Interview Preparation Content for Mathematics Students

1. Anubhav Singh, AIR 8, 2017

i. Tell me the difference between real number, natural number and imaginary number.

Suggested answer: Natural numbers are a subset of Real numbers which along with Imaginary numbers become the Complex number set. Natural numbers do not contain numbers like √2 and Imaginary numbers on the other hand use square roots of negative numbers.

ii. National mathematics day why and when celebrated. Which Prime Minister declared this day?

Suggested answer: National Mathematics Day is celebrated on 22nd December. It is the birth Anniversary of S. Ramanujan. It was declared by Shri Manmohan Singh.

iii. Important works of Ramanujan.

Notes: His mains areas of work are Prime numbers, Continued fractions, Hypergeometric series, Elliptic functions, Partitions, Probabilistic number theory. His work has been applied in Black holes, string theory, quantum gravity etc.

Black holes: His work on Mock modular forms saw direct application in Physics including understanding black holes.

Continued fractions: His work on continued fractions has been widely applied to multiple branches of mathematics. A simple example of a continued fraction is:

$$\Phi = \frac{1+\sqrt{5}}{2} = 1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \ddots}}}}$$

Hyper-geometric series: The series given by Ramanujan have been used to calculate the value of pi. The advantage was that they took far fewer terms to calculate the value of pi to a given level of accuracy.

Partitions: The partition function counts the number of ways an integer can be written as a sum of positive integer. He gave a value of P[200] which was unimaginable during his time.

iv. What is Game theory?

Suggested answer: Game theory is the study of how people, companies, nations etc. determine strategies in different situations. Especially when there are other players also coming up with their strategies. It involves elements of cooperation as well as conflict. It has direct application in science, politics and economics.

2. Siddharth Jain, AIR 13, 2015

i. How will mathematics help you in civil service?

SJ: Ma'am mathematics helps me in being objective and precise with my decisions. In particular, methods from numerical methods can be useful in analysing the impact of policy decisions …(told some more points).

Suggested additional points: Mathematics helps me develop problem solving approach. It involves analytical skills and logical approach. Also, advanced mathematics like Linear Programming has direct application in optimum utilization of resources...which again is directly relevant to administration. Probability and statistical models can be used to predict disease spread, agricultural prices etc. which again have direct relevance to administrators.

ii. X raised to power m =y raised to power m. What is the possible relation between x and y?

SJ: Sir, x=y ; x=-y(for m=even numbers)and if m=0 , x is not related to y.

Suggested correction: if m=0, x need not be related to y. In all this, we are assuming there is no zero raised to zero situation. That is an indeterminate form.

iii. If 2 raised to power 0 = 3 raised to power 0.Why 2 is not equal to 3.Tell me a mathematical answer.

SJ: (Told some unconvincing answer).

Suggested answer: As mentioned before when x^0 = y^0, x and y need not be related. Another way to look at this is (2/3)^0 = 1 but that does not imply 2/3 itself is 1.

3. Shilipi, AIR 198, 2015

   i. **Pure math vs applied math.**

   Suggested answer: Pure maths is maths done for its own sake. Applied maths is maths with a practical use. Nevertheless, the distinction is sort of outdated as many fields like Number theory, abstract algebra which used to be considered pure rather than applied mathematics, have proved to be immensely useful.

   ii. **How's philosophy related to pure mathematics?**

   Suggested answer: Logic is a connecting link between Mathematics and Philosophy. Ancient Indian mathematics had a strong link to philosophy including Nyaya School of thought. Ancient Greeks used to believe that Maths is the way to reach God.

   iii. Then he asked about **relationship with Indian philosophy**.. I explained something about Shankaracharya.

   iv. Then he went on with **relationship of Zero with philosophy**. At this point, I said 'sir ab aur nahi pata!' (don't know further)
   (I think he was referring to Shunyvada school of Buddhism but since I didn't know much about that school, I avoided telling him to avoid further discussion which would have revealed the actual depth of my philosophical knowledge)

   Suggested Answer: Sunyata is roughly the concept of 'nothingness' espoused by Acharya Nagarjuna in Madhyamaka school of philosophy. Often it is understood that there is no existence. But a better interpretation would be that existence is true. But things and phenomena are without their 'svabhava', their 'own being'. It motivates us to look at things as a part of a larger universe rather than look at everything as separate from the rest.

