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INTERDISCIPLINARY APPLICATIONS OF MATHEMATICS IN OTHER FIELDS

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Introduction

Mathematics has been vital to the development of civilization. From ancient to modern times mathematics has been fundamental to advances in science, engineering, and philosophy. Developments in modern mathematics have been driven by a number of motivations that can be categorized into the solution of a difficult problem and the creation of new theory enlarging the fields of applications of mathematics. Very often the solution of a concrete difficult problem is based on the creation of a new mathematical theory. While on the other hand creation of a new mathematical theory may lead to the solution of an old classical problem. This paper is discussing the current role of mathematics in other disciplines.

In the 18th and 19th century mathematical language was vague and did not allow much interaction among mathematicians of different fields. In the period 1950's to 1970's Mathematicians concentrated around problems of algebraic topology, algebraic geometry and complex analysis and they developed new concepts and new methods. New powerful mathematical tools were developed and the language of mathematics became highly developed and very powerful. When the basics were clear enough there was a search for powerful tools that allowed for development and expansion of the geometric intuition into new domains. Examples are topology, homological algebra and algebraic geometry.

The period l930's to 1970's saw a divergence within mathematics itself and between mathematics and other applied sciences. Mathematics became more inward looking, and the distinction between pure and applied mathematics became much more pronounced. The diversification of mathematics was first of all connected with external social phenomenon, the rapid growth of the scientific community and the breaking discoveries in physics.

Application Areas

The branch of mathematics traditionally used in the applications in physics is analysis and differential geometry. Most of the advances in pure mathematics were propelled by problems in physics. In the last part of the 20th century researchers in many other sciences have come to a point where they need serious mathematical tools. The tools of mathematical analysis and differential geometry were no longer adequate. For example a biologist trying to understand the genetic code will need tools of graph theory than differential equations because the genetic code is discrete. Issues of information content, redundancy or stability of the code are more likely to find tools of theoretical computer science useful than those of classical mathematics are. Even in physics discrete systems such as elementary particles need use of combinatorial tools and statistical mechanics need tools of graph theory and probability theory.

Inter-Discipline Mathematics

Currently, efforts are being undertaken to facilitate collaborative research across traditional academic fields and to help train a new generation of interdisciplinary mathematicians and scientists. Also similar efforts are slowly being introduced in undergraduate and postgraduate mathematics curricula and pedagogy. Disciplines that hitherto hardly used mathematics in their curricula are now demanding substantial doses of knowledge of and skills in mathematics. For example the pre-requisites for mathematical knowledge and skills for entry in into biological and other life sciences as well as the mathematics content in the university curricula of these programmes is becoming quite substantial. Curricula of some universities in the developed countries have inter-disciplinary programmes where mathematics students and students from other sciences (including social sciences) work jointly on projects. The aim is to prepare graduates for the new approaches and practices in their fields and careers.

Examples of Inter-Discipline in Research

Complexity theory is an example of inter-discipline and is the new focus on research in mathematics (Hoyningen-Huene, et al 1999). Certain essential details of complexity have been known for quite some time. At the end of the 19th century, the first source of a general idea of complex systems was research in dynamical systems, in the context of classical mechanics. It is an interdisciplinary approach fuelled by sophisticated mathematics, mathematical modeling and computer simulation, inspired by observations made on complex systems in the most diverse fields including meteorology, climate research, ecology, economics, physics, embryology, computer networks and many more. Examples are systems that adapt to changes in their environment in an extremely surprising way. They include Economics (economy of a country), Biodiversity (ecosystem of a pond), Biology (the immune system of an organism) and Artificial Intelligence (Computer Networks).

Role of mathematics in other Disciplines

A famous Jain mathematician, Acharya Mahavira writes that-“Bahubhirvi pralapaih Kim trailokye sacaracare, Yatkimcidvastu tatsarva ganitena bina nahi”. The verse shows the importance of mathematics as- “What is good of saying much in vain? Whatever there is in all three worlds, which are possessed of moving and non-moving being all the indeed cannot exist as apart from Mathematics”.

