Development of Industrial and Applied Mathematics in India

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Abstract

India is well known in the world for its contribution to the ancient Mathematics and even people agree in different parts of the world that India has done very well in the areas of pure mathematics during contemporary time through the work of researchers at Tata Institute of Fundamental Research at Bombay and large number of universities in the different parts of the country. It is true that in contemporary time most of the educational centers of higher education in India mainly focus on pure form of Mathematics, Definition, Existence and uniqueness theorems, Lemma and corollaries. Mainly problems are direct/well posed (solution exists which is unique and stable). However, illustration of mathematical problems with physical phenomena or processes and interpretation of solution and its visualization or formulation of Physical phenomena in appropriate mathematical concepts are not emphasized in the teaching of Pure or Applied Mathematics.

For a long time people in this part of the world thought Mechanics and Relativity Theory are the only parts of Applied Mathematics. Fourier analysis, in particular, and Harmonic Analysis in general, Applied Functional Analysis, Numerical Analysis were not considered as part of Applied Mathematics till the eighties. Till early sixties only classical mathematics like special function, sequence and series, mechanics, geometry were taught in most of the educational institutions. Modern Algebra, Topology, Measure Theory, Functional Analysis, Approximation Theory Harmonic Analysis, Probability Theory, Mathematical Statistics, Graph Theory, Differentiable Manifold, Complex Analysis and their applications to Real World Problems have become popular in India due to various steps taken by Indian Government on the initiative of a group of talented Indians since the beginning of sixties. In this article emergence of Applied and Industrial Mathematics in India will be discussed. It is also interesting to note that many significant applications of mathematics to solve real world problems have been carried out by engineers and scientists. It is also heartening to observe that some Indians received very prestigious awards for applying mathematics in their work such as Nobel laureate Subrahmanyan Chandrasekhar (He was Ph.D. supervisor of late Prof. S.K. Trehan, a distinguished Indian Applied Mathematician and I had privilege to host him at my residence in early nineties), Prof. Srinivasan S.R. Varadhan, Abel Prize winner and recipient of US National Medal of Science (widely considered the panache of scientific achievement), Prof. C.R. Rao (FRS) recipient of US National Medal of Science and Prof. Thomas Kailath, recipient of US National Medal of Science, Prof. K.R. Sreenivasan, a member of the National Academy of Sciences, and National Academy of Engineering and a fellow of the American Academy of Science and Arts and former Director ICTP.

The article is divided into three parts. First part is devoted to the development of Applied Mathematics prior to 1960, the second part deals with development of the Industrial and Applied Mathematics between 1960-1990 (1990 is the year of establishment of the Indian Society of Industrial and Applied Mathematics). The third part contains status of Industrial and Applied Mathematics in different parts of India during 1990-2015, giving the details of how emerging areas have spread. We conclude the article by presenting an assessment of what has been achieved till now and what is to be achieved in future.

I. Development during 500-1960

The period: 500-1200 A.D. is the golden period of Indian Mathematics during which besides invention of zero and operation with it, the knowledge of mathematics was provided solid foundation [1,4,5,6]. Area or perimeter of the standard geometrical figures including surface area and volume of sphere were introduced by Indians during this period along with fundamental concepts related to Trigonometry and Algebraic equations. Some of those results were rediscovered by Euler and Lagrange in the 18^{th} century [1, p.477]. The period: 1201-1800 is treated as the period of commentaries of the earlier work and known for two major achievements, one for study of infinite series by Kerala School of Mathematics and other for the establishment of five big stone observatories in Delhi, Jaipur, Banaras, Mathura and Ujjain by Sawai Jai Singh (1688-1743). He got this work done under the guidance of Portuguese and Missionary in order to promote interest in observational astronomy. The Kerala School of mathematics developed expansion of sin ø and cos ø about two hundred years before Gregory and others.

