Women in Mathematics

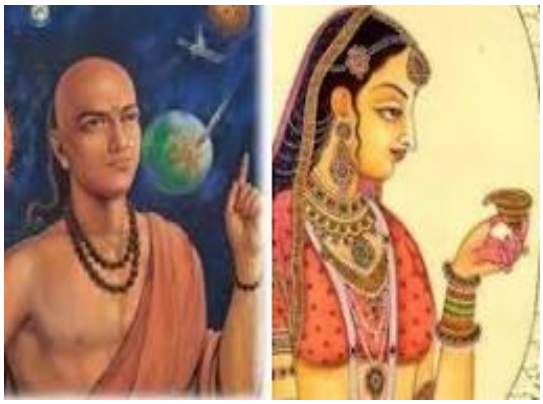
Madhu Raka

At the outset, I would like to express my gratitude to the Indian Mathematical Society and all its members for electing me as the President for the year 2024-2025. I feel humbled by this honour and it is a great privilege for me to address this august gathering of mathematicians and invited guests. I also thank the President, MIT Peace University, Pune and the Department of Mathematics of the Institute for hosting the ninetieth Annual Conference of the Society.The Indian Mathematical Society is the oldest scientific society in India founded in 1907 in Pune. It has a rich history and many stalwarts have held the office of the President of IMS like Prof. Hanraj Gupta, Prof. R. P. Bambah, Prof. S. G. Dani, Prof R. Balasubramanium, Prof. R. B. Bapat, Prof. I B S Passi, Prof. Dipendra Prasad, and Prof. S. Ghorpade, to name a few.

Looking at the list of past Office bearers on the website of IMS, I noticed that there have been only three women Presidents namely Professor Asha Rani Singal (1997-98), Professor Geetha S. Rao (2013-2014) and Prof. Manjul Gupta (2017-2018) out of a total of 115 Presidents of IMS during 1907-2023. Women are universally under represented in science and technology. India, though viewed as a potential powerhouse of innovations, is no exception. Number of women is small across all disciplines, but it is even smaller in mathematics. Is this because they have seen few role models of their gender ?

Despite facing numerous challenges and biases, women have made significant strides in mathematics, breaking barriers and paving the way for future generations. So I have chosen the topic of 'Women in mathematics' for this general talk. Starting from ancient Indian mathematician Lilavati to modern day pioneers like Maryam Mirzakhani, Maryana Vizovaska and Neena Gupta, I will briefly mention the achievements of some of these remarkable women, with emphasis on Indian women mathematicians.

1. **Lilavati**



Lilavati was the clever and intelligent daughter of the twelfth century Indian mathematician Bhaskara II (1114-1185). In the 12th century, mathematics in India was flourishing. As the story goes, the auspicious *muhurta* for her wedding passed and Lilavati remained unmarried throughout her life. One day, to wean his daughter out of her solitude, Bhaskaracharya had an idea. He knew that his daughter had a sharp intellect.

He posed a mathematical puzzle to her and said, “Lilavati ! Why don’t you solve this problem? You have always been interested in solving problems. Take it as a challenge and do it.” Lilavati took this challenge. As she got involved in solving the problem, she was totally drawn into it. She felt jubilant when she solved it. The dejection and depression disappeared magically. It was as if she was born again. Life became interesting and filled with possibilities.

Bhaskaracharya thought of new problems every day and set them in the form of verses that were rich in lyrical beauty. He gave his daughter difficult problems. Lilavati looked forward to the challenge posed by each of those problems. In time, she became adept at solving complex problems. Bhaskaracharya collected all those problems he had formulated for his daughter and arranged them into thirteen chapters. He named this work Lilavati, after his beloved daughter.

Indian Academy of Sciences has published a book in 2008 entitled “Lilavati’s daughters” which is a collection of biographical sketches of Indian women scientists.

2. **Sophie Germaine**

Sophie Germaine (1776-1831), a French mathematician, defied convention and excelled in a male-dominated field. Despite facing gender based discrimination and lack of formal education, she made ground breaking contribution to number theory and elasticity theory.

Her work on Fermat’s Last Theorem paved the way for Andrew Wiles’ eventual proof. Sophie Germaine’s famous identity in number theory states

$$a^4 + 4b^4 = (a^2 + 2ab + b^2)\,(a^2 - 2ab + b^2)$$

This identity has since been widely used in various areas of mathematics including algebra, Geometry and cryptography.

A prime number *p* is called a Sophie Germain prime if 2*p* + 1 is also prime. For example, 29 is a Sophie Germain prime because 2 × 29 + 1 = 59 is also a prime. 2,3,5,11,23,29,41,53,83,89, … … are Sophie Germain Primes. Sophie Germain used them in her investigations of Fermat's Last Theorem. Sophie Germain primes have applications in public key cryptography and primality testing. It has been conjectured that there are infinitely many Sophie Germain primes, but this remains unproven.