Here are some main disciplines in which Role of Mathematics is widely accepted:

Mathematics in Materials Sciences

Materials sciences is concerned with the synthesis and manufacture of new materials, the modification of materials, the understanding and prediction of material properties, and the evolution and control of these properties over a time period. Until recently, materials science was primarily an empirical study in metallurgy, ceramics, and plastics. Today it is a vast growing body of knowledge based on physical sciences, engineering, and mathematics. For example, mathematical models are emerging quite reliable in the synthesis and manufacture of polymers. Some of these models are based on statistics or statistical mechanics and others are based on a diffusion equation in finite or infinite dimensional spaces. Simpler but more phenomenological models of polymers are based on Continuum Mechanics with added terms to account for ‘memory.’ Stability and singularity of solutions are important issues for materials scientists. The mathematics is still lacking even for these simpler models. Another example is the study of composites. Motor companies, for example, are working with composites of aluminum and silicon-carbon grains, which provide lightweight alternative to steel. Fluid with magnetic particles or electrically charged particles will enhance the effects of brake fluid and shock absorbers in the car. Over the last decade, mathematicians have developed new tools in functional analysis, PDE, and numerical analysis, by which they have been able to estimate or compute the effective properties of composites. But the list of new composites is ever increasing and new materials are constantly being developed. These will continue to need mathematical input. Another example is the study of the formation of cracks in materials. When a uniform elastic body is subjected to high pressure, cracks will form. Where and how the cracks initiate, how they evolve, and when they branch out into several cracks are questions that are still being researched

Mathematics in Biology

Mathematical models are also emerging in the biological and medical sciences. For example in physiology, consider the kidney. One million tiny tubes around the kidney, called nephrons, have the task of absorbing salt from the blood into the kidney. They do it through contact with blood vessels by a transport process in which osmotic pressure and filtration play a role. Biologists have identified the body tissues and substances, which are involved in this process, but the precise rules of the process, are only barely understood. A simple mathematical model of the renal process shed some light on the formation of urine and on decisions made by the kidney on whether, for example, to excrete a large volume of diluted urine or a small volume of concentrated urine. A more complete model may include PDE, stochastic equations, fluid dynamics, elasticity theory, filtering theory, and control theory, and perhaps other tools. Other topics in physiology where recent mathematical studies have already made some progress include heart dynamics, calcium dynamics, the auditory process, cell adhesion and motility (vital for physiological processes such as inflammation and wound healing) and biofluids. Other areas where mathematics is poised to make important progress include the growth process in general and embryology in particular, cell signaling, immunology, emerging and reemerging infectious diseases, and ecological issues such as global phenomena in vegetation, modeling animal grouping and the human brain.

Mathematics in Digital Technology

The mathematics of multimedia encompasses a wide range of research areas, which include computer vision, image processing, speech recognition and language understanding, computer aided design, and new modes of networking. The mathematical tools in multimedia may include stochastic processes, Markov fields, statistical patterns, decision theory, PDE, numerical analysis, graph theory, graphic algorithms, image analysis and wavelets, and many others. Computer aided design is becoming a powerful tool in many industries. This technology is a potential area for research mathematicians. The future of the World Wide Web (www) will depend on the development of many new mathematical ideas and algorithms, and mathematicians will have to develop ever more secure cryptographic schemes and thus new developments from number theory, discrete mathematics, algebraic geometry, and dynamical systems, as well as other fields.

Mathematics in the Army

Recent trends in mathematics research in the USA Army have been influenced by lessons learnt during combat in Bosnia. The USA army could not bring heavy tanks in time and helicopters were not used to avoid casualty. Also there is need for lighter systems with same or improved requirement as before. Breakthroughs are urgently needed and mathematics research is being funded with a hope to get the urgently needed systems. These future automated systems are complex and nonlinear; they will likely be multiple units, small in size, light in weight, very efficient in energy utilization and extremely fast in speed and will likely be self organized and self coordinated to perform special tasks. Research areas are many and exciting. They include: (i) Mathematics for materials (Materials by design - Optimization on microstructures; Energy Source - compact power, Energy efficiency; Nonlinear Dynamics and Optimal Control). (ii) Security issues (needs in critical infrastructure protection, mathematics for Information and Communication, Mathematics for sensors, i.e. information/ data mining and fusion, information on the move i.e. mobile communication as well as network security and protection). (iii) Demands in software reliability where mathematics is needed for computer language, architecture, etc. (iv) Requirements for automated decision making (probability, stochastic analysis, mathematics of sensing, pattern analysis, and spectral analysis) and (v) Future systems (lighter vehicles, smaller satellites, ICBM Interceptors, Hit before being Hit, secured wireless communication systems, super efficient energy/ power sources, modeling and simulations, robotics and automation.

During the last 50 years, developments in mathematics, in computing and communication technologies have made it possible for most of the breath taking discoveries in basic sciences, for the tremendous innovations and inventions in engineering sciences and technology and for the great achievements and breakthroughs in economics and life sciences. These have led to the emergency of many new areas of mathematics and enabled areas that were dormant to explode. Now every branch of mathematics has a potential for applicability in other fields of mathematics and other disciplines. All these, have posed a big challenge on the mathematics curricula at all levels of the education systems, teacher preparation and pedagogy. The 21st Century mathematics thinking is to further strengthen efforts to bridge the division lines within mathematics, to open up more for other disciplines and to foster the line of inter-discipline research

Mathematics in Statistics

Statistics is the mathematical science involving the collection, analysis and interpretation of data. A number of specialties have evolved to apply statistical theory and methods to various disciplines. Certain topics have “statistical” in their name but relate to manipulations of probability distributions rather than to statistical analysis.

