*The Magical World of Mathematics – The Charm, Challenges and Career Prospects**

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Introduction

1. Dr. Rajeeva Karandikar, Director, Chennai Mathematical Institute; Dr. Mrs. J.K. Phadnis, Principal of the VES College of Arts, Science and Commerce; Prof. Amiya Kumar Pani, Chair Professor, Department of Mathematics, IIT Bombay; Mrs. Dipta Dasgupta, Convener of this conference aptly titled 'Mathemight', faculty members; other distinguished speakers and student participants; ladies and gentlemen. I am delighted to be here today in the midst of eminent scholars and students of mathematics. The Vivekananda Education Society has successfully completed fifty years in its 'Pursuit of Excellence in Higher Education' and I congratulate the Society on this achievement. I understand that the Society is organising frontline seminars and conferences for our younger generation to sow the seeds of curiosity and to enhance their knowledge base. You may recall that this year, we are celebrating the 150th birth anniversary of Swami Vivekananda, one of the greatest spiritual leaders of India. He once observed: 'you know how many sciences had their origin in India. Mathematics began there. You are even today counting 1, 2, 3, *etc.* to zero, after Sanskrit figures, and you all know that algebra also originated in India.' It is, therefore, very appropriate that the college, which is named after Swami Vivekananda, is organising this conference on Mathematics coinciding with the 150th birth anniversary of Swami Vivekananda.

2. This conference is most appropriately timed for several reasons. First, the year 2013 has been designated by the International Mathematical Union as The Year of Mathematics of Planet Earth. Second, we have recently celebrated the 125th birth anniversary of one of India's greatest mathematics geniuses, Srinivasa Ramanujan (1887-1920). Ramanujan's true legacy is the demonstration of how a humble, untutored village boy, with sheer passion, inspiration and inherent talent, rose to become one of the world's greatest mathematicians. From this perspective, this conference is perfectly positioned to create awareness amongst the undergraduates about the collaborative nature of mathematics, technology, commerce, science and social sciences and the vast opportunities that mathematics can offer. In this background, I plan to talk briefly about the attractions of mathematics, the need for studying mathematics, its applications, the challenges in mastering the subject, prospects it holds for those who pursue the discipline and about the risk of misusing mathematics.

Mathematics, the Prince Charming

3. What is Mathematics?

a. The word itself comes from Greek *'Mathema'* meaning knowledge, study, learning.

b. There seems to be no consensus among professionals on the issue of defining what Mathematics is. In fact, you will be surprised that there is even no consensus on whether it is an art or a science.

c. Definition-wise, there are three sets of definition that I am aware of :

   i. Logicist: Benjamin Pierce's 'the science that draws necessary conclusions', or Russell's 'all mathematics is symbolic logic'.

   ii. Intuitionist: From the philosophy of Brouwer 'Mathematics is the mental activity which consists in carrying out constructs one after the other.'

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iii. Formalist: Identifying mathematics with all its symbols and the rules for operating on them

4. Mathematics is, perhaps, the oldest of sciences that has existed, developed and matured in either explicit or in latent form over thousands of years. The concept of numbers was not only known to prehistoric man but may also be known to animals. For example, when lions hear a neighboring pride roaring, they calculate how many lions are roaring compared to the number of lions in their own pride. If there are more lions in their own pride, or the numbers are equal, or the other pride outnumbers them by up to three to one, they will always roar back. If the other pride outnumbers them by more than three to one, they stay quiet. Most animals would know the difference between a bowl containing 4 apples and one with 8 apples or even the fact that there is something common between 4 apples and 4 oranges.

5. The beauty and charm of mathematics has lured, intrigued and inspired countless geniuses across the globe to spend sleepless nights in the hope of unraveling its mysteries. Why have the seekers of knowledge been attracted to mathematics from time immemorial? I feel the primary charm of mathematics is that it is both interesting and, if you can crack its intricacies, enjoyable. People like its challenge, its clarity, and the fact that in solving problems of mathematics you know when you are right. The study of mathematics can satisfy a wide range of interests and abilities. It helps develop one's imagination and aids in building a clear and logical thought process.