In 1794, when Germain was 18, the École Polytechnique opened in Paris. Being a woman, Germain was barred from attending it but the lecture notes were made available to all who asked for. The students were required to submit written observations also. Germain obtained

the lecture notes and began sending her work to Lagrange under the pseudonym of "M. Le Blanc", the name of a former student. When Lagrange saw the intelligence of M. Le Blanc, he requested a meeting, and thus Sophie was forced to disclose her true identity.

Sophie Germaine was the first woman to receive the Paris Academy of Sciences prize for her theory of surface vibrations. Her determination and intellect serve as an inspiration to women in mathematics and science, showing that passion and talent can overcome all obstacles.

3. **Sofya Kovalevskaya**

Sofya Kovalevskaya (1850-1891) was a Russian mathematician who made noteworthy contributions to analysis, partial differential equations and and mechanics. She was a pioneer for women in mathematics around the world – the first woman to earn a doctorate (in the modern sense) in mathematics, the first woman appointed to a full professorship in northern Europe and one of the first women to work for a journal as an editor.

In 1868, Kovalevskaya entered into a marriage of convenience in order to leave Russia and continue her studies. The pair traveled together to Austria and then to Germany, where in 1869 she studied at the University of Heidelberg . The following year she moved to Berlin, where, having been refused admission to the university on account of her gender, she studied privately with the mathematician Karl Weierstrass. In 1874 she presented three papers—on partial differential equations, on Saturn's rings, and on elliptic integrals—to the University of Göttingen as her doctoral dissertation. Having gained her degree, she returned to Russia.

In 1883, Kovalevskaya accepted Mittag-Leffler's invitation to become a lecturer in mathematics at the University of Stockholm. She was promoted to full professor in 1889. In 1884 she joined the editorial board of the mathematical journal Acta Mathematica. After much lobbying on her behalf (and a change in the academy's rules) she was made a Corresponding Member of the Russian Academy of Sciences, but she was never offered a professorship in Russia. In 1888 she was awarded the *Prix Bordin* of the French Academy of Sciences for a paper on the rotation of a solid body around a fixed point.

4. **Emmy Noether**

Emmy Noether (1882-1935), a German mathematician, revolutionized abstract algebra and transformed the face of modern mathematics. She made many important contributions to abstract algebra. She formulated and proved Noether's first and second theorems, which are fundamental in mathematical physics. She was called a creative genius by Albert Einstein. As one of the leading mathematicians of her time, she developed theories of rings, fields, and algebras. Her ground breaking work on symmetry and conservation laws has far reaching implications in physics and beyond.

Noether was born to a Jewish family in the town of Erlangen; her father was a mathematician too. She was the first woman to get a degree from Univ. of Erlangen. After completing her doctorate in 1907 under the supervision of Paul Gordan, she worked at the Mathematical Institute of Erlangen without pay for seven year. At that time, women were largely excluded from academic positions. In 1915, she was invited by David Hilbert to join the mathematics Department at the University of Göttingen, a world-renowned center of mathematical research. The philosophical faculty objected, but she spent four years lecturing under Hilbert's name.

Noether remained a leading member of the Göttingen mathematics department until 1933; her students were sometimes called the "Noether boys". In 1924, Dutch mathematician B. L. van der Waerden joined her circle and soon became the leading expositor of Noether's ideas; her work was the foundation for the second volume of his influential 1931 textbook, Modern Algebra. By the time of her plenary address at the 1932 International Congress of Mathematicians in Zürich, her algebraic acumen was recognized around the world. The following year, Germany's Nazi government dismissed Jews from university positions, and Noether moved to the United States to take up a position at a College in Pennsylvania, where she taught many doctoral and post-graduate women including Olga Taussky-Todd, a leading algebraic number theorist.

Before passing on to women Fields medalists and prominent Indian women mathematicians, I would like to recall the contributions of two icons of Algebraic Coding Theory - **F. Jessie MacWilliams** and **Vera Pless.**

5. **F. Jessie MacWilliams**

Jessie MacWilliams (1907-1990), a british mathematician, made significant contributions to combinatorics, graph theory and cryptography. Her work on error-correcting codes, including

MacWilliams Identities has had a lasting impact on modern coding theory. She was one of the first women to publish in this field. She was a fellow of the Institute of Mathematics and its Applications (IMA) and the Royal Society of Edinburgh. She coauthored the famous book "The theory of error-correcting codes" in 1977 with Neil Sloane. In 1980 she gave the first Emmy Noether Lecture of the Association for Women in Mathematics (AWM).