Sir Autosh Mokherjee, is the first Indian Mathematicians (1864-1934) whose work includes pure as well as applied mathematics. His field of research includes theory of elliptic functions, Differential equations relating to different kinds of conics, and problems of hydro-kinematic equations relating to rotational and irrotational motions of fluids. He was elected fellow of AMS (American Mathematical Society) in 1900. He was the Vice-Chancellor of Calcutta University during 1906-14 and 1921-23. He got created first Chair of Applied Mathematics named, Ghose Chair of Applied Mathematics. It was offered to Professor Ganesh Prasad in 1914, who has proved himself as expert of both pure and Applied Mathematics. However, he joined Banaras Hindu University in 1918, Varanasi, where he motivated a young boy named Badri Nath Prasad to study Mathematics, now known as Prof. B. N. Prasad. Subsequently, he became a distinguished scholar who led directions in mathematics research for more than a decade. He died in Jan. 1966 at the age of 67 in Allahabad. He was elected President of the Indian Science Congress Association and presided its 1966 session (2^{nd} January to 10^{th} January, 1966). He was also nominated member of the Rajay Sabha (Member Upper House of the Indian Parliament, a unique honor for a mathematician by profession). He was expert of Fourier Analysis and several of his Ph.D. students like Prof. M.L. Misra, Prof. P.L. Bhatnagar, Prof. U.N. Singh, Prof. Jamil A. Siddiqi, Prof. T. Pati, Prof. Parmila Srivastav, Dr. S.R. Sinha, Dr. S.N. Bhatt, Prof. S.M. Mazhar etc. are renowned experts of their specialties. Prof. B.N. Prasad was closely associated with three reputed universities of India: Banaras Hindu University (BHU), Allahabad University (AU) and Aligarh Muslim University (AMU). His three Ph.D. Students, Prof. U.N. Singh (father of the present Vice-Chancellor, Delhi University, Prof. Dinesh Singh), Prof. Jamil A. Siddiqi (Supervisor of the founder Secretary of ISIAM Prof. A.H. Siddiqi) and Prof. S.M. Mazhar (it is mere coincidence that his Ph.D. student Prof. Niranjan Singh was my Ph.D. examiner) were associated with AMU and played significant roles in spreading Modern Mathematics and its applications in India, particularly northern part of India. To know further details about the contribution of Prof. B.N. Prasad, see [W2].

Contribution of Prof. B.N. Prasad, his research scholars, and research scholars of his research collaborators will be a major part of the Indian contributions in the Pure and Applied Mathematics during the last seventy years. In fact, he had taken the initiative in early sixties to establish a Research Institute of Mathematics in Allahabad on the pattern of TIFR, Bombay named Mehta Research Institute. Two illustrious Indian Applied Mathematicians, Prof. S.S. Shri Khande and Prof. P.L. Bhatnagar were its Directors. Later on this was shifted to a suburb, of Allahabad and named Harish Chandra Research Institute of Mathematical Sciences, managed by the Atomic Energy Commission, Government of India.

Ghose Chair was given to Sudhansu Kumar Banerjee in 1918, who was expert of sound waves of spherical surfaces. N.R. Sen was the third Ghose Chair holder who worked from 1924 to 1959. He has contributed a lot on Propagation of Waves in Canals and Elastic mediums, Heisenberg's Spectrum of turbulence, Isotropic turbulence, Equilibrium configuration of a Rotation Fluid. During his tenure, S.N. Bose (FRS, Padmabhusan for Bose – Einstein condensate, Bose-Einstein statistics quantum Mechanics, Bason), Meghnad Saha (Thermal Ionization equation, Stellar atmosphere) and Nobel Laureate C.V. Raman (he has made valuable contribution on new methods of kinematic theory, on new features of Fermat's law, quantum nature of light, scattering of light and its changing wavelength when passing through a transparent media leading to Raman effect) were also there. During 19th Century the Applied Mathematics comprised only classical and continuum Mechanics including Elasticity, Fluid Dynamics (both compressible and incompressible fluids), Rigid Dynamics and Transforms.

Between 1901 and 1960 several universities were established having well known Mathematics Department but with little focus on Applied Mathematics. These are Calcutta, Madras, Bombay, Allahabad, Banaras Hindu University (Varanasi), Aligarh Muslim University (Aligarh). Applied research in Mathematics got a boost in India by establishment of Indian Statistical Institute (ISI), in Calcutta in 1931 by serious efforts of P.C. Mahalanobis, Professor of Physics (FRS & D. Sc.). The publication of its Journal, Sankhya, in 1933 brought international fame to ISI. Illustrious applied Mathematicians such as Prof. C.R. Rao, Prof. S. Vardhan, G. Kallianpur who worked on Statistical Inference, Linear Models, Multivariate Analysis, Biometry, Functional equations, Probability theory, are product of this Institution.