4. Parth Jaiswal, AIR 299, 2014

   i. **1.5 hens give 1.5 eggs in 1.5 days, how many hens do we need to get 12 eggs in 6 days?**
   PJ – 3 hens

   Suggested modification: By simply using equations, we can conclude that 3 hens are required. Another approach would be to say that 1.5 hens means that one live and one dead hen (0.5). Also, there is nothing like 1.5 eggs. So question might have to be reframed.

5. Bhavesh Mishra, AIR 58, 2014

   i. **Tell me something about John Nash. Which disease was he suffering from?**
   BM: Narrated his life history in detail.
   Suggested Answer: John Nash is a mathematician famous for making groundbreaking contributions to Game Theory. He got a Nobel Prize in Economics for applying Game Theory to Economics. He was suffering from Schizophrenia.

   ii. **Who gave the concept of Game Theory first?**
   BM: Sorry sir, I don't recall the name.

   Suggested answer: John Von Neumann.

   iii. **How many Nobel prizes have been awarded in the field of game theory.**
   BM: I told him 6 but 11 was the answer.

6. Sumit Kumar, AIR 81, 2013

   i. Chairperson: You have Mathematics as your optional subject. What qualities/ values you learnt while you were preparing for civil services and how you would use those learnt values in administration?

Me: Ma'am, Mathematics thought me values of objectivity and precision. I have to be pin point accurate in my decisions. I also leant value of optimum utilisation of resources and how rational decision making is made. I will use values of objectivity, rationality, precision, accuracy and optimum utilisation of resources in day to day governance.

ii. **M3 : Your optional subject was Mathematics. Tell me how you will use mathematical knowledge in Governance and Administration?**

Me: Sir, I leant how to optimally utilise given resources through lineal programming models such as *simplex* and will utilise in wide range of governing areas such as health and education'. Computing models such as *Newton-Raphsons* can help us how to effective handle inflation, unemployment. They can also help us how we can better reap benefits of demographic dividend. Integral and calculus can help us to understand frequency and solve problems of congestion, transportation and infrastructure bottlenecks. Children too face problems in understanding mathematics and I can help departments how innovative and exciting learning models can make learning more attractive.

7. Mani Agarwal, 2016

i. **Who is this Manjul Bhargava?**

Notes: Manjul Bhargava is a Canadian-American Mathematician of Indian Origin, who got the Fields Medal in 2014. He is known for his contribution to number theory. He has also contributed to representation theory, algebraic number fields, arithmetic theory of elliptic curves etc. He has given a novel generalization of the factorial function, bhargava factorial, resolving a decades old conjecture by George Polya. His PhD thesis was the first major contribution to Gauss' theory of composition of binary forms for 200 years.

Representation theory: It seeks to represent every element of a group by a matrix. This is primarily done because Groups behave non-linearly. We represent groups by linear matrices and understand their behaviour in the linear world. Then we go back to the original problem.

Algebraic number fields: are Number Fields which are an extension of Q (rational number field). Every element of such fields is a solution of a polynomial equation over Q. These fields form the basis of algebraic number theory.

Elliptic curve theory: Elliptic curves with rational points are a special type of curves that allow us to do Arithmetic, geometry as well as abstract algebra over them. They are extremely useful to cryptography too.

Composition laws: Gauss' composition laws describe relationships between numbers that can be written in quadratic forms (these are numbers that can be written with two variables and as sums of only quadratic terms. Eg. x^2+y^2 , $3x^2+2xy$ etc). Manjul Bhargava gave 12 such composition laws in his PhD thesis.

More details at: https://www.quantamagazine.org/number-theorist-manjul-bhargava-is-awarded-fields-medal-20140812/

ii. **Have you heard of the movie "The man who knew infinity"?**

Notes: "The man who knew infinity" is a movie about the life of S.Ramanujan and his time under Prof. G.H.Hardy.

iii. **Quality of maths taught in schools.**

Notes: Only 40% of class VIII students in government schools can do simple division (ASER report 2018).