6. Let me share with you an example to illustrate the charm of mathematics. It is a well-known story about Ramanujan and his mentor, another famous mathematician, Prof. G. H. Hardy, who recognised his immense talent and took him to England. At one point of time, Ramanujan was unwell and lying in an England hospital where Hardy had gone to visit him. Hardy told him that he came in a taxi, the number plate of which had a most uninteresting number 1729. Ramanujan was very quick in his reply. He said it was one of the most interesting numbers that one came across. It is the smallest positive integer, which can be written as the sum of two cubes in two different ways, *viz.*, $(12)^3 + (1)^3$ and $(10)^3 + (9)^3$.

7. Prof. C. R. Rao, one of the most outstanding mathematicians in the world, once said, 'All sciences are, in the abstract, mathematics', which aptly captures the immense contribution of mathematics towards the development of other sciences. Perhaps, recognising this centuries ago, Gauss termed Mathematics as the 'Queen of all Sciences'.

Why Study Mathematics ?

8. Just type the words 'why study mathematics' in a Google search and you will get around 67 million results – these many people, institutes or articles trying to see the benefits of studying mathematics. Study of Mathematics is extremely important for many reasons. Maths surrounds us in many ways as we go about our everyday life. Let me now tell you why you should study mathematics:

a. Mathematics makes life simple by quantification. Numbers, units and dimensions help in comprehending things better and lead to precision and certainty in measurement and expression.

b. It helps formulate as well as establish measurement standards in respect of observable phenomena.

9. Take some simple examples:

a. 'Ajay is tall or Ajay is strong' – What do you make of such statements. It will make sense when we compare with some benchmark or measure and quantify it. Only then do we know what is tall or what is strong. Then things become precise.

b. Suppose your parents tell you, 'You have to study very hard' or 'you have to study very very hard' – do these sentences make much

sense? Yes, they certainly make. But, I am sure, 'you have to get 80 per cent marks' is something which will give you greater focus as the goal is unambiguously stated.

Mathematical concepts like measurement, which were applicable earlier only to physical sciences, are now being made use of in social as well as biological sciences too.

10. Turning to more formal discussion, one of the important features of a scientific investigation is its fixation with putting numbers to things, by quantification using mathematical formulae. Often, scientific work is judged more by the quality of its mathematics than by its empirical content. Let me quote what James Clerk Maxwell said 'All the mathematical sciences are founded on relations between physical laws and laws of numbers, so that the aim of exact science is to reduce the problems of nature to the determination of quantities by operations with numbers.'

11. Let me cite some classical examples.

i. First one relates to modeling of astronomical data, whereby you may recall how logarithmic tables were found useful for analysing centuries of astronomical observations collated by Tyco Brahe and put to use by Johannes Kepler to form the basic laws of Planetary motion in the early 1600s. Kepler's three laws of planetary motion are: (i) The path of the planets about the sun is elliptical in shape, with the center of the sun being located at one focus (The Law of Ellipses). (ii) An imaginary line drawn from the center of the sun to the center of the planet will sweep out equal areas in equal intervals of time (The Law of Equal Areas) and (iii) The ratio of the squares of the periods of any two planets is equal to the ratio of the cubes of their average distances from the sun. (The Law of Harmonies). It is the third law that involves difficult exponentiation of squares and cubes, which does not yield easily to the naked eye when the actual data are observed. Many would know how later Newton's universal law of gravitation could be found equivalent to Kepler's laws of planetary motion. But it is also no less magical that Kepler's Third Law of planetary motion can actually be traced back to Napier's invention of logarithms (1614), which is supposed to be the main force to derive the postulate about the third law almost twelve years after the establishment of the first two laws.

ii. Second, I would like to cite the Mendel's law of segregation of Hereditary Characters (1866), which was rediscovered at the beginning of the last century, without which, Darwin's theory of evolution could not be explained statistically. Here, I would also like to underscore that statistics is a major branch of mathematical science but with a difference. Math seems to be providing rigorous base for deterministic, logical framework of establishing truth whereas statistics comes out of measurements and observations with errors.

iii. The third one is the now well-known work of the French Mathematician, Louis Bachelier on the study of finance, which is treated historically as the first of its kind. His Ph. D thesis on the Theory of Speculation (1900) is credited with being the first such work on the phenomenon of Brownian Motion that was, much later, put into use to evaluate stock options.

iv. In modern times, majority of the financial mathematics driven formulae behind pricing of different financial assets are testimony to how they can be both used and abused if not verified rigorously based on real life data.