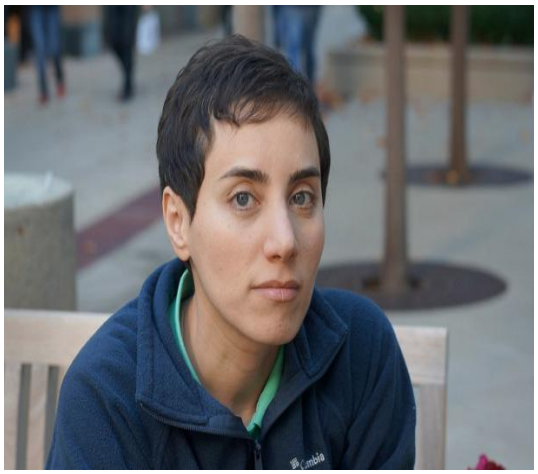
6. **Vera Pless**

Vera Pless (1931-2020), an American mathematician was a pioneer in combinatorial coding theory and error-correcting codes. Her contributions to the field have been recognized with numerous awards and honors, including the Noether Lecture, fellow of IEEE and fellow of American Mathematical Society. Vera Pless produced, with her coauthor W. Cary Huffman, two of the most important texts in coding theory. The first is "The handbook of coding theory" published in 1998. The second is "Fundamentals of error-correcting codes" published in 2003. It has become the standard reference for classical coding theory. She was a pioneer for women in mathematics and computer science, and mentored many female students and researchers in her field. True to her character, she died with a book in her hands.

7. **Maryam Mirzakhani**

Mirzakhani (1977-2017) was a professor of mathematics at Stanford University in California. A glass ceiling was broken in 2014 when an Iranian mathematician Maryam Mirzakhani was honored with **the Fields Medal**. She was the first woman and the first Iranian to win this top award in

mathematics. The award recognized Mirzakhani's “outstanding contributions to the fields of geometry and dynamical systems, particularly in understanding the symmetry of curved surfaces, such as spheres, the surfaces of doughnuts and of hyperbolic objects”.



Mirzakhani was born in Tehran, Iran in 1977. Her childhood dream of becoming a writer was replaced by another passion: mathematics. As a high school junior, she was among the first Iranian women to qualify for the International Mathematical Olympiad. She won a gold medal at the International Maths Olympiad in Hong Kong in 1994, scoring 41 out of 42 points. The following year, in Toronto, she became the first Iranian to achieve the full score and to win two gold medals in the International Mathematical Olympiad. After graduating from the Sharif University of Technology in Tehran, she moved to the United States where she earned a Ph.D. from Harvard University in 2004. In 2009, she was appointed professor of mathematics at Stanford University in California.

Today, Mirzakhani is a global icon for women in science. "I am sure there will be many more women winning this kind of award in coming years," Mirzakhani said in 2014. Sadly, she was not there to witness the second woman to win the Fields Medal in 2022: Ukrainian Maryna Viazovska. Maryam Mirzakhani died in 2017 of breast cancer at the age of 40.

8. **Maryna Viazovska**

Maryna Viazovska (born 1984) is a Ukrainian mathematician who has the Chair of Number Theory at the Institute of Mathematics of the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland. She won **Fields Medal in 2022** making her the second woman recipient in the medal’s 86-year history, to receive this honor. The award is for “the proof that the E_8 lattice provides the densest packing of identical spheres in 8 dimensions, and further contributions to related extremal problems and interpolation problems in Fourier analysis.”

A long-standing problem in mathematics is to find the densest way to pack identical spheres in a given dimension. It has been known for some time that the hexagonal packing of circles is the densest packing in 2 dimensions, while in 1998 Hales gave a computer assisted proof of the Kepler conjecture that the face- centered cubic lattice packing gives the densest packing in 3 dimensions.

The densest packing was not known in any other dimension until in 2016 Viazovska proved that the E_8 lattice gives the densest packing in 8 dimensions. Shortly afterwards, together with Cohn, Kumar, Miller and Radchenko, she proved that the Leech lattice gives the densest packing in 24 dimensions.

Viazovska, the oldest of three sisters, was born in Kyiv, when Ukraine was part of the Soviet Union. In Ukraine, she studied at the Taras Shevchenko National University of Kyiv, before earning a masters degree at Germany's University of Kaiserslautern and a PhD at the University of Bonn. Since 2018, she has held the chair of number theory at the EPFL known in English as the Swiss Federal Institute of Technology, Lausanne. It is sometimes referred to as the MIT of Europe. Apart from Fields Medal, she has won many other prestigious awards and honors such as Salem Prize (2016), Clay Research Award (2017), SASTRA Ramanujan Prize (2017) and Fermat Prize (2019). Viazovska was an invited speaker in the Combinatorics and Number Theory Section of the 2018 International Congress of Mathematicians (ICM) in Rio de Janeiro.