II. Development in Applied Mathematics 1960-1990

Establishment of IITS, at Kharagpur, Delhi, Kanpur, Madras, Indian Institute of Sciences (at Bangalore) around 1960, Tata Institute of Fundamental research in Bangalore in the eighties and Indian Institute of Mathematical Sciences in Madras in sixties enhanced the pace of research in Applied Mathematics. Creation of posts of Professors of Applied Mathematics in some central Universities such as AMU in the seventies also provided impetus for teaching and research of Applied Mathematics in India. Some well known Applied Mathematicians of this period are Proefessors J.N. Kapur, P.L. Bhatnagar, S.K. Trehan, M.P. Singh, B.R. Seth, O.P. Bhutani, M.K. Jain, N. Rudraiah, H.P. Dikshit, Phoolan Prasad, S.L. Sachdeva, S.K. Malik, D.K. Sinha, S. Kesavan, S.S. Shrikhande, M. Dutta, Roddam Narasimha, C.R. Rao, G. Kallianpur, S. R. Varadhan, Harish- Chandra etal. Nobel Laureate S. Chandrasekhar, Alladi Ramakrishnan, S.N. Bose, Nobel Laureate C.V. Raman, Meghnad Saha can be considered as distinguished Applied Mathematicians.

1. **J.N. Kapur:** Jagat Narian Kapur obtained his Ph.D. degree (1957) from the University of Delhi. His area of specialization was applied mathematics. The major part of his career was spent at IIT-Kanpur, where he rose to be Professor and Head of the Mathematics Department; Vice-Chancellor, Meerut University; and Visiting Professor at IIT, Delhi University, Jawaharlal Nehru University, Carnegie-Mellon, Manitoba and Waterloo Universities. He has also been a INSA Senior Scientist (1987-89). Kapur made contributions to internal ballistics of guns and rockets, super possibility of fluid flows, non-Newtonian fluid flows, inlet length flows, compressible and hypersonic fluid flows, magnet hydrodynamics, heat transfer, population growth models, time-delay models, age-structured models, mathematical bio-economics, biomechanics, measures of information, maximum entropy models, pattern recognition, image thresholding, marketing, income inequalities, flexible manufacturing system, etc. He published more than 50 non-textbook documents, 45 books on mathematical education, 15 books on supporting materials, five

books on higher education, five research-level books and several others. Kapur was a recipient of GP Chatterjee Award of Indian Science Congress (1988); Distinguished Service Award of Mathematical Association of India (1985); Education Minister Gold Medal and National Academy of Sciences Distinguished Research Award. He was the **President of ISIAM** since its inception till the last days of his life. He was awarded Dr. Zakir Husain award in 2001. He has played a major role in spreading Applied and Industrial Mathematics in the Indian subcontinent.

2. **Prabhu Lal Bhatnagar:** (8 August 1912- 5 October 1976), the founder Professor and the Head of the Department of Mathematics at IISc, which was established in 1956 as the Department of Applied Mathematics. He was a mathematician, an astrophysicist and fluid dynamicist. The BGK (Bhatnagar, Gross and Krook) model proposed in 1954 became the most important model to solve the integro-differential Boltzmann equation (proposed by Boltzmann in 1872). In BGK model, the nonlinear collision term of the Boltzmann equation is replaced by a simpler term and the model makes the derivation of the transport equations for macroscopic variables much easier. He was awarded the **Padma Bhushan** by the President of India on 26 January 1968. After he died on 5 October 1976 at Allahabad, the Illustrated Weekly of India paid a tribute to him through an article on him by the well known science writer Jagajit Singh. He was closely associated with Prof. B.N. Prasad who provided a great inspiration to Indian Mathematicians and Mathematics see wikipeida for more details (https://en.wikipedia.org/wiki/Prabhu_Lal_Bhatnagar).

3. **Alladi Ramakrishnan:** (9 August 1923 – 7 June 2008) **was an Indian physicist and the founder of the Institute of Mathematical Sciences** (Mat-science) in Chennai. He made contributions to Stochastic Process, Particle Physics, and algebra of matrices, special theory of **relativity and quantum mechanics**. During the 1950s he worked on the problem of Fluctuating Density Field, and published a series of eight papers on the subject. During 1957-1958 Ramakrishnan visited the **Institute for Advanced Study** in Princeton. It was the Institute of Advanced Study that inspired him to start similar institution in India. Ramakrishnan is noted for his work in quantum mechanics on giving a prescription for transition from Pauli to Dirac matrices. He also published several papers giving simple but insightful geometric derivations for the Lorentz transformations see Wikipedia for more details (https://en.wikipedia.org/wiki/Alladi_Ramakrishnan).

4. **Roddam Narasimha:** He was awarded Padma Vibhusan in 2013 and Dr. Zakir Husain award in 2009. He is a world leader of Fluid Mechanics. He has supervised his Ph.D. work of a galaxy of eminent scholars including Prof. K.R. Sreenivasan fame Director of ICTP, Trieste, Italy, for details see W [16].

