XPONENT 2017

DEPARTMENT OF MATHEMATICS
IIT KHARAGPUR

ACKNOWLEDGEMENT

We would like to take this opportunity to extend our heartfelt gratitude to all the members of the department, students and faculty alike, whose response to previous editions of the Xponent has motivated us to no limits. We would like to thank Head of the Department, Prof. M.P.Biswal, and the Professor-in-Charge of the Colloquium, Prof. R.K.Pandey, who had been most supportive of every Colloquium initiative.

FROM THE PRESIDENT'S DESK

On the behalf of The Mathematics Colloquium team, I am pleased to present to you the tenth edition of Xponent. It couldn't have been possible without the efforts of and enthusiasm shown by the whole team. Congratulations to all of you.

As I reach the end of my tenure, looking back, it seems only yesterday that the baton was passed over to me. Time flies!

An year has passed and the time has come for me to pass on the baton, as is the custom. A big thank you! To all, who came and enjoyed the events. To all, who helped in organizing them. We started off by Freshers' Introduction followed up by the Teachers' day celebrations and Saraswati Puja. Career Fundae session conducted for pre-final and final year students and talks conducted by in-house faculty were much appreciated. I would hereby also request the readers if they can come up with innovative ideas for more effective student-faculty interactions outside of class that remains our primary aim.

It has been a wonderful year; a unique learning experience both personally for me and for the club as well. The Mathematics Colloquium, in general, is fun and by being at the helm of a hobby club, I did out best for upholding the culture in the institute. I extend my sincere gratitude for being a part of our events and making them awesome.

Signing off is mixed feeling. You feel happy for what you have achieved in the tenure but simultaneously you feel sad for missing the family you have been part of for so long. My best wishes to the next team and hope they take the club to new heights.

Signing off,
Sushmita Pandula
President
The Mathematics Colloquium

EDITORIAL

Welcome to the 10th edition of Xponent. Hope it brings something for every reader interested in mathematics. Over ten years ago, the Mathematics Colloquium started to publish a magazine. And here you hold the 10th incarnation of the same.

Humor quotient is intact and affliction to the weird and amazing world of mathematics through the articles is a sure shot. I double dare you, stop reading this magazine, or you will be lovin' it. (This magazine was not sponsored by McDonalds, in case you got that lovin' pun)

We have an article on Simpsons as well. Why? Because that show is a legend! They have predicted almost every freaking phenomenon on this miserable planet. They predicted that I was going to write an article on them. They also predicted P=NP in one show and P≠NP in another show. I bet they had their own ballad 'Schrödinger- Schrödinger everywhere, be it Mathematics or Computing'. And that reminds me about the History of Undecidability, which finds a place in this humble magazine as well. Little had I known that bringing out a magazine demanded so much dedication and time. So be a good peeping tom and savor the contents. Bon Libre-Voyage!

Lastly, I wish the departing batch a very good luck for their future and am confident that they will be successful in their endeavors and make the department and IIT Kharagpur proud. I feel proud to hand over to you this Nostalgic Memorabilia.

Bhuvnesh Bhuwan
Editor
The Mathematics Colloquium

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SIMPSONS AND MATHEMATICS

Without doubt, the most mathematically sophisticated television show in the history of primetime broadcasting is *The Simpsons*. This is not a figment of my deranged mind, which admittedly is obsessed with both *The Simpsons* and mathematics, but rather it is a concrete claim backed up in a series of remarkable episodes.

The first proper episode of the series in 1989 contained numerous mathematical references (including a joke about calculus), while the infamous "Treehouse of Horror VI" episode presents the most intense five minutes of mathematics ever broadcast to a mass audience. Moreover, *The Simpsons* has even offered viewers an obscure joke about Fermat's Last Theorem, the most notorious equation in the history of mathematics.