India has a long and rich history of contributions to Mathematics going all the way back to the 1200 BCE. But if we think about all the famous Indian mathematicians- Aryabhatta (476–550 CE), or Bhaskara (1114–1185 CE), or Srinivasa Ramanujan (1887 –1920), or Harish Chandra (1923–1983), we realize that all of them were men! Indian women mathematicians came into prominence only in the 20th century and they are still not that many! Albeit the list is growing. I will mention some of them in my talk.

The list is not exhaustive and does not follow any order-seniority or prominence. There might be some other notable Indian women mathematicians who are not mentioned here. I apologize for that.

9. **R. Parimala**

Among Indian women mathematicians Professor Raman Parimala (born 1948) stands out as one who made significant contributions in the field of algebra using tools of number theory, algebraic geometry and topology. She is an inspiring figure for women aspiring to make a career in mathematics.

She is distinguished professor of mathematics at Emory University, USA. Before that, for many years, she was a professor at Tata Institute of Fundamental Research (TIFR), Mumbai. She has been on the Mathematical Sciences jury for the Infosys Prize from 2019.

Her excellence in algebra, has brought her many awards and recognitions. She is a fellow of Indian science academies- Indian National Science Academy (New Delhi), Indian Academy of Science (Bangalore), and the National Academy of Sciences (Allahabad). In 1987, she was awarded the Shanti Swarup Bhatnagar Prize, the highest science award for young scientists in India.

Another feather in Professor Parimala's cap was when she was chosen as one of the 11 Women in Science by the Govt. of India to be honored with a Chair in their names in 2020. She received one of the highest global honors in her field when she was selected the plenary speaker for the 2010 International Congress of Mathematicians held in Hyderabad. She was also selected as the Emmy Noether Lecturer in 2013 by the Association for Women in Math (AWM) and became the Fellow of American Mathematical Society (AMS) in 2013. She is also a recipient of The World Academy of Sciences (TWAS) prize for mathematics in 2005. Prof. Parimala's dedication to mathematics and her passion for teaching have inspired generations of students and researchers in India and abroad.

10**. Rajinder Jeet Hans-Gill**

Professor R. J. Hans-Gill (born 1943) had her early education in rural Punjab, where getting an education in any discipline, let alone in science, was difficult for girls. She had to pretend to be a boy and wear a turban to attend school for some time— a secret that was kept between her family and the head master. Professor Hans-Gill earned her BA Hons (Mathematics) and MA (Mathematics) from Government Colleges in Ludhiana. She obtained her PhD (1965) from Ohio State University under the guidance of Professor R. P. Bambah. She was the youngest Ph.D. at OSU at that time. She worked as a faculty in Ohio State University and University of Wisconsin, Madison, US for some time and then returned to Panjab University as Reader (associate professor).

Professor Hans-Gill is Emeritus Professor at Panjab University, Chandigarh after retiring as Professor from the same place. Her excellence in Geometry of Numbers and Discrete Geometry led to many awards and honors. Hans-Gill received the Narasinga Rao Gold Medal of the Indian Mathematical Society (1971). She is a Fellow of all the three Indian science academies- Indian National Science Academy (New Delhi), Indian Academy of Sciences (Bangalore), and the National Academy of Sciences (Allahabad). She is also a Fellow of the Academy of Sciences for the Developing World (TWAS) (2006). She was awarded Srinivasa Ramanujan Birth Centenary gold Medal by ISCA in 2010. She was a Member of the committee 'Women in Science' constituted by the Indian Academy of Sciences. She is a shining example of excellence and perseverance in mathematics and a role model for women in Mathematics.

11. **Ajit Iqbal Singh**

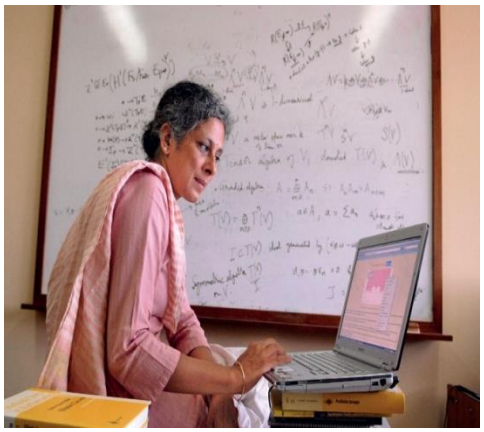
Professor Ajit Iqbal Singh (born 1943) specializing in functional analysis and harmonic analysis, is fellow of the Indian National Science Academy and of the National Academy of Sciences. Even at an age of 81, she is very active, full of enthusiasm and is continuing her research work in quantum information theory. Any person who gets the privilege to meet her becomes spellbound by her dedication to mathematics.