5. **Calyampudi Radhakrishna Rao: FRS** known as C R Rao (born 10 September, 1920) is an Indian-born **naturalized** American, **mathematician** and **statistician**. He is currently **professor emeritus at Penn State University** and Research Professor at the **University at Buffalo**. Rao has been honored by numerous colloquia, honorary degrees, and **festschrifts** and was awarded the **US National Medal of Science** in 2002. **The American Statistical Association** has described him as “a living legend whose work has influenced not just statistics, but has had far reaching implications for fields as varied as economics, genetics, anthropology, geology, national planning, demography, Biometry, and medicine”. **The Times of India** listed Rao as one of the top 10 Indian scientists of all

time. Dr. Rao is also a Senior Policy and Statistics advice for the **Indian Heart Association** non-profit focused on raising South Asian cardiovascular disease awareness.

6. **Sharadchandra Shankar Shrikhande:** (born October 19, 1917) is an **Indian Mathematician** with distinguished and well-recognized achievements in **combinatorial mathematics**. Shrikhande was a professor of mathematics at **Banaras Hindu University, Banaras** and the founding head of the department of mathematics, **University of Mumbai** and the founding director of the Center of Advanced Study in Mathematics, Mumbai until he retired in 1978. He is a fellow of the **Indian National Science Academy of Sciences** and the Institute of Mathematical Institute, USA for more details see Wikipedia(https://en.wikipedia.org/wiki/Sharadchandra_Shankar_Shrikhande)

7. **B.R. Seth:** He was a distinguished applied mathematician of his time who was appointed the head of Mathematics Department of IIT Kharagpur in 1951- the oldest IIT in India. His research scholars are spread all over India; trained fairly large number of students in Applied Mathematics. He was quite influential person of his time and held several important assignments. One of his favorite research scholars, Prof. O.P. Bhutani is actively associated with ISIAM, who was Dean, Postgraduate studies and Research of IIT Delhi. He has contributed a lot to the Flexure of a bar problem (Saint-Vanaut's problem, Transition theory to unify the elastic and plastic behavior of materials and continuum Mechanics.

8. **N. Rudraiah:** He is a distinguished Applied Mathematician and very active in research even at the age of 83. He has received several honors and awards. He was felicitated by ISIAM on August 2010 for his excellent contribution in Fluid and Biomechanics. For detailed contribution see [17].

9. **S.K. Trehan (1931-2004):** Prof. S.K. Trehan, after doing his M.Sc. From Delhi University, proceeded to the University of Chicago, where he had worked with Nobel Laureate Prof. S. Chandrasekhar for his Ph.D. in Plasma Physics. After spending a couple years as a Post-Doctoral Fellow at Princeton Plasma Physics Laboratory, he returned to work at Physics Department, Delhi University. He was an excellent teacher and guided a number of Ph.D. students both at the University of Delhi as well as at Department of Mathematics, Punjab University, Chnadigarh. He had worked at Goddard Space Flight Centre (GSFC), NASA, and had visited the High Altitude Observatory as well as Simon Fraser University, Vancouver, Canada a number of times. He was a Bhatnagar awardee and a fellow of Indian National Science Academy, Indian Academy of Sciences and National Academy of Sciences. He had served on several National Committees. Shockingly he suddenly passed away on September, 9 2004.

10. **S.K. Malik (Surender Kumar Malik, 1942-2007):** Surender Kumar Malik obtained his Ph.D. (1967) from University of Delhi specializing in applied mathematics, nonlinear phenomena, bifurcation theory and chaos. He served as Professor, Centre for Advanced Study in Mathematics, Panjab University, Chandigarh. Malik was a very active researcher of Magneto hydrodynamics, Magnetic Fluids and Chaos. He had obtained the long wave equation in magnetic fluids. He also investigated the long-short wave resonance interactions. The application of magnetic field decreases the domain of instability where this resonance occurs. He studied the nonlinear stability of electro hydrodynamic wavers in fluids resulting in solution. A weakly nonlinear theory of the evolution of two dimensional wave packets in the self-gravitating media is also studied

by him. Malik investigated the modulation instability in self-gravitating fluid column. He had shown greater ingenuity in obtaining a nonlinear Schrödinger equation, which is crucial in this study and finally, has shown the correlation of this work to the study of envelope soliton. He had also given the theory of the nonlinear breakup of self-gravitating column. The column breaks into main astronomical bodies and their satellites whose dimensions are sensitive to the wave numbers. This problem is of great importance in describing the phenomenon of condensation in the astronomical bodies. Professor Malik had also investigated the nonlinear dynamics instability of weakly joined plasma. Malik was among the first investigators to use the multiple scales in investigating non-linear stability problems for bounded systems. Some of his work had generated considerable interest in the literature. Malik received the SS Bhatnagar Prize (1985); Co-Chairman, International Conference on Continuum Mechanics and Its Applications, Canada (1989); UGC National Fellowship (1993-95). He was the Editor of INSA publications (1997-99).