8. Unknown, P.K.Joshi Board

i. **In a school in a village children of 9th and 10th are afraid of maths, you are asked to give a speech to encourage them as a DM. What will be that speech?**

Suggested answer: Maths is like playing cricket. Some would be naturally better than the others. But everyone can get better at it by practice. We are afraid of that which we do

not understand – like Ghosts or darkness. As we practice more, we will understand more and the fear will go away. Students should pair up based on their complementary strengths. Those who are good at maths can help out those who are bad at it and learn something else in return. And never be afraid to say – I didn't understand this. If you don't understand something a second time, meet your teacher personally. You don't have to be perfect at it. But if today you are better than tomorrow and even better the day after, nothing like it.

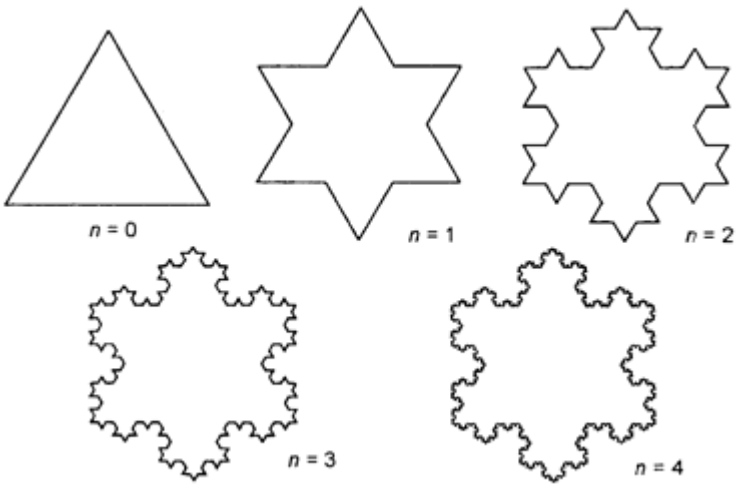
ii. **How will you explain them how geometric and harmonic mean are better than arithmetic mean through applications?**

Notes: There are a lot of situations where numbers don't add up as sums. In fact, their combined effect works through their product or reciprocals. For eg. If we want to find the average speed of a vehicle going to and fro between two points, we have to take the harmonic mean of the two speeds. Also, the geometric mean is frequently used in development studies and economics as Compouned Annual Growth Rate (CAGR).

iii. **Is the universe finite or infinite as a mathematician?**

Notes: It is yet an unanswered question. As a mathematician we can say that the universe is likely to be infinite but bounded. Like a fractal (A fractal is a non-regular geometric shape that has the same degree of non-regularity on all scales. Fractals can be thought of as never-ending patterns).

In the following figure, the length of the curve (called Koch Snowflake) increases by a factor of 4/3 after every iteration. So it goes to infinity as n tends to infinity. But, as is clear, the area of the curve itself is bounded. The universe need not behave like this, but this is just one of the many possibilies.



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More questions:

1. **Who is Shakuntala Devi? Why is she famous?**

   Notes: Shakuntala Devi is a writer of books on mathematics and a Mental calculator. She is popularly known as a 'human computer'. She has a Guiness World Record entry for quickly multiplying two thirteen digit numbers. Her books like the "Joy of numbers" and "Puzzles to puzzle you" are quite popular.

2. **Who is Alan Turing? There was a movie about him recently. What is his contribution?**

   Notes: Alan Turing is a British Mathematician who lead the British Cryptography team in decoding German messages during World War II. His decoding is supposed to have ended the war two years early. He is also responsible for coming up with the 'Turing Test'.

   Movie: The Imitation Game (2014)

   The Turing Test: The Turing test tests whether a machine can demonstrate human intelligence. In simple words, a person would interact with a Human and a computer. If, after the interaction, the person is unable to decide which is the Human and which the computer, then the computer is said to have achieved human intelligence. The Turing test is still a valid test for Artificial intelligence.