Prof. Ajit Iqbal Singh earned her BA Hons (Mathematics) and MA from Delhi University. After a brief stint as faculty at Indraprastha College, Delhi, she proceeded to University of Cambridge in 1966 as a Commonwealth Scholar under the supervision of F. Smithies and was awarded Ph.D (1969). Soon after, she joined Hindu College, Delhi University and continued teaching in addition to doing research on functional analysis and harmonic analysis. She was appointed Reader in Mathematics, University of Delhi South Campus (1974) and rose to the position of Professor there (1984-2008). She held visiting positions at the University of Oregon at Eugene USA, at

Panjab University, at Institute of Biomathematics and Biometry at GSF National Research Centre in Munich and at University of Ohio in Athens. After superannuation from University of Delhi, she has been a Visiting Professor as INSA Senior Scientist (2008-2013) and as INSA Honorary Scientist (2013-2014) at the Indian Statistical Institute, Delhi Centre. She is continuing her research work in quantum information theory as INSA Honorary Scientist.

12. **Sujata Ramdorai**

Sujatha Ramdorai (born 1962) is an algebraic number theorist known for her work on Iwasawa theory. She is a professor of mathematics and Canada Research Chair at University of British Columbia, Canada. She was previously a professor at Tata Institute of Fundamental Research. Professor Sujatha Ramdorai is a perfect example of a woman who pursued her passions, though she got married before her graduation but still achieved success in her profession. Inspired by her grandmother who constantly emphasized the value of education, Professor Ramdorai developed an acute desire to learn at a very young age. She was in primary school when she discovered her love for mathematics.



Upon finishing high school, she struggled to make a decision between engineering and pure science for her higher education. However, she realized that her love for abstract thinking made mathematics her true passion. Professor Ramdorai completed her B.Sc. in Mathematics at St. Joseph's College, Bangalore and then proceeded to do her M.Sc. with Annamalai University obtaining a PhD degree in 1992 from TIFR, under the guidance of Professor R. Parimala. She continued to work at TIFR, even though her peers working in the industry were earning six times her salary. Ramdorai became the first Indian to win the prestigious **ICTP Ramanujan Prize** in 2006. She was also awarded the Shanti Swarup Bhatnagar Award, the highest honour in scientific fields for a young scientist by the Indian Government in 2004. She is also the recipient of the 2020 Krieger–Nelson Prize for her exceptional contributions to mathematics research. She has been bestowed with **Padma Shri** award by the Government of India for 2023 in the field of science and engineering. She is a member of the Scientific Committee of several international research agencies such as the Indo-French Centre for Promotion of Advanced Research, Banff International Research Station, International Centre for Pure and Applied Mathematics. She was a Member of the National Knowledge Commission and is a Member of the Scientific Advisory Council to the Prime Minister of India.

13. **Ushadevi Narendra Bhosle**

Professor Ushadevi Narendra Bhosle (born 1949) is INSA Senior Scientist at Indian Statistical Institute, Bangalore from Jan 2019. She is regarded as an expert in the field of "moduli spaces of torsion free sheaves on singular curves"-a branch of Algebraic Geometry.

Professor Bhosle got B.Sc. degree in 1969 and M.Sc. degree in 1971 from University of Pune and Shivaji University respectively. She commenced her post-graduate studies in 1971 from Tata Institute of Fundamental Research and got her doctorate degree under the guidance of her mentor S. Ramanan in 1980. She started her career as research assistant at TIFR in 1971 and rose to the position of Senior Professor. She was the Raja Ramanna fellow 2014 - 2017 at Indian Institute of Science, Bangalore. She also was the senior associate of International Centre of Theoretical Physics, Italy. She is fellow of all the three national science academies namely INSA, IASc and NASI.

14. **Sudesh Kaur Khanduja**

Professor Sudesh Khanduja (born 1951) is Emeritus Professor at the Department of Mathematics, Panjab University and INSA Senior Scientist at the Indian Institute of Science Education and Research (IISER) Mohali, India.

A PhD and MA from Panjab University, Chandigarh, her primary research interests are in algebraic number theory and valuation theory. She got her doctorate degree under the guidance of Professor I. S. Luthar. She has authored the book "A textbook of algebraic number theory" published by Springer (2020).

Prof. Khanduja is a fellow of The World Academy Sciences(TWAS), the Indian Academy of Sciences, the National Academy of Sciences, and the Indian National Science Academy (INSA). She was awarded the Professor V.V. Narlikar Memorial Lecture Award of INSA in 2015, Srinivasa Ramanujan Lecture Award of Indian Mathematical Society (IMS) in 2022 and Srinivasa Ramanujan Medal (2022) of INSA.