The above examples relate to close approximation to reality with the help of mathematics, but based on well-established quantifications and measurement standards.

12. Whether we deal with mechanical, electrical or electronic objects such as the light, fan, TV, car, bicycle or computers – understanding their functioning calls for use of mathematics. We all perform tasks ranging from simple arithmetic to complex computations as we deal with money, deposits, insurance, income tax, and so on. Today's society would not be in existence without the application of mathematics. In The Republic, the great Greek philosopher Plato presented a profound argument for why mathematics should be required for all high school and college students. He argued that mathematics and geometry teach problem-solving skills and an ability to analyse and think. It is also important to study mathematics because it gives one a different perspective on things. Learning mathematics involves a different type of thinking that is not addressed in other subjects.

Applications of Mathematics

13. While we all have some familiarity with the everyday uses of the elementary aspects of mathematics, there are far more advanced and complex phenomena in almost all fields of science, where mathematics is widely used, but often in an unseen and unadvertised way. Let me give only a few examples of diverse applications of mathematics:

i. Travel by airplane would not have been possible without the mathematics of airflow and control systems.

ii. The spaceships' journey to the planets could not have been calculated without the mathematics of differential equations. The stunning pictures of far away planets sent by Voyager II could not have had their crispness and quality without mathematics.

iii. The advances in development of supercomputers is backed by the application of mathematical theory which instructs the computer on what is to be done, thereby allowing it to optimally utilise its capacity for speed and accuracy.

iv. The next generation of software requires the latest methods in Category Theory, a theory of mathematical structures which has given new perspectives on the foundations of mathematical logic.

v. Mathematical methods provide the backbone of Statistical theory and methodology for the analysis of wide varieties of data in Economics, Banking, Finance, Physical Sciences, Genetics, Biology, and so on.

vi. Body scanners are the expression of subtle mathematics, which makes it possible to construct an image of the inside of an object from information on a number of single X-ray views of it. Thus, mathematics is often involved in matters of life and death.

14. These applications have often been developed from the study of general ideas for their own sake: numbers, symmetry, area and volume, rate of change, shape, dimension, randomness and many others. Mathematics makes a special contribution to the study of these ideas, namely, the methods of (a) precise definitions; (b) careful and rigorous argument; representation of ideas by many methods, including symbols and formulae, pictures and graphics; (c) means of calculation; (d) obtaining precise solutions to clearly stated problems, or clear statements of the limits of knowledge. These features allow mathematics to provide a solid foundation to many aspects of daily life, and to give a comprehension of the complexities inherent in apparently simple situations.

15. However, while mathematics is applied to both physical sciences and social/biological sciences, there are certain differences in the application of mathematics to the two areas. As physical sciences are more exact in nature, mathematics can be readily

applied to them. However, social/biological sciences are more uncertain and involve elements of errors. Hence, statistics and probabilities find greater application in these areas. You, as students, have to decide on the area which is of greater interest to you and pursue knowledge and excellence in that area.

Maths in Indian Context

16. What is India's contribution to the subject of Mathematics? Let me refer to an old song from the movie 'Purab aur Paschim' (lyrics: Indeevar and others) picturised on the celebrated actor Manoj Kumar, ' ……Bharat ka rahne waala hoon, Bharat ki baat sunaata hoon….' – how many of you have heard? I am sure all of the speakers here and even the teachers. The song has some excellent lines depicting India's contribution to the subject of Mathematics. The lines are as under:

''जब जीरो दिया मेरे भारत ने, भारत ने मेरे भारत ने,
दुनिया को तब गिनती आई,
तारों की भाषा दुनिया को , भारत ने पहले सिखलाई ।
देता ना दशमलव भारत तो, यूँ चांद पे जाना मुश्किल था,
धरती और चांद की दूरी का, अंदाजा लगाना मुश्किल था ।''

Loosely translated, extolling the contribution of India to the field of mathematics and astronomy, the protagonist conveys that 'It was only with the invention of zero by Indian mathematicians that the World could get its number system. Also, without India's contribution to the decimal system, it would not have been possible to fathom the distance between Earth and the Moon or to manage a voyage to the Moon'.