3. **What is Golden Ratio? How is it related to Fibonacci series? Where do we see Golden Ratio and Fibonacci series in nature?**

   Notes: The Golden Ratio is approximately 1.618. It is a ratio such that its reciprocal is one less than itself. So we can say $(1/x) = x - 1$, which leads to the quadratic:

   $x^2 - x - 1 = 0$. The positive root is termed as Golden Ratio.

   The Fibonacci series is given by 0, 1, 1, 2, 3, 5, 8, 13,... where every successive term is the sum of the previous two terms. It has been proved that the ratio of consecutive terms of the Fibonacci series approaches the Golden Ratio.

   Fibonacci numbers: The number of petals on a flower is typically a Fibonacci number. The number of spirals in a sunflower or a pineapple is also likely to be a Fibonacci number.

   Golden Ratio: It was used in the design of Parthenon in Athens of ancient Greece. It has also been seen in the dimensions of the Taj mahal (The main building, without the dome). It is also seen in the shell of Nautilus (like a snail) and in Broccoli.

4. **Name any contemporary Indian Mathematician? What is his/her contribution?**

   Notes: Among the contemporary Mathematicians, Prof. C. R. Rao stands out. He was the director of Indian Statistical Institute, Kolkata. He has been awarded the Padma Vibhushan.

   Contribution: Prof. Rao has worked in areas of multivariate analysis, estimation theory, and differential geometry. The Cramer-Rao inequality and Rao-Blackwell theorem are considered fundamental to statistical analysis.

5. **Who is Manjul Bhargava? How did music help in his maths research and vice versa?**

   Notes: Manjul Bhargava (details given before) is also an accomplished Tabla player. He has studied under Ustad Zakir Hussain. He says playing the tabla helped him relax and clear his mind. In fact, it works the other way round too. After doing some maths, his tabla playing improved in his opinion.

   Example: He explains that in tabla there is a long beat of two beats and a short beat of one beat. He wanted to figure out all possible combinations of long and short beats that will make an 8 taal beat. It turns out to be the sum of all possible 6-taal beats and 7-taal beats. This is essentially the Fibonacci number series, now termed the Hemchandra-Fibonacci series to credit the Jain Scholar Hemchandra who gave the series 50 years before Fibonacci.

6. **Why is there no Nobel Prize in maths? What is the highest award given in maths?**

   Notes: The actual reason is not known. It has been speculated that Alfred Nobel did not consider mathematics to be a practical science. It is also possible that at the time there was a Scandinavian prize already felicitating work in mathematics. This made Alfred Nobel reluctant to start another award in the same field.

   The highest award given in mathematics is the Fields medal (named after Canadian mathematician John Charles Fields.). Manjul Bhargava is the only person of Indian Origin to get the award. Maryam Mirzakhani is the only woman and the only Iranian to get the award.

7. **What is the contribution of Indian mathematicians to the world - both ancient and modern?**

   Ancient:

   i. Baudhayan-Sulva Sutra- Pi.

ii. Aryabhatta – Aryabhattiya – Description of zero as a number, symbol and a concept; Number theory, Geometry (area of triangle) and Bija Ganita (Algebra); Astronomy – khagol shastra, earth's rotation on its axis etc.

iii. Brahmagupta – Brahmasputa Siddhantika – Negative numbers and operations on zero;

iv. Bhaskaracharya – Siddhanta Shiromani – Chakravat or the cyclic method to solve algebraic equations.

v. Mahaviracharya – Ganita Sara Sangraha – arithmetic in present day form, including concept of LCM.

vi. Varahamihira – Brihatsamhita – Moon revolves around earth, and earth revolves around sun.

Modern:

i. Prof. C. R. Rao – Described.

ii. Prof. Harish Chandra – India's leading research institute in theoretical physics and mathematics – the Harish Chandra Research Institute is named after him. He has received Padma Bhushan for his work.
His main area of work is Representation theory and Lorentz group.

8. **What is the role of maths in Artificial Intelligence? Cryptocurrency?**
Notes:
AI: It is said that a person working with AI who cannot do maths is like a politician who cannot persuade. AI requires multiple branches of mathematics like Linear Algebra, Probability, Multivariate Calculus, Optimization etc.
Cryptocurrency: Bitcoins use elliptic curve cryptography in securing the transactions. New bitcoins are created by solving complicated problems. Doing this number crunching is called 'mining' bitcoins. Almost every step of 'mining' and validating bitcoin transactions has mathematics behind it.

