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ROLE OF MATHEMATICAL ANALYSIS IN RESEARCH

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ABSTRACT

Mathematics is used to analyze and solve real world problems. Behind every technology and achievement, there is mathematical technology and brain. Mathematics is well integrated into the technological, industrial, military, economic, and various other disciplines and that mathematics has been relying on these systems for the material bases of its continuing progress. In this paper, we discuss the integration of mathematics with other disciplines. Mathematics make research problem to understand and solve easily by its various proficiency standards as discussed in the paper. The various research theme in mathematics are basic problem solving or may be integrated with an application. The challenges of research for mathematician are also analyzed.

INTRODUCTION:

Like certain other great disciplines (physics, chemistry, technology, computer science, economics, biology, medicine, the humanities), mathematics occupies a central place in the contemporary scientific world as well as in the modern economy. It plays an essential role, for example, in the modeling tools used by other disciplines. Though this fact often goes unnoticed, mathematics is omnipresent in our technological society. Examples include the use of arithmetic in coding and cryptography, wavelet analysis in image-compression algorithms (such as the JPEG 2000 standard), partial derivative equations and numerical methods in weather forecasts, and stochastic computations in finance.

The need for mathematical competence is present in many professions—among highly qualified workers and technical personnel, for example, as well as executives in industry, public administration, business, and engineering.

MATHEMATICS AND OTHER DISCIPLINES:

Mathematicians use mathematical theory, computational techniques, algorithms, and the latest computer technology [17] to solve economic, scientific, engineering, physics, and business problems. The work of mathematicians falls into two broad classes. Firstly, theoretical (pure) mathematics and secondly applied mathematics. These classes, however, are not sharply defined and often overlap. The inter-relationship between Science, Engineering and technology is explained in [1]

The development of new methods and theories and application in mathematics are useful in every area of science, engineering, industry and business. It requires rigorous thinking and analysis to solve problems in the business sector. Mathematical specialties include Modeling and Simulation, Numerical Methods/Analysis, Statistics, Probability, Engineering Analysis / Differential Equations, Operation Research, and Discrete Mathematics. Mathematics has been successfully used in all these areas see for example [2-7,9-15]. Neunzert [10] has emphasized teaching of mathematics as a technology. Neunzert and Siddiqi [8] have discussed in detail industrial mathematics and fields of mathematics covered under this heading. K R Sreenivasan [12] has elaborated in these lectures role of mathematics in real world problems. In [7] role of mathematics is discussed in great detail for hydrocarbon exploration and production. Furati et al. [2-6] have discussed the role of mathematics in superconductivity.

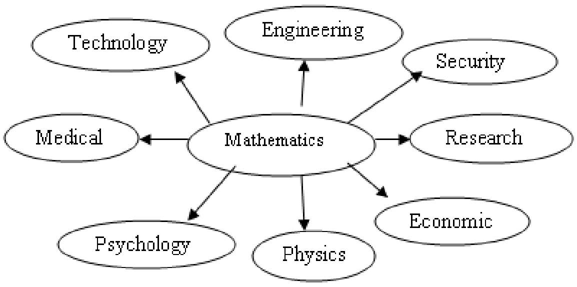

Figure1.1. Mathematics Relation with other disciplines

MATHEMATICS AND RESEARCH- A KEY OF RELIABILITY AND SUCCESS:

Many of the contributions and uses of mathematics are closely related to the need for mathematical modeling and simulation of physical phenomena on the computer. In addition, the analysis and control of processes, and optimization and scheduling of resources use significant mathematics. For example, the finance industry uses sophisticated mathematical models for pricing of securities, while the petroleum industry models the flow of oil in underground rock formations to help in oil recovery. Image processing, whether producing clear pictures from satellite imagery or making medical images (CAT, MRI) to detect and diagnose, all use significant mathematics. Industrial design, whether structural components for airplanes or automobile parts, uses a tremendous amount of mathematical modeling; much of which is embodied in CAD/CAM computer software. Such techniques were used in the design of the Boeing 777, as well as in the design of automobiles. Computational modeling is also used in airplane and automobile design to analyze the flow of air over vehicles to determine fuel economy and efficiency. The use of mathematics is pervasive in modern industry. The result is that learning and knowledge of mathematics is compulsory in almost every field, including engineering research, telecommunications, computer services and software, energy systems, computer manufacturers, aerospace and automotive, chemicals and pharmaceuticals, and government laboratories, among others.

The discipline of mathematics permeates various specialized fields, all of which have been touched by the digital revolution. These include statistics and finance, of course, as well as nuclear energy, biology, insurance, the social sciences, and new information technologies.The speed of development and variety of uses of mathematics, moreover, has cast doubt on the old distinction between its pure and applied forms. From junior statistician to professor of mathematics, from actuary to consulting engineer—mathematics is central to attractive careers in research, consulting, engineering, media (TV, film, Web, multimedia), banking and finance, automobiles, telecommunications, high technology, laboratory analysis, and manufacturing.

MATHEMATICAL PROFICIENCY IN RESEARCH:

There are five interwoven and interdependent strands of mathematical proficiency:

• Conceptual Understanding

It includes comprehension of mathematical concepts, operations, and relations.