15. **Nalini Anantharaman**

Professor Nalini Anantharaman (born in Paris in 1976) is Chair of Mathematics, Institute of Advanced Study, University of Strasbourg, France. **The Infosys Prize 2018 in Mathematics was awarded to her** in recognition of her work related to "Quantum Chaos", specifically for the effective use of entropy in the study of semi classical limits of eigen states in quantum analogs of chaotic dynamical systems and for her work on the delocalization of eigen functions on large regular graphs.

Nalini Anantharaman completed her Ph.D. at the University of Paris in 2000. She held positions at ENS in Lyon, CNRS (The French National Center for Scientific Research) and the École Polytechnique in Paris, becoming a full Professor at the University of Paris-Sud in 2009. She was a visitor at the Princeton Institute for Advanced Study in 2013 and moved to Strasbourg University in 2014. She was awarded the Salem Prize and the Jacques Herbrand Prize in 2011, the Henri Poincarè prize in 2012 and the CNRS silver medal in 2013. **She was an invited plenary speaker at ICM 2018**.

16. Mythily Ramaswamy

Professor Mythily Ramaswamy (born 1954) is Senior Scientist in mathematics at the International Centre for Theoretical Sciences-TIFR, Bengaluru. She did her PhD in 1990 at Paris. She was faculty at the TIFR Centre for Applicable Mathematics, Bengaluru (until retirement in 2019). She is Adjunct Professor at Chennai Mathematical Institute since 2019. She was elected Fellow

of the Indian Academy of Science in 2007 and of NASI also in 2007. She is member of NBHM board as well.

Her early childhood was spent in a small village, Kadayam, in Tirunelveli district, deep inside Tamilnadu . After her school education, she was lucky to have college education in Bombay . After M.Sc., she was looking for a clerical job in a bank but was not able to secure any bank job as she did not qualify for a domicile certificate in Maharashtra. Then she applied to T.I.F.R. for research and was selected for the TIFR-IISc joint mathematics programme on Applications of Mathematics, at IISc Bangalore. From there she moved to Paris on a INRIA Scholarship for her Ph.D. Her research involves functional analysis and controllability of partial differential equations.

17. **Saradha Natarajan**

Professor Saradha Natarajan (born 1954) is an INSA Senior Scientist at the DAE Center for Excellence in Basic Sciences (CEBS) at the University of Mumbai. Earlier, she was a Professor of Mathematics at TIFR, Mumbai, until 2016. She is an elected fellow of the Indian National Science Academy (INSA). She obtained her Ph.D. in 1983 from Ramanujan Institute for Advanced Study in Mathematics, University of Madras, Chennai.

Her area of specialization is number theory, in general, and transcendental number theory and Diophantine equations, in particular. She has collaborated with many mathematicians both in India and abroad and guided students for Ph.D. and graduation.

She is co-author of the book 'Pillars of Transcendental Number Theory' published by Springer (2020) and also edited the book 'Diophantine Equations' (2007).

18. **Meena Mahajan**

Meena Mahajan (born 1965) is a professor at The Institute of Mathematical Sciences (IMSc) in Chennai. Prof. Mahajan's research interests encompass many aspects of computational complexity theory, including Boolean function complexity, algebraic circuits, proof complexity, and space bounded computation. She completed her undergraduate and postgraduate degrees from the department of computer science and engineering at IIT-Bombay and went on to receive her Ph.D. from IIT-Madras.

Prof. Mahajan has held several professional roles. Since 2019, she has been an ACM, (Association for computing machinery) Eminent Speaker. She is an elected Fellow of the Indian Academy of Sciences (2022) and serves on the ICM Structure Committee for the coming ICM 2026.

19**. Neela Natraj**

Neela Nataraj (born 1968) is a Professor in Department of Mathematics, IIT Bombay. She obtained her Ph.D. in 1998 from IIT Delhi under the supervision of Prof. P.K. Bhattacharya. She was appointed a faculty member in the Department of Mathematics at the same institute in 1999. She moved to IIT Bombay in 2003 and became a Full Professor in 2014. Presently, she is an Institute Chair Professor in the Department of Mathematics of IIT Bombay. She has also been serving as Dean (Faculty Affairs) of IIT Bombay since 2021. Her research interests are Numerical Analysis, Finite Element Methods, Finite Volume Methods and Optimal Control Problems.

Prof. Neela Nataraj was conferred the Indian National Science Academy Teachers Award in 2019. She is a Fellow of the National Academy of Sciences (2019) and of Indian Academy of Sciences (2021). She was the chairperson of the IWM Executive Committee during 2019-22. She has been featured in the film 'Journeys of Women in Mathematics (2018)', produced by the International Mathematical Union Committee for Women in Mathematics.

She was awarded 34th P.L. Bhanagar Memorial Award Lecture in the 86th Annual Conference of Indian Mathematical Society (2020).

20. **Vijaylaxmi Trivedi**

Vijaylaxmi Trivedi (born 1966) is a professor at School of Mathematics, TIFR, Mumbai. Her specialization is Commutative Algebra and Algebraic Geometry.