17. It is necessary to reminisce about the past heady days of Indian mathematics, beginning from the Vedic period. The ancient Vedas (synthesised about 5,000 years ago) contained Vedanga Jyotisha comprising three parts, one of which pertains to basic math about arithmetic, algebra, geometry, trigonometry and equations (Sameekaran). India's primacy in establishing the foundations of math is widely accepted among the scholars and practitioners in math. It is apt to note what the famous French mathematician Laplace (1749 – 1827) had remarked: 'It is India that gave us the ingenious method of expressing all numbers by means of ten symbols, each symbol receiving a place value position as well as an absolute value. The idea escaped the genius of Archimedes and Apollonius'. While the Indian system of counting has been the most successful intellectual innovation ever made, the most intelligent invention is that of zero, the inclusion of which added much needed wholeness and completeness to the system of natural numbers and for making it the very basic building block of the real number system. Unfortunately, the rich heritage and achievements of our ancient and pre-medieval Indian mathematicians were sort of rediscovered and then reintroduced from the West in the regular curricula on mathematics.

18. It is, indeed, very saddening to note that for the past 2000 years India's contribution in the field of mathematics has been negligible. We should not rest on our past laurels and allow complacency to set in. We need to re-establish our position of pre-eminence in the area of mathematics and mathematical research by contributing new thoughts and concepts to the body of knowledge on mathematics. Our students and teachers of mathematics and others associated with the academic world have to contribute significantly to make it happen.

Mathematics is challenging

19. One should, however, remember that mathematics is also one of the most challenging disciplines. It calls for special skills and mental ability to visualise the mysteries of the universe through abstract patterns, symbols, structures and formulae, which is mathematics. As Galileo said many centuries ago, 'The great book of nature can be read only by those who know the language in which it was written. And that language is mathematics.'

20. I must add a word of caution here. I believe that you must have the necessary aptitude for studying

higher mathematics. In case you do not have the numerical aptitude and liking for numbers, please do not pursue higher studies in mathematics.

Mathematics as a Career Option

21. Those who qualify in mathematics are in the fortunate position of having a wide range of career choices. Their abilities (i) to use logical thought; (ii) to formulate a problem in a way which allows for computation and decision; (iii) to make deductions from assumptions; (iv) to use advanced concepts, are all enhanced by a mathematics degree course. It is for this reason that mathematicians are increasingly in demand. With a mathematics degree, you should be able to try your hand in banking and finance, statistics, engineering, computers, teaching, econometrics, biometrics, or accountancy with a unique edge that may not be available to those graduating in other streams.

22. Thus, one of the benefits of studying mathematics is the variety of career options that open up. A recent survey has shown that graduates in mathematics and computer science were at the top of the earning lists, six years after graduation. In one such study in The Wall Street Journal (2009) on the best and worst jobs in the US, it was observed that the top three out of the best two hundred jobs listed in order of income and other factors were careers suited for math majors, namely, mathematics, actuary and statistics. Besides other favourable conditions like indoor working conditions and places free of toxic fumes or noise, the study also considers pay, which was determined by measuring each job's median income and growth potential. Another recent survey shows that the top 15 highest-earning college degrees have a common element: mathematics.

23. Some of the preferred career options for students of mathematics are: (a) Mathematics proper as teaching assignment as well as research in the theoretical aspects; (b) Actuarial science that develops applied tools using mathematics and statistics and using them in finance and insurance; it includes a number of inter-related disciplines, including probability and statistics, finance, and economics; (c) Computer science, based on the theoretical foundations of computation and their implementation and application in computer systems. Students of maths, with their training in logical and precise thinking, are highly prized in this field. (d) Operations research, developed as an interdisciplinary branch of mathematics to arrive at optimal decisions to problems in maximising or minimising things like costs or profits. (e) Biomathematics or mathematical biology, also an interdisciplinary field of study that helps in modeling natural and biological processes using mathematical techniques and tools. Results have been applied to areas such as cellular neurobiology, epidemic modeling, and population genetics. (f) Cryptography is the practice and study of hiding information. Cryptography is considered to be a branch of both mathematics and computer science.

24. While applied mathematics is appreciated and understood by many people, pure maths is considered very elitist. Another career and research prospect that has got tremendous boost of late is computation based analysis, which many purists do not accept as mainstream mathematics. Actually, many IT professionals who joined in the big leap of Silicon Valley revolution in the last couple of decades are now increasingly finding this job of analytics more rewarding and challenging.