Actuarial Science is the discipline that applies mathematical and statistical methods to assess risks in the insurance and finance industries.

Astrostatistics is the discipline that applies statistical analysis to the understanding of astronomical data.

Biostatistics is a branch of biology that studies biological phenomena and observations by means of statistical analysis, and includes medical statistical.

Environmental Statistics is the application of statistical methods to environmental science. Weather, climate, air and water quality are included as are studies of plant and animal populations.

Geostatistics is a branch of geography that deals with the analysis of data from disciplines such as petroleum geology, hydrogeology, hydrology, meteorology, oceanography, geochemistry, etc.

Mathematics in Arts

"Mathematics and art are just two different languages that can be used to express the same ideas." It is considered that the universe is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures. The old Goethic Architecture is based on geometry. Even the Egyptians Pyramids, the greatest feat of human architecture and engineering, were based on mathematics. Artists who strive and seek to study nature must therefore first fully understand mathematics. On the other hand, mathematicians have sought to interpret and analyze art though the lens of geometry and rationality. This branch of mathematics studies the nature of geometric objects by allowing them to distort and change. An area that benefits most from the visual approach is topology.

Mathematics in Management

Mathematics in Management is a great challenge to imaginative minds. It is not meant for the routine thinkers. Different Mathematical models are being used to discuss management problems of hospitals, public, health, pollution, educational planning and administration and similar other problems of social decisions. In order to apply mathematics to management, one must know the mathematical techniques and the conditions under which these techniques are applicable. In addition, one must also understand the situations under which these can be applied. In all the problems of management, the basic problem is the maximization or minimization of some objective function, subject to the constraints in available resources in manpower and materials. Thus OR techniques is the most powerful mathematical tool in the field of management.

Mathematics in Engineering and Technology

Mathematics has played an important role in the development of mechanical, civil, aeronautical and chemical engineering through its contributions to mechanics of rigid bodies, hydrodynamics, aerodynamics, heat transfer, lubrication, turbulence, elasticity, etc. It has become of great interest to electrical engineers through its applications to information theory, cybernetics, analysis, and synthesis of networks, automatic control systems, design of digital computers etc.

The new mathematical sciences of magneto-hydrodynamics and plasma dynamics are used for making flow meters, magneto-hydrodynamic generates and for experiments in controlled nuclear fusion.

Mathematics in Psychology and Archaeology

Mathematics is even necessary in many of the social sciences, such as psychology and Archaeology. Archaeologists use a variety of mathematical and statistical techniques to present the data from archaeological service and try to distinguish patterns in their results that shed light on past human behavior.

Statistical measures are used during excavation to monitor which pits are most successful and decide on further excavation. Finds are analyzed using statistical and numerical methods to spot patterns in the way the archaeological record changes over time and geographically within a site and across the country. Archaeologists also use statistics to test the reliability of their interpretations.

Mathematics in Social Networks

Graph theory, text analysis, multidimensional scaling and cluster analysis, and a variety of special models are some mathematical techniques used in analyzing data on a variety of social networks.

Mathematics in Political Science

In mathematical political science, we analyze past election results to see changes in voting patterns and the influence of various factors on voting behavior, on switching of votes among political parties and mathematical model for conflict resolution. Here we make use of game theory.

Mathematical Linguistics

The concepts of structures and transformation are as important for linguistic as they are for mathematics. Development of machine languages and comparison with natural and artificial language require a high degree of mathematical ability.

Information theory, mathematical biology, mathematical psychology, etc. are all needed in the study of linguistics.

Mathematics has had a great influence on research in literature. In deciding whether a given poem or essay could have been written by a particular poet or author, we can compare all the characteristics of the given composition with the characteristics of the poet or other works of the author with the help of a computers.

Mathematics in Music

Calculations are the root of all sorts of advancement in different disciplines. The rhythm that we find in all music notes is a result of innumerable permutations and combinations of SAPTSWAR. Music theorists often use mathematics to understand musical structure and communicate new ways of hearing music. This has lead to musical applications of said theory, abstract algebra, and number theory.

Music scholars have also used mathematics to understand musical scales, and some composers have incorporated the golden ratio and Fibonacci numbers into their work. Most of today’s music is produced using synthesizers and digital processors to correct pitch or add effect to the sound. These tools are created by audio software engineers who works out ways of manipulating and digital sound, by using a mathematical technique called Fourier analysis.