11. **Om Prakash Bhutani:** Professor Bhutani has made significant contributions in the area of irreversible thermodynamics, with special reference to fluid flow analysis. He has also worked on the existence and formulation of variational principles, and exact solutions of nonlinear partial differential equations of physical and engineering systems via group theoretic methods. His studies on linear and non-linear wave propagation and stability analysis have resulted in qualitative and quantitative estimates of the coupling mechanism in such varied areas as magneto-gas dynamics, radiation gas dynamics, non-equilibrium gas dynamics, multiphase flows, and ocean dynamics. He has made significant contributions towards the existence and formulation of variational principles for various irreversible systems, and studied exact solutions of several of the nonlinear partial differential equations that arise in mathematical physics.

12. **H.P. Dikshit:** Ex. President, ISIAM: Ramanujan Birth Centenary Year Award of ISCA given by the Prime Minister of Indian in 2002 for contributions to Science, for more details see (https://siam-india.in/wp/associated-persons/108-2/)

13. **N.K. Gupta (Ex. President, ISIAM):** Works in the area of large deformations of metals and composites at low, medium and high rates of loading. His researches find applications in development of constitutive behavior of materials, understanding of the basic mechanics of large deformation, design for safety in defence applications and in design of metal forming processes. He has published his researches extensively in national and international journals, guided researches at Ph.D. and M. Tech. levels, and undertaken national and international research and consultancy projects, for more details see (http://am.iitd.ac.in/nkgupta.html).

14. **Subramanyan Chandrasekhar:** He shared the Nobel Prize of Physics in 1983 [W 26]. He is cited for his Mathematical theory of the physical processes of importance to the structure and evaluation of the stars for his Nobel Prize, for details see W [26] a & b.

15. **M.S. Narasimhan (Mudumbai Seshacharlu Narasimhan):** For detailed account of Prof. Narasimhan achievement, one can refer to website at S. No. 10 and references in External links mentioned there. He is the recipient of the Shanti Swarup Bhatnagar Prize, Third World Academy Award for Mathematics (1987) Padam Bhusan (1990) and the Arab World Nobel Prize for Science, 2006- King Faisal Prize (website at S. No. 11) (Shared with Simon Donaldson, Imperial College) see [W10, W11]. The basis of this

award is the relevance of his mathematical contribution to theoretical Physics surrounding index theory and gauge theory. As the founder Chairman of the National Board of Higher Mathematics, he promoted teaching and research in those areas of mathematics such as Sobolev spaces, Distribution Theory, Lie Groups, Variational Methods, Variational Inequities etc. which provide foundation for present-day Industrial and Applied Mathematics. He sanctioned three instructional conferences about one month each. One was held in April 1984 at IIT Kanpur, second at Kashmir University, Srinagar in June 1984 and third at TIFR, Bangalore in May 1985 (Indo-French Instructional and research conference). First two Instructional conferences were organized on the initiative of Prof. S.I. Husain of AMU and for third one initiative was taken by Prof. J. Boujot of Orllean University of France who was research scholar of Prof. J.L. Lions and had visited AMU on the invitation of Prof. A.H. Siddiqi. Several present day Indian Applied and Industrial Mathematicians benefited a lot from his efforts in India and by his endeavors while at ICTP, Trieste.

Prof. J.N. Kapur, Prof. S.K. Trehan and Prof. S.K. Malik, Prof. B.R. Seth, Prof. S.K. Sinha worked hard to develop Applied Mathematics in the North and Eastern Part of India. In 1980 the government of India paid special attention to Mathematics and appointed Prof. D.N. Misra as an advisor in the CSRI to highlight the application of Mathematics to Science and Industry. It provided momentum to the Research in India. Subsequently Prof. Misra, who was very much enthusiastic to work more for Mathematics and its application, was appointed Vice Chancellor of the Banaras Hindu University, Varanasi (one of the largest residential university in India).

