		**Mathematical topics of particular importance to engineers**

Core zero mathematics is the material which ideally should have been studied before entry to an undergraduate engineering degree programme. It contains material which together forms a solid platform on which to build a study of engineering mathematics at university.

Core level 1

At a basic level, mathematical topics of particular importance to engineers include:

- a fluency and confidence with number
- a fluency and confidence with algebra
- a knowledge of trigonometric functions
- an understanding of basic calculus and its application to 'real-world' situations
- a proficiency with the collection, management and interpretation of data.

The declining standard of mathematical knowledge and skills of new entrants to engineering degree courses leads to some problems that is partially solved if varius measures are taken among which:

- reducing syllabus content, replacing some of the harder material with one of lower level work;
- developing additional units of study;
- establishing mathematics support centres;

Reference

Mathematics for the european engineer a curriculum for the twenty-first century, A Report by the **SEFI MATHEMATICS WORKING GROUP,** Edited by Leslie Mustoe and Duncan Lawson, March 2002, Published by SEFI HQ, 119 rue de Stassart, 1050 Brussels, Belgium, ISBN 2-87352-045-0

Core level 1	***WHY Mathematics***	***WHAT Mathematics***	+	***WHEN***	+	***WHERE***
for undergraduate students		Advanced Calculus (Real numbers, Differential and integral calculus of functions of one variable, Infinite sequences and series)		Study year I		Faculty of Electrical Engineering, Faculty of Power of Engineering, Faculty of Material Science and Engineerting, Faculty of medical Engineering, Faculty of Applied Sciences, Faculty of Applied Chemistry and Materials Science
	Physical Problems leads to equations of mathematical phisycs	Differential and Integral Calculus (Metric spaces, Real-valued and vector-valued functions of several variables, Integrals of functions of several variables)		Study year I		
		Complex Analysis and Transforms		Study year I, II		
		Linear and nonlinear systems (Liniar Algebra and Geometry), ODE and PDE		Study year I, II		
		Probability Theory and Statistics		Study year I,II		
		Numerical Analisys		Study year II,III		
		Nonlinear Programming		Study year III, IV		

Basic Calculus and Real Analysis	**Advanced Mathematics**
C1. Real functions. Sequences and series	**C1. Field Theory**
1. Basic on set theory. Limits, derivatives and graphs of real functions. Representations of plane and spatial domains.	1. Scalar, vectorial fields. Vectorial calculus. Gradient, divergence, curl and Laplace operators
2. Sequences and series of real numbers	2. Vector integrals. Green identities, Stokes, Divergence theorem
3. Sequences and series of functions.	4. Curvilinear coordinates
4. Power series. Taylor series	**C2. Complex Analysis**
C2. Differential calculus	1.Complex numbers and complex functions and multivaluedness
1. Limits and continuity for functions of several variables	2. Holomorphy and derivability. Complex potential. Conformal mapping
2. Derivative of a function and differentials. Jacobians and change of variables	3. Complex integration. Cauchy theorems
3. Extrema of a function of several variables	4. Residue Theorems. Application of residue theorem to trigonometric and real improper integral calculus
4. Implicit functions of several variables	**C3. Fourier Series. Fourier and Laplace Transform. Discrete Transforms.**
C3. Integral calculus	1. Fourier Series of a periodic function.
1. Indefinite and definite integration. Integral calculus methods	2. Fourier Transform. Cosine and sine Transforms
2. Improper and parameter integrals. Euler Integrals.	3. Laplace Transform. 4. Discrete Transforms
3. Curvilinear Integrals	**C4. Mathematical physiscs equations (PDE)**
4. Double and volume integrals	1. Canonical form for PDE of order two
5. Surface integrals and integral formulas	2. Cauchy promlem for wave equation and heat equation. Sturm - Liuville theory
	3. Laplace equation. Separation of variables-cartesian/noncartesian coordinates

III. TYPES OF ENGINEERING PROBLEMS VS. MATHEMATICAL MODELING

Engineering Problems	Statistics and Probability
Analysis of data (Analysis of Variance, using chi-squared test)	Basics Probability and Statistics (Basic Rules of Combining Probabilities, Addition Rule, Multiplication Rule,Bayes' Rule)
Chemical process control; Metal analysis	Regression and Correlation
Choosing a distribution type for a sample analysis; t-distribution, when to use over normal distribution	Descriptive Statistics: Summary Numbers (Central Location,Variability or Spread of the Data, Quartiles, Deciles, Percentiles, and Quantiles, Using a Computer to Calculate Summary Numbers)
Correlations	Grouped Frequencies and Graphical Descriptions
Estimating demand using Poisson distribution	Probability Distributions of Discrete Variables and Continuous Variables
Experiment design, testing effectiveness	The Normal Distribution
Particle size distribution	Sampling and Combination of Variables
Plotting and analyzing data sets	Statistical Inferences for the Mean
Process control	Statistical Inferences for Variance and Proportion
Production line quality; Reliability, time to failure	Introduction to Design of Experiments
Random sampling; Sampling components on production line	Introduction to Analysis of Variance
Testing for defective components	Chi-squared Test for Frequency Distributions