These examples are just the tip of the iceberg, because the show's writing team includes several mathematical heavyweights. Al Jean, who worked on the first series and is now executive producer, went to Harvard University to study mathematics at the age of just 16. Others have similarly impressive degrees in maths, a few can even boast PhDs, and Jeff Westbrook resigned from a senior research post at Yale University to write scripts for Homer, Marge and the other residents of Springfield. (Simpsons writer Al Jean, third from left in the back row, in the mathematics team from 1977 Roeper School yearbook. Photograph: Courtesy of Al Jean)

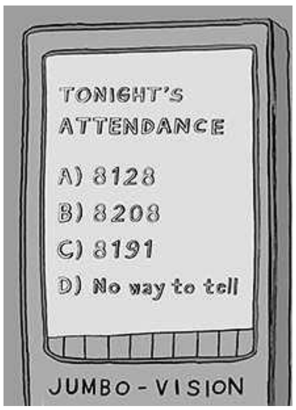
When they moved from academia to Fox Studios, these writers retained their passion for numbers and they have secretly planted mathematical references in dozens of episodes. Until now, only extreme geeks have been aware that the writers have been smuggling mathematics into their scripts while the rest of the planet has been oblivious to the numerous nods to number theory and geometry.

The 2006 episode "Marge and Homer turn a Couple Play" for example, contains a triple dose of secret mathematics. The storyline revolves around Marge and Homer's efforts to help baseball star Buck Mitchell and his wife Tabitha Vixx, who are experiencing marital difficulties. The episode climaxes with Tabitha appearing on the Jumbo Vision screen at the Springfield stadium, where she publicly proclaims her love for Buck. More important, just before she appears on the screen, it displays a question that asks the baseball fans in the crowd to guess the attendance.

The Jumbo Vision screen from 'Marge and Homer Turn a Couple Play', showing a perfect number, a narcissistic number and a Mersenne prime number.

The screen displays three multiple choice options; 8,128, 8,208 and 8,191. These digits might seem arbitrary and innocuous, but in fact they represent a perfect number, a narcissistic number and a Mersenne Prime.

8,128 is called a perfect number, because its divisors add up to the number itself. The smallest perfect number is 6, because 1, 2 and 3 not only divide into 6, but they also add up to 6. The second perfect number is 28, because 1, 2, 4, 7 and 14 not only divide into 28, but they also add up to 28. The third perfect number is 496, and the fourth one is 8,128, which appears in this episode. As René Descartes, the 17th-century French mathematician (and philosopher) pointed out: "Perfect numbers, like perfect men, are very rare."



8,208 is a narcissistic number because it contains 4 digits, and raising each of these digits to the 4th power generates four numbers that add up to itself: $8^4 + 2^4 + 0^4 + 8^4 = 8{,}208$.

The fact that 8,208 can recreate itself from its own components hints that the number is in love with itself, hence the narcissistic label. Among the infinity of numbers, fewer than 100 exhibit narcissism.

8,191 is a prime number, because it has no divisors other than 1 and the number itself, and it is labelled a Mersenne prime because another 17th-century French mathematician, Marin Mersenne, spotted that 8,191 was equal to $2^{13} - 1$. More generally, Mersenne primes fit the pattern $2^p - 1$, where p is any prime number.

Not surprisingly, several of the mathematical quips in *The Simpsons* relate to Homer and Marge's daughter, Lisa. She is proud to be a nerd and her grasp of everything from trigonometry to logarithms is recognized by Principal Skinner in the episode "Treehouse of Horror X" (1999). After a stack of bench seats falls on Lisa, he cries out: "She's been crushed! And so, have the hopes of our Mathletics team."