Where Math can help in Central Banking

25. Two important areas of application of Mathematics, more specifically Statistics, are economic modeling and forecasting, and financial mathematics. Central Banks around the world are engaged in developing a suite of modern macroeconomic/ econometric models of the economy as a basis for informed macroeconomic, monetary, financial sector and fiscal policy decisions. It is now of critical importance, particularly, in light of the current challenges facing the economy. The importance of

modeling macroeconomic variables has become all the more critical because macroeconomic policy formulation needs to anchor its functional role in developing a full understanding of the economy as well as influencing domestic policy formulation in a logical framework.

Let me explain what is modeling and why it is important:

It is trying to study and analyse different phenomena. For this – you have to quantify the phenomenon so as to be able to relate to them. For example, how much space does a box contain?

We know volume = length X width X height and as the length, width and height can be measured, we have a simple model to represent the space inside a box.

26. Financial mathematics is a relatively new discipline, rooted in modern economic thought, yet steeped in the classical intellectual disciplines of chance and uncertainty. Tracing its origins to the early 1970s, and maybe more so, to the introduction of the personal computer, financial engineering's early triumphs include the development of structured mortgage-backed securities (now the biggest bond market) and a rationale for option pricing – the consequences of which are totally pervasive in modern investing, the markets, and finance. Central Banking job has been made much more challenging because it needs to understand, may be ahead of others in a forward looking framework, the finer aspects used to construct and deploy the financial transactions and processes. These are the mechanisms enabling the creation/employment of wealth and for the worldwide distribution of well-being within the constraints and intent of global financial policy.

27. Modeling exercises in macroeconomics have been rendered more complex and arduous because of complexities and nonlinearities displayed by behavioral aspects of economic agents. The traditional economic models depended heavily on linearisation of complex economic behaviour expressed in simple mathematical terms.

28. Like much of engineering, financial mathematics constructively uses fundamental mathematical and scientific principles with professional practices to yield products and processes. Rather than trying to understand the socio-economic interplay of wealth and well-being, financial mathematics considers a flow of cash (the cash-flow): its exchange, its contingency, and its value both in a relative and an absolute sense. These could be from the standpoint of the investor (central bank, insurance company, mutual fund, for example), a Wall Street dealer, a global bank, or a hedge fund. The flow of cash could be packaged as a stock, bond, option, swap, or exchange of currency.

29. Unlike positive sciences like physics and chemistry, one has to take a lot of care when dealing with behavioural sciences like economics and finance. Lots of measurement and benchmarking issues come up, particularly, in the modern complex world of business and commerce that await proper quantifications and standardisation with precision and rigor. Many would have read how floating of risky financial products, not tractable by the established norms of controllable behavioral norms, jeopardised functioning of markets and the global economy. With the expanding scope of business and finance, demand for mathematical acumen and empirical analyses have become ever increasing. However, we need to guard against utter predominance and capture of the finance profession by the students of mathematics.

Problems with numbers – Life in a Central Bank is as challenging as is the real life

30. Now that I have shared with you the uses of mathematics in Central Banking, let me also discuss some challenges/difficulties that the 'use of numbers' pose in our day-to-day office work *vis-à-vis* the general perception prevalent in the public domain due to improper interpretation of maths. Let me give three examples:

a. **Gold Purchases:** You may have come across news reports about the large current account deficit facing the country and the large import of gold being one of the important reasons for this. We often hear the argument that people buy gold as a hedge against inflation or that they are investing in a 'safe asset'. These people use, or should one say, misuse mathematics to buttress their argument by relying on the figure of gold price appreciation in the recent past. However, to me, the data on gold price appreciation is the most convincing argument for why investing in gold is neither a hedge against inflation, nor a safe asset. Let me explain. What is the characteristic of a hedge against inflation? – it should protect your principal by giving a return slightly above the inflation rate. However, the rate of gold price appreciation in the recent past has been far in excess of the inflation rate and, hence, cannot be characterised as a hedge. In contrast, it can be termed as speculation against inflation. Similarly, the fundamental principle of risk-return trade-off states that greater returns can be achieved only by assuming greater risks. The significantly higher returns offered by gold in the past few years only indicates that the risks implicit in investing in gold have also significantly increased. Even if we calculate volatility in the gold prices over a longer time horizon, it would be far in excess of that observed in other financial assets. Hence, the rationale for investing in gold as a 'safe asset' is contrary to conventional wisdom of what constitutes a 'safe investment'. Mathematics disapproves that gold is a hedge against inflation or that it is a safe asset. Unfortunately, this is not fully understood either by investors in gold or even a significant section of opinion makers and policy makers. We have no problem if proponents of gold encourage gold purchases by portraying it as a 'speculation against inflation' or a 'risky investment' (*i.e.,* right use of mathematics) rather than by calling it as a 'hedge against inflation' or a 'safe investment' (improper use of mathematics).

