ROLE OF MATHEMATICS FOR ECONOMIC AND SCIENTIFIC DEVELOPMENT

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ABSTRACT. In this paper areas of mathematics, that are frequently applied to analyze and solve real world problems, are discussed. It is indicated that these topics are quite useful for economic and scientific development of Arab States in particular and other nations in general. It is observed that these user friendly topics of Mathematical Sciences have not attracted attention of academicians of Arab states. Concrete steps are suggested to popularize these topics in this region.

1. RELEVANCE OF MATHEMATICS TO REAL WORLD SYSTEM

It is well known that Galileo highlighted mathematics as the language of nature. Common wealth countries understood it as the queen of all sciences. It has been treated as the mother of all technologies in USA and now all other industrialized nations-G8 countries have also accepted this role of mathematics. Behind each major achievements, may it be landing at moon, invention of television and fax machine, planning and designing of rockets and satellites, planning and determining strategies of war, manufacturing of sophisticated weapons and armors, invention of computers and their various variants, scanning of brain, manufacturing of powerful telescope, weather forecast, prediction of stock markets, there is a mathematical technology and a mathematical brain.

In this paper, areas of mathematics that are frequently used to analyze and solve real world problems, are discussed. It is indicated that these topics are quite useful for economic and scientific development of Arab States in particular and other nations in general. It is observed that these user friendly topics of Mathematical Sciences have not attracted attention of academicians of Arab states. Concrete steps are suggested to popularize these topics in this region.

Establishment of the Society of Industrial and Applied Mathematics, Philadelphia, U.S.A. in 1952 was a serious effort to enhance the role and involvement of mathematics in investigations of industrial and real life problems. An international organization, called International Congress of Industrial Mathematicians (ICIAM) was established with its first conference in Paris (1987), second in Washington D.C. (1991), 3rd in Humburg (1995), 4th in Edinburg (1999), 5th in Sydney (2003), 6th in Zurich (2007) and 7th (is scheduled) in Vancour (2011). Every industrialized country has its national society for developing industrial and applied Mathematics. India and China also joined ICIAM in mid nineties. Now International Mathematics Union, American Mathematical Society, European Mathematical Society and an important Russian Mathematical Society have also joined this organization. The main goal of this organization is to promote those branches of mathematics that are more relevant to economic and scientific development. ICIAM07 (16-20, July 2007 at Zurich) focused its deliberations on the following themes:

(i) Computing (including: Computational Science and Engineering, Scientific Computing, parallel computing, high performance computing etc).

(ii) Applied Analysis (including integral and functional equations, Fourier and Wavelet analysis, perturbation methods).

(iii) Optimization (including optimization with PDE, complementarity problem, variational inequalities, security and defense).
(iv) Stochastic PDE and Numerical Methods such as finite element method, boundary element method and particle method.
(v) Image Processing, Fractals, Wavelets.
(vi) Financial Mathematics.
(vii) Data Analysis.
(viii) Discrete Mathematics (including integer programming, network).
(ix) Elasticity and Plasticity.
(x) Material properties and microstructure.
(xi) Molecular modeling.
(xii) Flow through porous media.
(xiii) Applications of mathematics to agriculture, ecology, epidemiology, tumor and cardiac modeling, DNA sequencing, gene technology.
(xiv) Applications of mathematics to meteorology, earthquake, tsunami, hydrocarbon exploration.
(xv) Semiconductor and superconductor.
(xvi) Modeling and simulation for industry including manufacturing, micro-scale, inverse problems.
(xvii) Application to culture history and civilization.

There may be many more topics of mathematics which could be applied to solve real world problems. Very often all these topics are put under the Umbrella of Industrial and financial mathematics. Industrial Mathematics comprises three steps namely (i) Description of a situation in words and its mathematical formulation. Mathematical equations or concepts representing the situations are called models (ii) Analysis and finding exact solution, if possible, of the model. Finding approximate solutions by discretizing models. (iii) Visualization of solutions on screen of the computer. (iv) Interpretation of solutions.