In "Money Bart", much of the episode is dedicated to Lisa's ruthlessly mathematical approach to coaching a winning baseball team. The entire storyline is rooted in statistics, but the most significant nerd reference appears and disappears in a blink of an eye. Just before her first big game in charge, we see Lisa poring over piles of technical books. This extraordinary sight prompts a reporter to remark: "I haven't seen these many books in a dugout since Albert Einstein went canoeing." Those who concentrate hard enough will spot that one of the books is titled "$e^{i\pi} + 1 = 0$". To the untrained eye, this is just another random equation. To the mathematical eye, this is the single most beautiful equation in history, because it combines five of the fundamental ingredients of mathematics (0, 1, e, i, and π) in one elegant recipe. It is known as Euler's identity, and named after the 18th-century Swiss genius Leonhard Euler.

When I met the writers in Los Angeles last year, they explained that this reference to Euler's identity is a perfect example of a freeze-frame gag, a form of humor that was largely developed by the show's writing team. Freeze-frame gags are visual quips that fly by unnoticed during the normal course of viewing, but which become more obvious when the program is paused.

To some extent, the freeze-frame gag was a product of technological developments. Roughly 65% of American households owned a video recorder by 1989, when *The Simpsons* was launched. This meant that fans could watch episodes several times and pause a scene when they had spotted something curious. Also, in 1989 more than 10% of households had a home computer and a few people even had access to the internet. The following year saw the birth of alt.tv.simpsons, a usenet newsgroup that allowed fans to share, among other things, their freeze-frame discoveries.

The writers relished the notion of the freeze-frame gag, because it enabled them to increase the comedic density. The mathematicians on the show were doubly keen because freeze-frame gags also gave them the opportunity to introduce obscure references that rewarded the hard-core number nerds.

My favorite freeze-frame gag appears in "The Wizard of Evergreen Terrace" (1998), in which Homer tries to become an inventor. In one scene, we see him busily scribbling equations on a blackboard. One of the equations relates to the mass of the Higgs boson, another concerns cosmology and the bottom line explores the geometry of doughnuts, but the most interesting equation is the second one, which appears to be a counterexample to Fermat's last theorem.

Although it was only on screen for a moment, this equation immediately caught my eye, because I have written a book on Fermat's last theorem. Homer's scribble sent a shiver down my spine. I was so shocked that I almost snapped my slide rule.

To appreciate my reaction, it is necessary to be aware of the colorful history behind Fermat's last theorem. In short, a 17th-century French mathematician called Pierre de Fermat believed that it was impossible to find numbers that fitted a particular equation, and he left a tantalizing note proclaiming that he had a proof of this fact, but he never wrote down the proof itself. For more than 300 years, mathematicians desperately tried and failed to rediscover Fermat's proof, which only made his inadvertent challenge even more infamous. Eventually, in the 1980s, Professor Andrew Wiles (now Sir Andrew Wiles) worked in secrecy for seven years to fulfil a childhood dream and build a proof that confirmed that Fermat was right, inasmuch as the following equation has no solution: $x^n + y^n = z^n$, for $n > 2$. It is neither necessary to understand the proof nor to examine the equation in detail, except I should stress again that both Wiles and Fermat claimed, indeed proved, that this equation has no solutions, yet Homer's blackboard proves the opposite!

$3987^{12} + 4365^{12} = 4472^{12}$.

Check it for yourself on your phone calculator and you will find that the equation balances! I realize that I have used two exclamation marks in two consecutive sentences, but this is an extraordinary mathematical circumstance. Homer had the audacity and genius to defy two of the greatest mathematicians in history.

Unfortunately, this is a "close but no cigar" moment for Homer. Although the numbers appear to work on a phone calculator with display of perhaps 10 digits, a closer inspection reveals that this is a so-called near miss solution. In other words, there is a minuscule margin of error, with the left side of the equation being 0.000000002% larger than the right side.