III. Development during 1990-2015:

Message of Industrial Mathematics in India mainly reached through Professor Helmut Neunzert, founder of one of the biggest Institute of Industrial and Business Mathematics at Kaiserlartern, Germany through his academic activities at ICTP, Trieste, Italy during 1988-1989. A beautiful account of development of Industrial Mathematics in developed and developing countries is given by Neunzert and Siddiqi [11]. N. G. Bartor [3], Director ICIAM 2003 at Sydney in a very interesting paper presents his observations in a structured form, which looks at past, present and future prospective, both for Australia and the world. Here a brief report is presented on the activities of Industrial and Applied Mathematics in the last 25 years in different parts of India. Prof. Abul Hasan Siddiqi (A.H. Siddiqi) was appointed Professor of Applied Mathematics in April 1978 in the main department of Mathematics of the Aligarh Muslim University (This was famous for research in pure Mathematics; Prof. Anodre Weil, Prof. S.M. Shah, Prof. Jamil A. Siddiqi, Prof. Q.I. Rehman, Prof. D.N. Kusambhi, Sir Ziauddin, Prof. U.N. Singh, Prof. P. N. Misra, J.S. Rastogi, T. Husain et al were among its faculty members), through a selection committee comprising three stalwarts of Applied Mathematics of that period in India and chaired by a distinguished economist (Prof. A.M. Khusro) who was subsequently appointed as Indian Ambassador to Germany and Member Planning Commission, Government of India. At the time of his appointment an assurance was taken from Prof. Siddiqi to introduce and popularize those areas of mathematics which are very much used in developed countries to solve real world problems. After joining, he set a mission to popularize those topics not in AMU but to the entire country. During his stay in Algeria 1980-1983 at Constantine University as a professor under Indo-Algerian accord he met Prof. L. Tartar (University of Paris), late Prof. (Ms.) J. Boujot (Orlean University, France) and Prof. R. Lozi (CNRS, Nice). From them he enriched his

knowledge of several areas like PDEs, Homogenization, Variational Methods including Variational Inequalities, Quasi Variational inequalities, Vector optimization, optimal control, Bifurcation Theory, Fractal and chaos. He tried to propagate studies and research in these areas through workshops, symposiums and conferences. His effort was boosted by financial support of the International Centre of Theoretic Physics Trieste, Italy (UNESCO organization), Council of Scientific and Industrial Research (CSIR), DAAD (German Academic Exchange Programme).

Indian Society of Industrial and Applied Mathematics was established under the inspiration of reputed German Industrial and Applied Mathematician, Prof. Dr. Helmut Neunzert, recipient of SIAM Pioneering Prize (shared with Coifman) in 1999. He was introduced to the Indian subcontinent by Prof. A.H. Siddiqi. He trained fairly good number of Industrial and Applied Mathematicians who are occupying good positions in different parts of India and abroad such as Prof. Sunder, IIT Madras, Dr. Akhtar Khan, Rochester Institute of Technology, USA. Several well known scientists of IIT's and IISc were visiting his Institute regularly. He himself has visited and has organized academic activities in various parts of India, namely AMU (Aligarh), JMI (Delhi), Jamia Hamdard (Delhi), IIT Roorkee (Roorkee), IISc (Bangalore), IIT Madras, IIT Bombay, M.S. University (Vadodra).

A brief history of ISIAM can be seen at [W 12]. It has organized 12 Biennial Conferences and several workshops and mini-symposiums in ICIAM (1999-2015). The list of invited speakers in ISIAM conferences, workshops and Mini-symposiums includes Professor H. Neunzert, K. R. Srineevasan, R. Lozi, M. Brokate, S. Kesavan, P. N. Srikant, Adimurti, G.D.V. Gowda, Phoolan Prasad, Karmeshu, Rudraiah, N.K. Gupta, D.K. Sinha, M.P. Singh, O.P. Bhutani, G.C. Sharma, V.P. Saxena, V.S. Rekhi, J.B. Shukla, A.K. Pani, V. Singh, U.P. Singh, R.T. Rockfellar, A. Bensousan F. Schipp, M.B. Mathur, Anand Jagota, T. Husain, W. Zalesko, W.O. Oettali, N.I.M. Gould, Phillip L. Toint, Evans, L.M. Sanchez, S.A. Saxon, C. Mohan, M. Rasulova, M. Kumar, J.N. Kapur, Dr. Mashelkar, Engle, Schachermayer, P.C. Das, R.S. Pathak, P. Achutan, Prabha Mani, R. Patil, D. Singh, K.R. Paradasni, P.L. Butzer, M. Zuhair Nashed, N.G. Barton, Graeme Fairweather, H.D. Mittelman, J.R. Higgins, R.C. Stens, M. Kocvara, Zafer Aslan, M. Chapman, K.M. Furati, I.S. Sloan, Alain Arneodo, P. Markowich, K.R. Sreenivasan, N.K. Govil, S. Fridli, Roddam Narasimha, R. Jeltsch, O. Christensen, A. Zayed, I.S. Duff, M.H. Gutknecht, S.R. Hashim, D.P. Agrawal, Alemdar Hasanoglu, Nekka Fahima, Bhola Ishwar, Mesaoud Boulbrachene, D.N. Arnold, Barbara L. Keyfitz, Alistair Fitt, Pavel Exner, H. Okamoto, U.B. Desai, V. Mehrmann, Andreas Griewank, Alian Damlamian, Peter Maass, Ranjan K. Malik, Arvind Gupta, K. Aoyama, S.A. Messaudi, N.A. Sontakke, N. Singh, V.K. Kukreja, H.G. Feichtinger, Maria Farge, Osman Ucan, S.P. Singh, S. Sunder, P. Singh, N. Singh, Nassereddin Tatar, P. Kandaswamy, L.P. Rai, H.G. Sharma, Khalil Ahmad, R.K. Mohanti, Krishan Lal, Moinuddin, D.K. Chaturvedi, Stephen Didas, Venkateswaran, P. Krishnan, Gaik Ambartsoumian, S.P. Chakarabarty, Maria Skopina, Y. Farkov, D. Walnut, G. Pfander, Siraj Hasan, Majaz Moonis, Mushahid Husain, Manjusha Majumdar, B. Bhasker Bhattacharya.