9. **How is maths relevant to encryption? Why is Whatsapp's end to end encryption so difficult to crack? Have you heard of the unhackable method of encryption developed by China recently?**
Notes: The entire field of cryptography is heavily dependent on mathematics. A simple example is that many public key encryption systems are secured by semi-primes which are obtained by

multiplying two large prime numbers. Apart from this, modular mathematics and Fermat's little theorem using primes is also commonly used in securing keys.

Whatsapp: Whatsapp's end-to-end encryption is hard to crack for the simple reason that it is end-to-end meaning even whatsapp does not have a key to the encrypted message. It is not known if there is a backdoor – a loophole in this system, but even if it is, whatsapp won't be aware of it by design.

Chinese encryption: In 2017, Chinese scientists made the first 'unhackable' call to Vienna. It uses the method of Quantum communications, which send information embedded in entangled particles of light via satellite. If someone tries to intercept the photons exchanged between the satellite and the ground station and to measure their polarization, the quantum state of the photons will be changed by this measurement attempt. So it is always possible to tell if the information has been intercepted.

Quantum encryption: Quantum encryption doesn't encrypt user data, but makes it possible for users to securely distribute keys to each other, which can then be used for encrypted communication. Here the key was based on quantum entanglement. Essentially photons from the transmitter are polarised using filters. These photons can be accurately measured again only using filters like the one that originally produced them. If an interceptor uses a different filter, then it will change the spin of the photons and thus leave its mark on the key. It also uses the phenomenon of quantum entanglement where pairs of entangled photons between the sender and receiver are used for verification of purity of data.

10. Do you know the ASER statistics on maths? Why are kids in primary sections so bad in basic maths?

Notes: (ASER statistics given before). Studies have shown that an intuitive sense of numbers is transferred from parents to children. There is a strong correlation between parents who were bad at mathematics and children who are too. Therefore children in primary sections have wide variation in their development of 'number sense'. Our current system is unable to deal with this variation. Children who need time just end up developing aversion towards the subject. At primary level, especially for slow learners number sense can be developed by playing games, and developing graphic techniques. Our primary schools are underfunded and teachers overloaded

with ‘baby-sitting’ responsibilities. Naturally, they are unable to use these unconventional methods.

11. **With the onset of tablet-based learning, do you think kids can learn maths without the help of a teacher?**

    Suggested points: Experience from around the world shows that, over time, teachers’ role becomes more central - and not peripheral- as a result of the introduction of new technologies. Introducing new technologies will replace some of the things that teachers do and will require teachers to take up newer duties and responsibilities. Nevertheless, teachers who aren’t comfortable with technologies will be replaced by teachers who are. Also, in rural areas of our country, where teacher absenteeism is a major problem, tablet based learning can solve part of the problem.

    For eg. Tablets are perfect for modular learning. These modules can be of varying level of difficulty. Teachers can assign modules based on a child’s current level of understanding and capability. Also, the job of monitoring progress and counselling students as well as parents in how to proceed with the child’s curriculum is something the teachers only can take up. Tablets will be good for repetitive tasks like practicing simple questions, but as difficulty of questions and concepts rise, only a good teacher can do justice to it.

12. **Where does India stand on the world stage in mathematics research? Why has no Indian received a field’s medal? Why can’t we produce a Ramanujan again?**

    Notes: A few Indian Institutes do have some standing Internationally – Indian Institute of Science, Bangalore; Indian Statistical Institute, Kolkata, Tata Institute of Fundamental Research, Mumbai; Indian Institutes of Technology; Institute of Mathematical Sciences, Chennai; Chennai Mathematical Institute.