References

Statistics and Probability for Engineering Applications With Microsoft® Excel, W.J. DeCoursey, College of Engineering,University of Saskatchewan, Saskatoon, Elsevier Science (USA), Woburn, 2003, ISBN: 0-7506-7618-3

IV. APPLIED MATHEMATICS vs. INTERDISCIPLINARY MATHEMATICS IN ENGINEERING

What is optimization? Optimization can be defined in different ways. Some define it as "the art of making things the *best*."

- ✓ Interestingly, many people do not like that definition as it may not be reasonable, or even possible, **to do something in the very *best* possible way**. In practice, doing something *as well as possible within practical constraints* is very desirable. Designing a product and doing all we can to increase profit as much as is practically possible is also very desirable.
- ✓ These comments may begin to give you an idea of **what optimization is attempting to do in practice**. It provides us with the means to make things happen in the best possible practical way. Now, we may ask how this is different from what all engineers, all financial analysts, and most other professionals try to do? Well, the answer to this question is important indeed. Without optimization, we accomplish this by using experience, intuition, and justplain luck! **With optimization, we do it in a systematic way**, where we use the power of a computer to examine more possibilities than any human being could ever attempt. Furthermore, the optimization approach makes sure that the search is done as efficiently as possible.
- ✓ Other applications of the optimization could be **the genetic methods of multiobjective optimization**. Thus, evolutionary multiobjective optimization algorithms are recommended in solving multiobjective optimization problems with conflicting objectives. Working on multiple solutions at each iteration, they stood out for their robustness, leading to very good results in various applications. Classical and new numerical schemes are generated using evolutionary computing.

What mathematics needed**? Core zero** and **core level 1**

1. Necessary Conditions for Local Optimum
2. Stationary Points and Inflection Points
3. Sufficient Conditions for Local Optima
4. Gradient and Hessian of a Function
5. Genetic algorithms in numerical optimization, evolutionary computation

References

Optimization in Practice with Matlab, for engineering students and professionals, Achille Messac, Cambridge Univ. Press, 2015

What is fractional calculus and wavelets theory?

- ✓ The last decades proved that derivatives and integrals of arbitrary order are very convenient for describing properties of real materials (for example, polymers). The new fractional-order models are more satisfying than former integer-order ones. **Fractional derivatives are a remarkable tool for describing the memory and hereditary properties of various materials and processes** while in integer-order models such effects are neglected. The fractional calculus has significant applications in different fields of science, including the theory of fractals, numerical analysis, physics, engineering, biology, economics, and finance. Also, fractional derivatives and integrals, respectively **fractional differential equations are used in the theory of control of dynamical systems** to describe the controlled system and the controller.

- ✓ As many notions - dynamic system, Fourier analysis, processing algorithms, Shannon information, etc., the notion of signal is claimed not only by communications engineering, but also by mathematics, in communion with computer techniques. The **theory of waves ("wavelets")** became the subject of scientific research and also of the disciplines to be learned, after 1980; this theory does not replace Fourier analysis, as an extension of it, with special virtues, we mention in this sense **the good localization of signals** (in time, frequency and scale); decomposition of signals and 2D images into "rocks", with the creation of zooms; digital analysis (A/D), directly related to the digital age in which we have irreversibly entered. **Wavelet transform** is a mathematical approach widely used for signal processing applications. It can decompose special patterns hidden in mass of data. Regarding the prediction issue through time series and neural networks, we need modeling task. Wavelet transform **has the ability to simultaneously display functions and manifest their local characteristics in time-frequency domain.**

References
http://thinkbs.khas.edu.tr/index.php

What mathematics needed**? Core zero** and **core level 1**

1. Real functions. Sequences and series
2. Differential and integral calculus
3. Complex analysis
4. Fourier analysis
5. Operational calculus or analysis