In 2002, Prof. A.H. Siddiqi, Prof. S.K. Dube, Prof. Phoolan Prasad were honored as well known Indian Applied Mathematician by a Committee chaired by Prof. J.N. Kapur during a conference at Netaji Subash Chandra Bose Institute of Technology Dwarika Delhi while in August 2010, Prof. N. Rudraiah, Prof. Phoolan Prasad, Prof. S.

Kesavan and Prof. U.P. Desai were honored as distinguished applied mathematician of India by ISIAM.

ICM 2010 was held in Hyderabad during 19-25, 2010. The organizers, especially Prof. M.S. Ranganathan and Prof. S. Kesavan were kind enough to help ISIAM to organize the Satellite conference of ICM 2010: Mathematics in Science and Technology, (Mathematical Methods, Models and algorithms) in Science and Technology during 14-17, 2010. International Council of Industrial and Applied Mathematics (ICIAM) was kind enough to hold its annual meeting on 14th August, 2010 at India Habitat Centre, New Delhi, 27 members representing all developed countries and developing countries like Brazil, China, Singapore and India attended the meeting. Perhaps it was the first occasion that so many distinguished Applied Mathematicians were present in New Delhi for this meeting and the Satellite Conference.

The ISIAM has a joint project with Springer to publish books under the series Industrial and Applied Mathematics since 2014. There are already four volumes in this series visit http://www.springer.com and other four are expected. The society is publishing a journal since 2004 named Indian Journal of Industrial and Applied Mathematics. The editorial board comprises distinguished Indian Academicians and experts from different countries of the world.

Dr. Zakir Husain Award: Dr. Zakir Husain, the Third President of the Republic of India had a special relationship with the Duty Society, Aligarh Muslim University, a voluntary organization established in 1889. To pay its humble tribute to his valuable services to the Society the functionaries and life members of this society have instituted an award in the memory of Zakir Sahib to be given to an academician of international repute and standing for his valuable services to ISIAM and contributions in promoting the teaching and research in applications of mathematics to solve real world problems.

Recipients of Dr. Zakir Husain award are:

1. Prof. J.N. Kapur

2. Prof. H. Neunzert

3. Prof. K.R. Sreenivasan

4. Prof. R. Narasimha

5. Prof. H.P. Dikshit

6. Prof. M.Z. Nasshed

\ 7. Prof. U.B. Desai

8. Prof. R. Lozi

9. Prof. A. Adimurthi

The history of ISIAM will be incomplete without mentioning the valuable services to ISIAM rendered by Prof. U.P. Singh, Ex. President Indian Mathematicial Society and Ex. Vice-Chancellor, Purvanchal University. He was Chairman of the Silver Jubilee celebration committee of the society and due to his efforts, Shri Rajnath Singh, Hon'ble Home Minister of India was the chief guest of the main function.

M.C. Joshi [W23] and A.K. Pani [W24] of IIT Bombay have done very good job in spreading Industrial and Applied Mathematics in western part of Indian. Prof. S. Sunder of IIT Madras is a favorite research collaborator of Prof. Helmut Neunzert who has helped fairly good member of Indian students to learn this field. Ramanujan Mathematical Society is also encouraging to learn new aspects of Applied Mathematics, for example Financial Mathematics. IIT Guwahat, particularly Siddartha P. Chakrabarty is interested in financial Mathematics and trying to propagate this emerging field. Prof. A Adimurthi and Prof. G.D.V. Gowda, TFIR CAM have played very significant role in enrolling more than 150 members of ISIAM from prestigious institutions in India.