    Nevertheless, for the size of our university system (>300), Indian mathematics research has been dismal. Some of the reasons are:

    i. The university system incentivises teaching at a large scale, rather than research.
    ii. Traditionally Indian Mathematics research has been theory-oriented. We were slow to take up computational aspect of mathematics research, which had negative consequences. Interdisciplinary research was also neglected until a few decades ago. For

example, mathematical biology, or use of advanced mathematics in social sciences is largely unheard of.

iii. Funding is a general concern for most research areas in universities. Even so, the administrative procedures tend to slow down the output.

iv. In Advanced mathematics research, the output in terms of benefit to public is not immediately obvious. So, for a middle income country like India, it is a difficult choice to invest large sums in mathematics research.

v. Collaborations with industry is still largely restricted to engineering departments, and even there it is the exception rather than the rule. Unless we have cutting edge industrial units like Bell Labs, expectation of industry pushing mathematics research is low.

vi. Because of difference in lifestyle, well established mathematics faculty tend to remain in developed countries. Our few good institutes have not been able to extend their reach into the smaller universities.

As of now, even if we do produce a mathematician of the same standing as Ramanujan, he or she will have to become a part of the global network from the developed countries, and be Indian only in origin – like Manjul Bhargava, Amartya Sen or Abhijeet Banerjee.

13. How will you explain Game theory to a lay person?

Notes: One of the easiest ways to introduce a lay person to game theory is by the example of 'prisoners' dilemma'.

The Dilemma: Two prisoners A and B are being interrogated by the police for a crime (say robbery). They can either cooperate with each other (by staying silent) or defect each other (by naming the other in the crime – a betrayal). Now, if both stay silent, both serve 1 year sentence (total 2 years). If both betray each other, both serve 2 years sentence (total 4 years). But if A cooperates and B betrays A, then B gets zero sentence, and A gets 3 years sentence (total 3 years).

	B stays silent (Cooperates)	B Betrays A (Defects)
A stays silent (Cooperates)	Both serve 1 year	A serves 3 years, B goes free
A Betrays B (Defects)	A goes free, B serves 3 years	Both serves 2 years

It is clear that the most beneficial strategy for the pair is to remain silent, but it is not the most rewarding option for the individuals themselves.

Application: This kind of decision making is frequent in economics, politics, policy making, even running a household. The prisoners' dilemma itself is seen in the 'tragedy of the commons' eg. Preserving the environment by use of public transport rather than private vehicles. The behaviour that is most beneficial for the collective group must be incentivised and/or legally enforced.

14. What is Chaos theory? Can we apply it in administration?

Notes: Chaos theory is an attempt to see and understand the underlying order of complex systems that may appear to be without order at first glance. The main idea is that small differences in the initial state of a system can cause large differences in a future state of the system. This is also termed as "non-linear dynamics". This is one the reasons why even the largest computers cannot predict the weather accurately over the medium term. Minor differences in the measurement of current state of weather, can cause wide variation in the possible weather a few weeks in the future.

Other examples: Stock markets are inherently chaotic. This is one of the reasons why even the brightest minds can sometimes not see an upcoming market crash. Also, no one can predict the market accurately for the same reason.

Similarly, turbulence is a field where chaotic nature seems inherent, causing enormous difficulty to mathematicians in predicting the behaviour of the system. Another simple example would be the double pendulum. Its behaviour depends on the starting point, and no single equation can predict its motion.

Administration: Chaos theory is able to deal with uncertainty in a way previously established deterministic mathematics was not able to. This makes chaos theory extremely useful in understanding, modelling and predicting the behaviour of complex organizations and their administration. This is primarily due to non-linear dynamics of modern organizations including cities and societies. It has been said that much of empirical research from distinct areas such as disaster recovery, crisis management in business, and psychological aspect of stress embrace the theoretical framework of chaos theory. For eg. The revival of functioning administrative and social systems in the aftermath of Hurricane Katrina were reliably predicted by chaos theory.

15. **Why does a tripod have three legs?**

    Notes: This is because of the mathematical principle that three points will always lie on a plane. While an equilibrium can be formed by two legs, it would be an unstable one. On the other hand, a four-legged stand is likely to wobble, because four points need not lie on the same plane.

16. **Why do most fans have 3 blades. If 3 is the best configuration, why do some have 4 blades?**

    Notes: Fans with 4 or 5 blades are common in US and Canada, whereas fans with 3 blades are the most common in India. Although all the configurations can do the job of cooling, fans with 3 blades are of lighter weight. So, they can run at a greater rpm and it reduces the cost. Since, in North America, Air conditioners are quite common, fans only have to augment their cooling effect, hence are run at slower speeds. Whereas in India, fans have to necessarily run at a high rpm. Cost and speed are the factors that make 3-blade fans more appropriate for india.