According to reliable sources emerging technologies and challenging real world problems are (i) Advanced materials (ii) Advanced semiconductor devices (iii) Artificial vision and intelligence (iv) Bio-technology (v) Digital image technology (vi) Flexible integral manufacturing (vii) High density data storage (viii) High performance computing (ix) Medical devices and diagnostics (x) Opto-electronic (xi) Sensor technology (xii) Super conductors (xiii) Nano-technology (xiv) Simulation of processes and products (xv) Optimization and control (xvi) Uncertainty and Risk (xvii) Management and Exploitation of data (xviii) Food and Health related problems.

Mathematics has been successfully used in all these areas see for example [2-7,9-15] and references there in. Inter-relationship between science, engineering and technologies are nicely presented in [1].

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. As an illustration, implications of these studies are mentioned.

By application of mathematical methods the exploration cost of oil, and communication cost of images could be reduced. Techniques of wavelets and fractals are used for this purpose. Numerical simulation of mathematical models for type – II superconductivity

may help to manufacture super conductor cables to reduce the cost of electricity. Knowledge of Maxwell's equations and variational inequalities are required for a systematic study.

Scientific computing, optimization, wavelet analysis, stochastic analysis, signal and image processing are some of the areas mentioned above which could be particularly useful for economic and scientific development of Arab states. We elaborate below the three areas of contemporary applications of mathematical methods.

Mathematical Methods and Models for Hydrocarbon Exploration and Production:

An excellent reference [7] comprises13 chapters, each one authored by internationally renowned experts from academic and industrial institutions. Experts of Schlumberger have actively participated in its writing and production. A careful study of this volume can convince any one that topics of mathematics mentioned above could reduce substantially exploration and production cost of hydrocarbons. It is well known that above 70% of today oil and gas production rate comes from hydrocarbon field that are more than 30 years old. Managers and researchers of oil industry are engaged in developing new technological methods, based on contemporary mathematical methods and scientific tools from areas of geophysics, geology, petroleum engineering, signal processing and computer science, which may improve economic conditions of oil producing countries and consequently also of other developing countries.

Mathematics of Superconductors:

Electricity is the source of all developmental activities. Increase in the cost of electricity increases the cost of living in any country. Reasonable price of electricity is the need of any country in the world. There are attempts in different parts of the world to develop superconducting materials at high temperature to produce cheap electricity. For proper understanding and utilization of superconductors at high temperature, besides chemistry and physics of this phenomenon, new mathematical models and methods are needed. The main goal is to manufacture superconducting power cables.

Nano-Technology:

Nano technology is becoming a popular theme through out world including the Kingdom of Saudi Arabia. However, understanding the mathematical rigorness, an important ingredient for any minute details in nano-technology and its special impact, is missing. There is hardly any mathematician in Arab states who is studying mathematics of nano-technology.

An interesting symposium (IC/MP39/154) on Nano-mathematics was organized during ICIAM07 [13] by Leela Rakesh (Central Michigan University, USA). It was to support the emerging nano-technology and nano-science revolution through an interdisciplinary mathematical modeling and simulation applied to the understanding of Biology, Chemistry and Physics of nano-materials. The US Department of Energy has identified a key potential research target for future development of the field: "lack of development of theory, analytic techniques, modeling and simulation tools (TAMS). The symposium was mainly devoted to the basic understanding of fluid dynamics and better analytic techniques, thus enabling the better design, modeling, predictability, efficiency and control of systems that involve fluids. Mathematicians have to play an important role in this emerging field.

2. REVIEW OF MATHEMATICS EDUCATION IN ARAB STATES

Most of the mathematics departments of universities in Arab States are mainly focusing to topics in "Pure Mathematics" such as Abstract Algebra, Abstract Analysis, Topology, Geometry and Theory of Differential equations. The faculty members are trained in these areas and consequently they are encouraging their students, who are likely to be future

faculty members, to pursue their specialization. KFUPM is the only university which has made some serious efforts to introduce some topics mentioned above. Some of its faculty members have attended ICIAM 1999, ICIAM 2003 and ICIAM 2007 and have organized minisymposiums. The centre of Petroleum and Minerals, RI, KFUPM is also focusing on mathematical techniques of proper understanding of well logs and creation of virtual oil wells. Mathematicians are being encouraged to participate in this venture. The Deanship of scientific research of the KFUPM is also financing projects on applications of wavelets and fractals to analyze the meteorological data of the Kingdom of Saudi Arabia.