Professor Vijaylaxmi Trivedi was elected as a Fellow of the Indian Academy of Sciences, Bengaluru, 2022 and a fellow of INSA in 2023. She has served as the chair of executive committee of IWM (Indian women in Mathematics) 2022-2024.

21**. Sanoli Gun**

Sanoli Gun (born 1975) is a Professor at IMSc (The institute of Mathematical Sciences), Chennai, since 2015. She obtained her Ph.D from Harish Chandra Research Institute (HRI), Allahabad. She was Post doctoral fellow at University of Toronto (2006 - 2007) and at Queen's University (2007 - 2008) before joining IMSc. Her specialization is in Modular Forms, Special Values of L-Functions and Algebraic Number Theory.

Professor Sanoli Gun was elected as a Fellow of the Indian Academy of Sciences, Bengaluru, 2021. In 2022, she became the first president **of Asia-Oceania Women in Mathematics (AOWM),** the continental organisation for women mathematicians, with over 200 founding members from the continents.

22**. Radha Kessar**

Professor Radha Kessar received her first degree from Panjab University in 1991 and a Ph.D. from Ohio State University in 1995 under the supervision of Professor Solomon. She held postdoctoral positions at Yale University, the University of Minnesota, Oxford University, and faculty positions at Ohio State University (Assistant Professor), the University of Aberdeen (Senior Lecturer, Reader, and Professor) and City University of London (Professor). Since April 2024, she has held the Fielden Chair in Pure Mathematics at the University of Manchester.

Radha Kessar works in the representation theory of finite groups, a branch of abstract algebra. She is the only woman to have been a professor of mathematics at the University of Aberdeen. Besides research and teaching, Radha serves on the editorial boards of several prestigious international mathemati cal journals. She has co authored the book "Fusion Systems in Algebra and Topology". She has won the Berwick prize of the London Mathematical Society. Radha Kessar is the first woman recipient since the prize's inception in 1946. Other honors include a Simon's Visiting Professorship at the Mathematical Sciences Research Institute in Berkeley, and an invited lecture at the European Congress of Mathematicians.

23. **Gurmeet K. Bakshi**

Gurmeet K. Bakshi (born 1970) is a professor at the Department of Mathematics, Panjab University, Chandigarh. She obtained her Ph.D. under the guidance of Prof. I. B. S. Passi from Panjab University in 1996. Prof. Bakshi's research interests include Group Rings, Representation Theory, and Algebraic Coding theory. She has authored many research articles and given several invited talks in workshops/conferences.

She has guided a number of Ph. D. students. Prof. Bakshi is a fellow of the National Academy of Sciences, Allahabad (2015). She is recipient of the Hansraj Gupta memorial lecture award (2019) from the Indian Mathematical Society. She is a member of the executive committee of Indian Women and Mathematics (IWM). She is on the editorial board of Indian Journal of Pure and Applied Mathematics. She is Member of of NBHM board since 2023.

24. **Ridhhi Shah**

Riddhi Shah (born 1964) is a professor of mathematics at Jawaharlal Nehru University in Delhi and at present chair of the IWM executive committee. She is member of NBHM board also. After receiving MSc degree in Mathematics from IIT Bombay, she joined the Tata Institute of Fundamental Research (TIFR), Mumbai for her doctoral studies and obtained her Ph.D in 1991. She was a faculty member at TIFR , Mumbai from 1990 to 2007. She moved to the national capital in 2007 so that she and her husband, a theoretical physicist, could finally be together after 14 years of marriage. Her research interests include dynamics of group actions and probabilities on groups. She was awarded INSA medal for young scientists in 1995, the Alexander von Humboldt Fellowship in 1997, CNRS fellowship in 2003 and an Invitation Fellowship in 2004 from the Japan Society for Promotion of Science (JSPS). She was elected Fellow of NASI in 2022.

25. **Geeta Venkataraman**

Geetha Venkataraman (born 1967) is a Professor of Mathematics at Ambedkar University Delhi (AUD). She did MA and DPhil (doctorate) in Mathematics at the University of Oxford. At AUD, she has served as Dean (Research and Consultancy) and Dean School of Undergraduate Studies. Her area of research is finite group theory. She has co-authored three books.

Apart from her interest in Group Theory and related areas, she is deeply interested in popularising mathematics, mathematics education, issues related to women in mathematics and women in leadership in academia. Geetha is one of 5 CWM (Committee for Women in Mathematics, International Mathematical Union) ambassadors from India and was a member of Executive committee of IWM (Indian Women and Mathematics).

She was also a panelist in the panel discussion titled `Girls in Mathematics: Reflections and Initiatives' held as part of the World Meeting of Women in Mathematics (WM)^2 (2022), prior to the International Congress of Mathematicians (ICM).