17. **Where can I see negative integers in real life? What about imaginary numbers?**

    Notes: Negative integers can be seen in negative temperatures and negative bank balance (loan etc). Negative interest rates have occasionally been seen in some European economies. Negative growth rate is seen in a recession. Negative marking in exams etc.

    Imaginary numbers: Imaginary numbers, or rather complex numbers are an entire number system based on the square root of -1. Complex numbers are like air – they may not be visible but we can feel their effects. Primarily, complex numbers were necessary to solve polynomial equations, which led to solutions of differential equations, which are applicable in everything from modelling the weather to architecture, computation to epidemiology etc. On a more real-world sense, complex numbers are essential in understanding the behaviour of AC (alternating

current). As we have seen, complex analysis is also directly helpful in modelling fluid dynamics, especially vortices.

18. **What comes after Gigabytes? What units are smaller than nanometers?**

    Notes: Giga- < Tera- < Peta- < Exa- (varying by a factor of 1000)

    Also, Nano- > Pico- > Femto- > Atto- (varying by a factor of 1000)

19. **Why is a circle 360 degrees? Why 24 hours in a day? 12 months in a year?**

    Notes: The Babylonians used a number system based on 60. And the Egyptians had a year that was formed of 360 days and 6 seasons. This eventually brought 360 degrees, 60 minutes and 60 seconds into use.

    12 months: 12 lunar cycles in a year.

20. **What is the geometry behind 'yantras'?**

    Notes: The Sri Yantra contains geometric shapes such as an outer square, three circles, 16 and 8 petal lotuses, and interlocked triangles. Each geometric shape has its own symbolic meaning. Overall, it is believed that this Yantra helps create energy that will help in meditation. Neverthess, rigorous research using control groups and tests of reproducibility and falsifiability has not been conducted. So it cannot be said with confidence that these claims are justified.

21. **Since you have fluid mechanics in syllabus, why are vortices formed?**

    Notes: Mathematically vortices are formed when the curl of velocity is non-zero. Physically, a vortex is formed whenever a fluid is forced through a hole. When too many particles are forced through a hole, conservation of mass and momentum necessitates that every particle must move towards the hole but now taking a longer route. This creates a spiralling effect, which when followed by all the particles becomes a vortex.

22. **Is there any maths in human body?**

    Notes: Apart from the number of limbs, digits etc, mathematics is everywhere in the human body. Mathematics is there in the beating of the heart, the rhythm of breathing, and the fluid flow of blood to every part of the body.

Pattern: The left-right symmetry itself is a geometric pattern. Golden ratio is found at many places in the body including: ratio of length of the body above the navel to below the navel; length of hand to forearm; length of the hand above and below the elbow; length of the leg above and below the knee etc. Even the ear follows the geometry of the golden spiral, a spiral formed by using golden ratio.

Brain: The brain especially uses complex mathematical computations to process incoming electrical signals and convert it into information about our surroundings, responding to stimuli, making decisions and even thinking.

23. Is there any maths in this room?

Notes: Dimensions of the room, the furniture etc; Maths was used to design the building; Bodies of all the members sitting here; The money flow in bring all the furniture, as well as the people in the room also involved maths.

24. What are transcendental numbers? Why are they called so?

Notes: Transcendental numbers are those that aren't roots of some polynomial equation. Most famous transcendental numbers are *e* and π.

Transcendental numbers are called so because our intuitive idea of numbers is more or less limited to algebraic numbers. Numbers like *e* transcend that idea.

25. What exactly is *e*?

Notes: The intuitive idea of *e* comes from the function $f(x) = e^x$

The speciality of this function is that at any point, value of the function is the same as its slope at that point. This is the only function which grows at the same rate as its value at any point. Later it has been found that e is the infinite sum of reciprocals of factorials. i.e. $\Sigma(1/n!)$

A real world way to look at *e* would be that it is the amount of money generated if a unit principal amount is compounded every moment.