Mathematics in Economics

In economic theory and econometrics, a great deal of mathematical work is being done all over the world. In econometrics, tools of matrices, probability and statistics are used. A great deal of mathematical thinking goes in the task of national economic planning, and a number of mathematical models for planning have been developed.

The models may be stochastic or deterministic, linear or non-linear, static or dynamic, continuous or discrete, microscopic or macroscopic and all types of algebraic, differential, difference and integral equations arise for the solution of these models. At a later stage more sophisticated models for international economies, for predicting the results of various economic policies and for optimizing the results are developed.

Another important subject for the economics is game theory. The whole economic situation is regarded as a game between consumer, distributers and the producers, each group trying to optimize its profits. The subject tries to develop optimal strategies for each group and the equilibrium values of games.

Mathematics in Biological Sciences

Biomathematics is a rich fertile field with open, challenging and fascination problems in the areas of mathematical genetics, mathematical ecology, mathematical neuron-psychology, development of computer software for special biological and medical problems, mathematical theory of epidemics, use of mathematical programming and reliability theory in biosciences and mathematical problems in biomechanics, bioengineering and bioelectronics.

Mathematical and computational methods have been able to compliment experimental structural biology by adding the motion to molecular structure. These techniques have been able to bring molecules to life in a most realistic manner, reproducing experimental data of a wide range of structural, energetic and kinetic properties. Mathematical models have played, and will continue to play an important role in cellular biology.

Mathematics in Physical Oceanography

Important fluid dynamics problem arise in physical oceanography. Problems of waves, tides, cyclones flows in bays and estuaries, the effect of efflux of pollutants from nuclear and other plants in sea water, particularly on fish population in the ocean are important for the study. From defense point of view, the problem of underwater explosions, are also important.

Mathematics in Chemistry

Math is extremely important in physical chemistry especially in advanced topics such as quantum or statistical mechanics. Quantum relies heavily on group theory and linear algebra and requires knowledge of mathematical/physical topics such as Hilbert spaces and Hamiltonian operators. Statistical mechanics relies heavily on probability theory.

Other field of chemistry also uses a significant amount of math. Even biochemistry has important topics which rely heavily on math, such as binding theory and kinetics.

Even pharmaceutical companies require teams of mathematicians to work on clinical data about the effectiveness or dangers of new drugs. Pure scientific research in chemistry and biology also needs mathematicians, particularly those with higher degrees in computer science, to help develop models of complicated process.

Mathematics in Physical Sciences

In mathematical physics, some basic axioms about mass, momentum, energy, force, temperature, heat etc. are abstracted, from observations and physical experiments and then the techniques of abstraction, generalization and logical deduction are used. It is the branch of mathematical analysis that emphasizes tools and techniques of particular use to physicists and engineers. It focuses on vector spaces, matrix algebra, differential equation, integral equation, integral transforms, infinite series and complex variables. Its approach can be adapted to applications in electromagnetism, classic mechanics, and quantum mechanics.

In mathematics a particle is a point-like, perfectly rigid, solid object. Particle mechanics deals with the results of subjecting particles to forces. It includes celestial mechanics- the study of the motion of celestial objects. The role of space dynamics is very important in mechanics. Here we have to consider the trajectories which are time-optimal i.e. which take the least time in going from one point to another and in which the object starts and reaches the destination with zero velocity.

Similarly we may have to consider energy-optimal trajectories. We have also to consider the internal and eternal ballistic of rocket and the path of intercontinental ballistic missiles.

Mathematics in Fluid Dynamics

Understanding the conditions that result in avalanches, and developing ways to predict when they might occur, uses an area of mathematics called Fluid mechanics. Many mathematicians and physicists applied the basic laws of Newton to obtain mathematical models for solids and fluid mechanics. This is one of the most widely applied areas of mathematics, and is also used in understanding volcanic eruptions, flight, ocean currents.

Civil and mechanic engineers still base their models on this work, and numerical analysis is one their basic tools. In the 19th c, phenomena involving heat, electricity and magnetism were successfully modeled; and in the 20th c, relativistic mechanics, quantum mechanics and other theoretical concepts were created to extend and improve the applicability of earlier ideas

One of the most wide spread numerical analysis techniques for working with such models involves approximating a complex, continuous surface, structure or process by a finite number of simple elements known as the finite element method (FEM).

Mathematics in Computational Fluid Dynamics

Computational fluid dynamics is a discipline wherein we use computers to solve the navier-stokes equations for specified initial and boundary condition for sub sonic, transonic and hypersonic flows. Many of our research workers use computers, but usually these are used at the final stage when drastic simplification have already been made, partial differential equation have been reduced to ordinary differential equations and those equations have even been solved.

REFERENCE:

1. www.google.com
2.wikipedia.org