Mathematics- Core level 1 (year IV)	Mathematics - Core level 2 - Master (MDRP)
Educational databases. Concept and Optimization	Data Mining: Predictive and classification models
Deterministic and stochastic models of competitiveness analysis	Decision optimization with applications in tax-accounting consulting
Profitability and volatility on capital market	Applications of time series in economics
Data-Mining analysis models with applications	Risky decisions and dispersion analysis
Value-at-Risk, the risk management measure	Applied Mathematical Methods in Project Management
Mathematical applications in urbanism	Mathematical modeling and simulation of production processes
Interest rate risk management	Risk models in personal insurance
Predictive analysis models	Applied mathematics in risk management
The problem of transport with applications in engineering	Analysis of types of lending and choosing a loan to start a business
	Mathematical models to substantiate the decision to expand a company
	Analysis of choosing an investment using European funds
	The theory of ruin with actuarial applications
	Risk management and standardization
	Risk analysis using ARCH models

V. COMMUNICATION SESSIONS PLACE FOR CREATIVITY

The Student Scientific Communications Session aims to encourage students (undergraduate and master's degree) in engineering to carry out scientific research activities, including **interdisciplinarity**, to master the rigors and principles of research (up-to-date documentation, citation, modeling, simulation), written and spoken presentation and to improve their communication and dialogue skills.

Workshops- Workshop on Innovative Techniques, Diversity & Connectivity, May 21, 2020

Session: Applied Mathematics in Information Technology	***Session: Interdisciplinary mathematics in CiTi domains: a students' vision of reality and adversity***
Approaches of securing IoT using blocchain	Generalised Fractional-order Householder's method
Internet: the place where cyber criminals are born	Hybrid Systems for Alternative Energy Production
Security analysis of open source content management systems - Wordpress	Access to the Dark Web through the TOR network
The impact of COVID-19 on cybercrime	New Fractional Differential and LoG Operator Based Algorithms for Image Edge Detection
Applications of the Quantum Fourier Transform in Data Security	Mathematical Approaches in Health Security
Applications of advanced mathematics in quantum physics	Risk management in e-government projects
	Applications of fractional-order Butterworth filter in radar display technology

Papers connected

Semion PELESKOV, Ana-Maria-Ruxandra RESCANU and Mihai REBENCIUC" ***The Role of Wind Farms in Estimating Energy Demand in A Microgrid***" Proceedings of the 36th International Business Information Management Association (IBIMA), ISBN: 978-0-9998551-5-7, 4-5 November 2020, Granada, Spain.

George-Alexandru NEAGU, Stefan-Alexandru MITACHE and Mihai REBENCIUC" ***Covid-19 Sentinels***" Proceedings of the 36th International Business Information Management Association (IBIMA), ISBN: 978-0-9998551-5-7, 4-5 November 2020, Granada, Spain.

Aurelia-Mihaela VOICAN, Ioana-Simina STAN and Mihai REBENCIUC "***Fuzzy Sets Supervision of a Pollution Level in the Context of Smart City***" Proceedings of the 36th International Business Information Management Association (IBIMA), ISBN: 978-0-9998551-5-7, 4-5 November 2020, Granada, Spain.

V.L. DOSAN, E.C. CIPU: ***Quantum Algorithms for Quantum Fourier Transform Used in Quantum Information Theory*** Proceedings of the 36th International Business Information Management Association, (IBIMA), ISBN: 978-0-9998551-5-7, 4-5 November 2020, Granada, Spain.

V.A. ANDRONESCU, E.C. CIPU: ***A Mathematical Study Regarding Wind Turbines***, Proceedings of the 36th International Business Information Management Association (IBIMA), ISBN: 978-0-9998551-5-7, 4-5 November 2020, Granada, Spain.

E.C.CIPU, S.M. BIBIC, A. TOMA: S***ome Applications of Mathematical Modeling of Risk Assessment***, U.P.B. Sci. Bull., Series A, Vol. 82, Iss. 4, 2020, ISSN 1223-7027

FINAL COMMENTS

Ladies and gentlemen, I look forward to your advices upon how to approach mathematics/applied mathematics to technology and engineering processes. I am glad that we have meet even online.

Also, I think we teachers are going to have a problem with the teaching act.

With, or without epidemics, it looks like we're entering an age of massive digitization, unless we've already entered it. In these circumstances, we will have to redefine the basic components of teaching, learning, and evaluation, or, in other words, the didactic act. Concerning these redefinitions and even rethinking the engineering profession, we will perhaps rethink the mathematical content needed by a future engineer.

Wishing us success in the face of the challenges that lie ahead. Thank you!