Researchers of some countries in Asia such as Turkey, India, Singapore have achieved competence to certain level in areas mentioned in section 1.

3. STEPS REQUIRED FOR TRAINING MATHEMATICIANS TO MEET CHALLENGES OF ECONOMIC AND SCIENTIFIC DEVELOPMENT

The following steps may provide impetus for education of those areas of mathematics which have great potential for economic and scientific development of a nation.

(i) Creating facilities for training existing faculty members in Arab states to impart instruction in areas discussed in Section 1. A regional centre on the lines of ICTP (www.ictp.it) is an ideal model for this purpose. Participation of students from neighboring developing countries such as Turkey, India, Pakistan, Bangladesh may be encouraged.

(ii) Undergraduate and Postgraduate programmes of Industrial mathematics and Financial mathematics in Arab states be started. Awareness of such disciplines must be created in Arab States.

(iii) Talents of countries like India, Pakistan, Bangladesh, Turkey, Uzbekistan and financial resources of Arab states such as Saudi Arabia, Kuwait, Muscat, Oman, UAE should be pooled together to promote teaching and research of areas mention in Section 1. Specialists of these areas are limited even in industrialized nations and more over they are in high demand in their own country or region. However, experts of non-Arab developing countries mentioned above may be willing to train people in Arab states in these areas.

(iv) Active interaction of institutions in Arab states with organization such as ICTP (www.ictp.it), ICIAM (www.iciam.org), SIAM (www.siam.org) must be established.

(v) New mathematics courses be introduced incorporating the areas mention in section 1 with application oriented approach.

(vi) Active collaboration, in the research fields mentioned in Section 1, between Arab states and other countries must be encouraged both at individual and institution level.

4. CONCLUSION

The paper is concluded with the remark that Arab countries have great potential to embark on challenging problems of science and technology, essential for their economic and scientific upliftment, through applications of emerging techniques and methods narrated in Section 1. In order to achieve efficiency to tackle economic and scientific development, the Arab states must initiate individual or collective time bound programmes mentioned in Section 3. It must be emphasized that unless a country or a group of countries are well equipped with appropriate scientific and technological knowledge having solid foundation they will be lagging behind in the race of development.

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[15] Publications and Website of SIAM Philadelphia (www.siam.org) particularly its deliberations during 50th anniversary conference July 2002, Philadelphia, USA.

Appendix-1

Author has served as a Professor in the Department of Mathematics, King Fahd University of Petroleum and Minerals (KFUPM) Dhahran, Saudi during 1998-2007 and currently engaged in two of its research projects as a consultant. He has also served as a Professor of Mathematics at the University of Constantine, Algeria during 1980-83. He has served as a Professor of Mathematics at the University of Tabriz, Iran during 1972-73. He served the Aligarh Muslim University as a Professor during 1978-1998 and held various administrative positions including Chairman Department of Mathematics, Dean Faculty of Science, Pro-Vice Chancellor and Acting Vice-Chancellor of the Aligarh Muslim University. He is associated with the International Centre of Theoretical Physics Trieste, Italy (UNESCO organization) since 1987 and he is currently its senior Associate. The author has visited a fairly large number of countries in the world including USA, Canada, China, Australia to deliver lectures and participate in conferences. He has supervised Ph.D. work of two dozen research scholars who are holding good assignments in different countries. He has experience of working with various committees related to educational systems of developing countries. He represents India at the International Council of Industrial and Applied Mathematics in the capacity of the secretary, Indian Society of Industrial and Applied Mathematics (ISIAM).