This prank was planted into the episode by David S Cohen, who later changed his name to David X Cohen, in part to reflect his love of algebra. Cohen joined the writing team of *The Simpsons* soon after completing a masters' degree in computer science at the University of California, Berkeley. While working on "The Wizard of Evergreen Terrace", Cohen took a break in order to write a computer program that would scan through values of x, y, z, and n until it found a pseudo-solution to Fermat's equation. (Simpsons writer David X Cohen pictured in the Dwight Morrow High School yearbook of 1984. Photograph: Courtesy of David X Cohen)

As soon as the episode aired, Cohen patrolled the online message boards to see if anybody had noticed his fake equation. He eventually spotted a posting that read: "I know this would seem to disprove Fermat's last theorem, but I typed it in my calculator and it worked. What in the world is going on here?"

In the late 1990s, Cohen worked with Matt Groening (creator of *The Simpsons*) to develop *Futurama*, an animated science fiction series set a thousand years into the future. He recruited some more mathematicians to join *Futurama's* writing team, including Ken Keeler whose doctoral thesis in applied mathematics was entitled "Map Representations and Optimal Encoding for Image Segmentation".

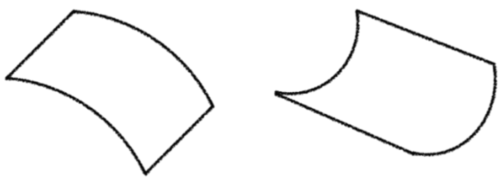
Not surprisingly, this sister series contained dozens of subtle mathematical references, including an indirect tribute to the great Indian mathematician Ramanujan, objects based on the geometry of the impossible Klein bottle, a freeze-frame gag about the unsolved P v NP problem, a script line about uncountable infinites and much more. Indeed, *Futurama* can boast the first piece of genuinely innovative and bespoke mathematics to have been created solely for the purposes of a comedy storyline.

Meanwhile, *The Simpsons* fought back with even more nerdy references, with appearances by the French mathematician Blaise Pascal, numerous jokes about π, a reframing of a classic puzzle by the English polymath Alcuin of York (c735 – 804) and much more.

After spending a week with the writers, it was clear that their fascination with numbers is as strong as ever, and to some extent there was even regret that they had abandoned mathematics in favor of television. In the case of Cohen, his regret at neither proving a deep conjecture nor discovering new geometries is tempered by the feeling that he might have made an indirect contribution to research: "I really would have preferred to live my whole life as a researcher, but I do think that *The Simpsons* and *Futurama* make mathematics and science fun, and perhaps that could influence a new generation of people; so, somebody else down the line might achieve what I didn't achieve. I can certainly console myself and sleep at night with thoughts like that."

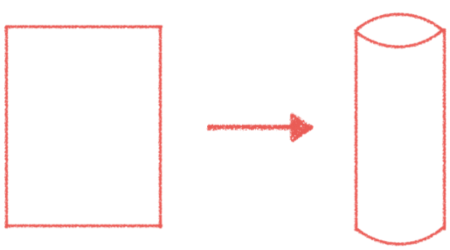
HOW TO EAT PIZZA a.k.a THEOREMA EGREGIUM

WE'VE ALL BEEN there. You pick up a slice of pizza and you're about to take a bite, but it flops over and dangles limply from your fingers instead. The crust isn't stiff enough to support the weight of the slice. Maybe you should have gone for fewer toppings. But there's no need to despair, for years of pizza eating experience have taught you how to deal with this situation. Just fold the pizza slice into a U shape (aka the fold hold). This keeps the slice from flopping over, and you can proceed to enjoy your meal. (If you don't have a slice of pizza handy, you can try this out with a sheet of paper.)



Dangle a sheet of paper and it flops over, but give it a fold and it becomes stiff. Why?

Behind this pizza trick lies a powerful mathematical result about curved surfaces, one that's so startling that its discoverer, the mathematical genius Carl Friedrich Gauss, named it Theorema Egregium, Latin for excellent or remarkable theorem.



Take a sheet of paper and roll it into a cylinder. It might seem obvious that the paper is flat, while the cylinder is curved. But Gauss thought about this differently. He wanted to define the curvature of a surface in a way that doesn't change when you bend the surface.