I conclude this article by citing extracts from

A. Foreword [14] by K.R. Sreenivasan
B. A paper by H. Neunzert and A.H. Siddiqi [11]
C. A paper by N. G. Barton [3]

A. Extracts from K.R. Sreenivasan foreword: "Thanks to Professor Siddiqi, I got involved in this society, ISIAM. Owing to the efforts of the office bearers of this Society, which includes Professors Siddiqi, Gupta, Dikshit, Manchanda and others, from the past, the scientific meetings of ISIAM are constantly improving: the invited talks are usually first rate, the Dr. Zakir Husain awards are of high caliber…….. . However, Applied Mathematics is still not yet a well-organized and well-knit community within the country, in comparison with its importance. The participation of the members of this community in the technological development within the country is yet to reach a critical level; and applied mathematics graduate students, whose numbers seem to have increased recently, do not find satisfying jobs quickly enough. Applied Mathematics in India has not yet made central contributions to the grand challenges of our times: climate change, new materials, energy, problems of mega cities, ground water depletion, spread of infectious diseases, ever-changing economic environment, security, etc.

Please don't get me wrong or think of me as being overly critical. I believe that there are accomplished applied mathematicians in this country. Indeed, ISIAM has itself honored a number of them including some at this meeting. There are also some first-rate students in applied mathematics. My point is simply that the quality is not sufficiently uniform, visibility too low. We should strive to improve the situation on all fronts.

The first important need, however, is the spirit of learning, of placing one's own work as part of a bigger landscape. Hardly are great things possible without this spirit and hard work-especially in mathematics. While it is not possible to do good Applied Mathematics without knowing Mathematics, it is not enough to know good Mathematics; one has to move in circles where applications present themselves as opportunities. The second important element is to ensure that there is adequate support for younger researchers. This is where ISIAM can and should do more."

B. Extract from H. Neunzert and A.H. Siddiqi paper [11]: Only recently the 3rd world began to receive the message of Industrial Mathematics. Therefore, there is an acute shortage of properly educated mathematicians. There are of course, some excellent pure mathematicians and quite a member of good applied mathematicians in the traditional British sense. But their work is mainly method driven (I do what I am able to do), but not problem driven (I do, what should be done").

Academic careers make this attitude necessary: One has to belong to a scientific family (even if it is very small), one has to publish (even if it is a generalization of a generalization) in order to be promoted. Who dares to work on a modeling problem, when he/she does not know, which kind of mathematics is needed, what the result will be, where it should be published, who (besides may be a company) will be interested in? However: Real career jumps need surprising results, new problems and new ideas – all that could not be expected without taking a risk! Moreover, senior professors do not need a security belt when working on new problem; they could go ahead and give the young scientists a chance and some credit to work on industrial problems. Governments press scientist to contribute to the economic welfare of the country. Does this really mean a cultural loss? Once more: The very few very best have some right to maintain that – and it is the duty of the many others to protect them, to protect them by proving that their ideas and mathematics as a whole is one of the most useful and valuable technologies.

C. Extract from N.G. Barton [3]: Mathematics-in-Industry initiatives around the world.

It identifies 5 distinct phases:

(i) Pure Basic research

(ii) Applied basic research

(iii) Applied research

(iv) Experimental development

(v) Commercialization

Universities are heavily involved at the research and of the R& D spectrum (stags 1-2), Private companies exploring mathematicians usually operate at stages 4 or 5, while government laboratories occupy the middle ground, mainly stage 3.

7. What lies ahead? General trends for the future, I expect intense research in medicine (genetics, disease managements by gene-technology, gerontology, the brain), and into human factors (population growth, epidemiology). Mathematics is already playing a role in these fields and I expect increasing mathematization. There will undoubtly be exciting new fields that will open up and demand the best technology, including mathematical technology. Nano-machines and genetically modified materials are good examples.

8. Predictions for less developed countries in the 21st century Dare I make prediction for future role of mathematics in the technological development of 3rd world countries? One hopes mathematics might provide support (such as optimization, data analysis, and mathematical and statistical modeling) for

- Industries in which there is local competitive advantage (mining, lumber, agriculture)
- For tourism based on indigenous attractions
- Exploitation of niches not occupied by multinational companies
- Stabilization of population growth
- Improved management of contagious including AIDS

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