• Procedural Fluency

It includes skill in carrying out procedures flexibly, accurately, efficiently, and appropriately.

• Strategic Competence

It includes ability to formulate, represent, and solve mathematical problems.

• Adaptive reasoning

It includes capacity for logical thought, reflection, explanation, and justification.

• Productive disposition

It includes habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy.

RESEARCH THEMES IN MATHEMATICS:

Basic Mathematics

Large, unsolved problems often turn out to be engines of scientific advancement. They are often linked, loosely or directly, to pending questions in other sciences, and their solution may give rise to unexpected applications. Some examples follow in which mathematicians played a key role: classification of low-dimensional varieties; the Langland's program; algebraic ciborium; and the ongoing merger of algebraic topology and algebraic geometry. On the other side of the great problems, new ideas regularly arise, such as techniques of concentration of measure, hypo elliptic calculus, optimal transport, and wavelet theory.

Interdisciplinary Interactions

The large questions in fields in which mathematics provides important conceptual tools are a major source of new challenges for the discipline. Reciprocally, mathematical theories often find their most eloquent expression, or fulfillment, outside mathematics. Examples include partial derivative equations; algebraic and combinatorial structures; geometric structures; probabilistic aspects of statistical mechanics and thermo-dynamics; non-commutative probabilities; the consistency of certain theories in physics; theories of complexity and proof; and statistics. In addition to physics and computer science, other domains, including chemistry, biology, engineering, and information science, involve major mathematical problems.

Modeling And Computation Operational mathematics produces quantitative results for technological [16] applications. Examples include modeling based on partial derivative equations; stochastic and statistical modeling; optimization and control; signal and image processing; and scientific computing.

Broad Fields Of Application

Some of the broad fields in which mathematics is applied are chemistry and materials (quantum chemistry and process engineering); biology and medicine (neurosciences, image processing, fluid and structural mechanics, statistics, discrete mathematics); genomics (statistical analysis, automated sequencing procedures); problems of energy and the environment (storage of wastes, climate change, natural catastrophes); transportation (aeronautics, automobiles, road traffic management); decision support (financial mathematics, actuarial methods, operational research); telecommunications and data transmission (coding, cryptology[8], electromagnetism, network queues; nanotechnologies).

CHALLENGES OF MATHEMATICS IN RESEARCH:

From the point of view of research, mathematics is an enabling technology. Research faces new challenges; mathematician's ready respond can make significant contributions. The main challenges includes-

Complexity

Large-scale research problems are often modeled as large systems or networks of interacting objects. The objects themselves may be networks describing the technological, economical, financial, and social aspects of the problem, or they may represent components or steps of a technical process. The analysis of the behavior and evolution of such systems or networks poses formidable challenges to research managers and decision makers. Even when the dynamics of the individual components are understood, the (nonlinear) interactions among the components make it inherently difficult to predict, let alone control, the evolution of the system as a whole.

Uncertainty

Uncertainty is an inherent feature of many research problems. Relations among individual components of a system are sometimes imperfectly understood, cause and effect cannot always be determined with certainty, and the only data available may be incomplete or subject to experimental error. The need to consider the human interface and the mandate to account for environmental and social considerations can add further uncertainty.

Large-Scale Simulations

Computational science and engineering have become integral elements of the research design process. Large-scale, Multiple Scales research problems do not usually play out on one length or time scale. For example, the macroscopic behavior of a material depends on the interactions of atoms and molecules, and details about the latter are increasingly necessary to better understand the former. Also, the long-term dynamics of a complex system may depend critically on the details of what happens to the individual components on a much shorter time scale.

Numerical simulations are replacing experiments where the latter have become too expensive or even impossible. The aircraft industry provides a striking illustration of this phenomenon. While off-the-shelf software was often adequate for the computational solution of most of yesterday's problems across the industrial spectrum, simulations today require specialized numerical algorithms and sophisticated software management tools; without these, the simulations will be unable to keep pace with modern research demand.

Data and Information

The ubiquity of networked computers, sensors, communication modules, and monitoring devices yields an ever-increasing stream of data. Not only does the quantity of data increase, but also the way the data is obtained, often from multiple sources and with varying degrees of precision. Integrating so-called multimodal data is already a formidable challenge, which is compounded if one is concerned about rare events, as in national security and economic activities. While classical statistical techniques work well as long as the number of variables is small, sampling techniques for high-dimensional data sets are still not fully developed. The recent popularity of search engines such as Google is due in large part to the development of novel mathematical ways to extract information from high-dimensional data sets.

CONCLUSION:

Mathematics plays an important role in research. Mathematics integrated with various disciplines to make applications useful for industry or business. Various challenges of researcher in field of mathematics include complexity, uncertainty, multiple scales, simulation corrections, ambiguity of data and information. Mathematics is used to prove correctness and complexity of algorithm in computer science field. Mathematics also used in medical science for curing various diseases like Cancer. Mathematics makes research problem understanding easy and uses strategic and adaptive reasoning for its solution.

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