26. **Neena Gupta**

Neena Gupta (born in 1984) is a professor at the Indian Statistical Institute (ISI), Kolkata. Her primary fields of interest are commutative algebra and affine algebraic geometry. She has been awarded the 2021 **DST-ICTP-IMU Ramanujan Prize** for young mathematicians from developing countries. She received the prize for her outstanding solution to the Zariski cancellation problem for affine spaces. The problem was posed by one of the most eminent founders of modern Algebraic Geometry, Oscar Zariski, in 1949. The Zariski Cancellation Problem is considered to be one of the most difficult problems in mathematics. She is the third woman from India who got this award (after teacher-student duo Raman Parimala (1987) and Sujatha Ramdorai(2004)).

Professor Neena Gupta was previously an INSPIRE faculty at ISI Kolkata and a visiting fellow at TIFR. She has won INSA Young Scientist award in 2014 and Shanti Swarup Bhatnagar Prize (2019). Her work has also earned her the inaugural Saraswathi Cowsik Medal in 2013, awarded by the TIFR Alumni Association.

She is fellow of Indian Academy of Sciences (2021) and of Indian National Science Academy (2023). She won A. K. Agarwal award for best publication by the Indian Mathematical Society in 2014 and received Nari Shakti Puraskar (2021) by the President of India on 8th March 2022. Neena Gupta used to spend hours doing maths as a young girl and loved solving mathematical problems. She was an invited speaker at ICM- 2022. She received TWAS-CAS young scientist award in Mathematics/AI by The World Academy of Sciences and the Chinese Academy of Sciences (2023).

She has been selected to deliver the 44th Emmy Noether Lecture at the Joint Mathematics Meetings to be held in Seattle, WA during January 8 – 11, 2025.

There are many more prominent Indian women mathematicians. To name a few – Professor **Jaya N Iyer of IMSc**, Chennai, Professor **V Lakshmibai** of Northeastern University Boston, Professor **Asha Rani Singal** of Meerut University, Professor **Geeta Srinivas Rao** of

University of Madras, Professor **Uma Basu of University of Calcutta**, Professor **Rukmini Dey** of ICTS , Bengaluru, Prof **B. Sri Padmavati** of University of Hyderabad, Prof. **Pratima Panigrahi**, IIT Kharagpur, Prof. **Manjul Gupta** of IIT Kanpur, Prof. **Shobha Madan** of IIT Kanpur, Prof. **Punita Batra** of HRI, Allahabad, Prof. **Shashi Prabha Arya** of Maitreyi College, Delhi, Prof. **Girija Jayaraman** of IIT Delhi, Professor **Mangala Narlikar** of TIFR, Prof. **Indira Narayanaswamy** of M. S. Ramaiah University of Applied Sciences, Bangalore, Prof. Siuli **Mukhopadhyay of IIT Bombay**, Prof. **Ranjeet Sehmi** of PEC Chandigarh and Prof. **Subuhi Khan** of Aligarh Muslim University. Some next generation budding women mathematicians are Professors **Kaneenika Sinha** of IISER Pune, **Pooja Singla** of IIT Kanpur, **Anuradha Sharma** of IIIT, Delhi, **Rama Mishra** of IISER Pune, **Tanvi Jain** of ISI, New Delhi, **Anita Naolekar** of ISI, Bengaluru, **Siddhi Pathak** of the Chennai Mathematical Institute, **Nikita Agarwal** of IISER Bhopal, **Radhika Ganapathy** of IISc, Bangalore, **Sugandha Maheshwari** of IIT Roorkee, **Purvi Gupta** of IISc Bangalore, **Radhika Gupta** of TIFR Mumbai**, Srimathy Srinivasan** of TIFR Mumbai, **Prajakta Nimbhorkar** of CMI Chennai and **… … … … …**

Girls outnumber boys in almost all B.Sc/M.Sc courses in colleges and universities these days. In Panjab University Mathematics department, there was only one woman faculty in 1967, now in 2024 they outnumber their male counterpart. There might be about 2,000 women working in maths in India today, including PhD students, postdocs, and faculty (as per an estimate made by Anita Naolekar, a member of the executive committee of IWM). The numbers are slowly and surely increasing but the concern is - the percentage of women continuing research after obtaining PhD is very low. This may be because the road to the top is never smooth. Many of the women acknowledge a lack of institutional support, double standards in measuring their achievements, self-imposed limitations and most importantly the multiple roles that married women with families have to juggle. They have used many strategies for survival. The most important is their passion for their work. Somebody has rightly said “Mathematics is the divine language of the Universe and women are becoming its fluent speakers”. Indian women are breaking barriers and shattering glass ceilings in mathematics, paving the way for future generations.

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