b. **Productivity in Banks:** In banks, one of the most commonly used measures of productivity is Business per Employee. However, any student of mathematics having some basic understanding of the concept of unit and dimension will say that Business per Employee may be a good measure of productivity across space but a very poor measure of productivity over time. If we use this ratio as a measure of productivity over time in banks/financial institutions for deciding manpower issues, *viz.,* recruitment of staff, promotions, *etc.*, consequences would not only be erroneous but can also be dangerous. Even in deciding on the number of General Managers (GMs) or Executive Directors (EDs) to be provided to banks, policy makers are depending on the volume of business. Can we not decide on these issues in a better way by proper use of mathematics, say, based on staff expenses per 100 rupees of asset/business or salary paid to GMs/EDs as a percentage of total assets/business of banks?

c. **Financial inclusion and numbers:** I am sure you have heard of our initiatives towards financial inclusion, the business correspondents, the basic banking accounts, *etc.* Banks often use 'number of accounts' and 'number of transactions' as two indicators for measuring progress in financial inclusion. It is common for banks to claim progress in financial inclusion stating that the number of accounts opened has gone up by 100 per cent over a period. This use of mathematics to

claim progress in financial inclusion can be terribly misleading. On delving deeper, one realises that while 100 accounts in the previous period have, indeed, increased to 200 accounts, there is no substantive progress in terms of banking penetration and financial inclusion in real terms, since the total number of villages covered, number of BCs employed, have also increased manifold during the period. The increase in number of accounts is, thus, merely a reflection of the expanded geographical coverage and not of any improvement in banking penetration in existing locations. Similarly, the number of transactions made per month may have gone up from 50 to 100 but, simultaneously, the total number of accounts may also have gone up from 200 to 1000. Thus, this 100 per cent increase in the number of transactions does not indicate an increase in efficiency or deepening of financial inclusion. Number of accounts per 1000 population and number of transactions per account are better mathematical ratios to judge the progress in financial inclusion.

31. The above three examples that I have given based on my day to day office experience, are only indicative of the irrational choices that could be made, if mathematics, as a decision making tool, is not properly used. The students of mathematics must, therefore, be extremely careful as conclusions based on improper use of numbers can lead to adverse policy decisions.

Conclusion

32. The key message that I want to convey, particularly to the students, is that not only the past, but also the future of mathematics and mathematicians is glorious and bright. While mathematics, in its pure form, is scaling greater heights, the horizons of its applications in various classical and new fields of science are expanding at a fast pace. Besides the physical and biological sciences, new applications are found in economics, finance, banking and many other fields. In view of such diverse applications of mathematics, the whole world needs mathematicians. Internationally, Indian students and scientists are considered to have a reputation in mathematics. There is a need to nurture and sustain this natural advantage which will attract bright students to the field of mathematics and also provide them with numerous career options. However, in view of the numerous applications of mathematics, students have to identify their areas of interest and develop domain knowledge in that particular area. While a career in mathematics research could be pursued by those with a passion for it, others need to focus on building up specialised expertise in their chosen area of application of mathematics.

33. While concluding, I would always want you to be like the mathematician in the story that I am going to tell you:

A mathematician, a physicist, and an engineer were traveling through Scotland when they saw a black sheep through the window of the train. 'Aha,' says the engineer, 'I see that Scottish sheep are black.' 'Hmm,' says the physicist, 'You mean that some Scottish sheep are black.' 'No,' says the mathematician, 'All we know is that there is at least one sheep in Scotland, and that at least one side of that one sheep is black!'

34. I would end by once again thanking the organisers for inviting me to this forum which, I am sure, will generate valuable awareness and insight about the prospects for mathematics and mathematicians. I have told you so much about maths, its applicability in central banking and problems with numbers that I encounter in my day to day work at the RBI, I hope that all of you will study mathematics, make a name and a great career for yourself. I wish you all a bright future and the Conference all success!

Thank You.

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