If you zoom in on an ant that lives on the cylinder, there are many possible paths the ant could take. It could decide to walk down the curved path, tracing out a circle, or it could walk along the flat path, tracing out a straight line. Or it might do something in between, tracing out a helix.

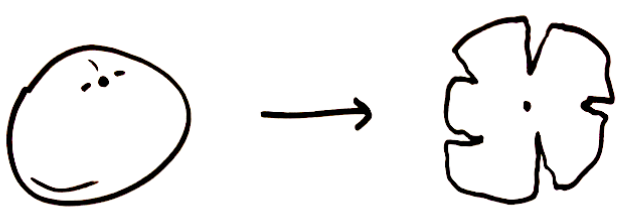
Gauss's brilliant insight was to define the curvature of a surface in a way that takes all these choices into account. Here's how it works. Starting at any point, find the two most extreme paths that an ant can choose (i.e. the most concave path and the most convex path). Then multiply the curvature of those paths together (curvature is positive for concave paths, zero for flat paths, and negative for convex paths). And, voila, the number you get is Gauss's definition of the curvature at that point.

Let's try some examples. For the ant on the cylinder, the two extreme paths available to it are the curved, circle-shaped path, and the flat, straight-line path. But since the flat path has zero curvature, when you multiply the two curvatures together you get zero. As mathematicians would say, a cylinder is flat — it has zero Gaussian curvature. Which reflects the fact that you can roll one out of a sheet of paper.

If, instead, the ant lived on a ball, there would be no flat paths available to it. Now every path curves by the same amount, and so the Gaussian curvature is some positive number. So, spheres are curved while cylinders are flat. You can bend a sheet of paper into a tube, but you can never bend it into a ball.

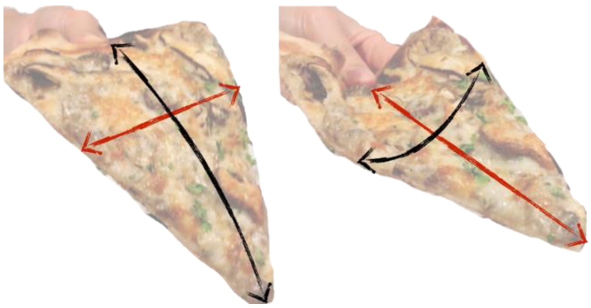
Gauss's remarkable theorem, the one which I like to imagine made him giggle with joy, is that an ant living on a surface can work out its curvature without ever having to step outside the surface, just by measuring distances and doing some math. This, by the way, is what allows us to determine whether our universe is curved without ever having to step outside of the universe (as far as we can tell, it's flat).

A surprising consequence of this result is that you can take a surface and bend it any way you like, so long as you don't stretch, shrink or tear it, and the Gaussian curvature stays the same. That's because bending doesn't change any distances on the surface, and so the ant living on the surface would still calculate the same Gaussian curvature as before.



This might sound a little abstract, but it has real-life consequences. Cut an orange in half, eat the insides (yum), then place the dome-shaped peel on the ground and stomp on it. The peel will never flatten out into a circle. Instead, it'll tear itself apart. That's because a sphere and a flat surface have different Gaussian curvatures, so there's no way to flatten a sphere without distorting or tearing it. Ever tried gift wrapping a basketball? Same problem. No matter how you bend a sheet of paper, it’ll always retain a trace of its original flatness, so you end up with a crinkled mess.

Another consequence of Gauss’s theorem is that it’s impossible to accurately depict a map on paper. The map of the world that you’re used to seeing depicts angles correctly, but it grossly distorts areas. The Museum of Math points out that clothing designers have a similar challenge — they design patterns on a flat surface that have to fit our curved bodies.



What does any of this have to do with pizza? Well, the pizza slice was flat before you picked it up (in math speak, it has zero Gaussian curvature). Gauss’s remarkable theorem assures us that one direction of the slice must always remain flat — no matter how you bend it, the pizza must retain a trace of its original flatness. When the slice flops over, the flat direction (shown in red below) is pointed sideways, which isn’t helpful for eating it. But by folding the pizza slice sideways, you’re forcing it to become flat in the other direction – the one that points towards your mouth. Theorema egregium, indeed.

By curving a sheet in one direction, you force it to become stiff in the other direction. Once you recognize this idea, you start seeing it everywhere. Look closely at a blade of grass. It’s often folded along its central vein, which adds stiffness and prevents it from flopping over. Engineers frequently use curvature to add strength to structures. In the Zarzuela race track in Madrid, the Spanish structural engineer Eduardo Torroja designed an innovative concrete roof that stretches out from the stadium, covering a large area while remaining just a few inches thick. It’s the pizza trick in disguise.

Curvature creates strength. Think about this: you can stand on an empty soda can, and it’ll easily carry your weight. Yet the wall of this can is just a few thousandths of an inch thick, or about as thick as a sheet of paper. The secret to a soda can’s incredible stiffness is its curvature. You can demonstrate this dramatically if someone pokes the can with a pencil while you’re standing on it. With even just a tiny dent, it’ll catastrophically buckle under your weight.

Strength through curvature is an idea that shapes our world, and it has its roots in geometry. So, the next time that you grab a slice, take a moment to look around, and appreciate the vast legacy behind this simple pizza trick.

THE P vs NP PROBLEM, OR HOW SUDOKU CAN CURE CANCER

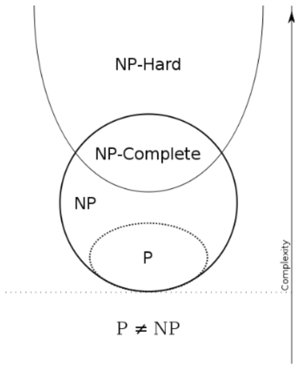
The P versus NP problem is the deepest unanswered question in computer science and maybe in all of math. This article certainly dares not to solve the problem, but will look at the intricacies surrounding it and how problems as seemingly difficult as protein folding and making up crossword puzzles share a common core difficulty that turns out to be a lot like Sudoku. Well…okay! Basically, it is a sudoku!

In 2000, the Clay Institute offered 1 Million Dollars each for the solutions to the seven key problems in Math, the Millennium Prize Problems. These are profound and difficult problems and for most of them it takes a lot of specialized knowledge to even understand the question.

Millennium Prize Problems:
1. Birch and Swinnerton-Dyer Conjecture
2. Hodge Conjecture
3. Navier-Stokes Equations
4. P vs NP
5. Poincare Conjecture
6. Riemann Hypothesis
7. Yang-Mills Theory

Of the seven problems, P vs NP was both the most recently conceived (in 1971) and by far the easiest one to understand and explain. And in March,2010 the Clay Institute awarded the first of its seven prizes for the solution to Poincare Conjecture, and not P vs NP.

P stands for Polynomial time. All the P-Class problems have time complexity as some polynomial function of its size. NP stands for Non-Deterministic Polynomial time which being a math terminology is almost a mean-spirited way of saying that if you had a bajillion computers then you could check all possible answers at the same time and you could find a correct solution in polynomial time.



So, what is the P vs NP Question? Back in the 1970s, computer scientists were busily figuring out how to program their retro fabulous, cabinet-sized computers to solve all the world's problems. Sometimes the first program anyone could think of for a particular problem would be unworkably slow. But then, over time people would come up with clever ways to make it faster, or at least, that happened for some problems. For others, nobody was coming up with faster programs. To get a handle on the situation, they started sorting the problems into classes based on how fast the program can solve them. For problems like multiplication they had really fast programs, and for others, like playing absolutely perfect chess they figured out there was just no fast program. But for a bunch in between they weren't sure whether there was a fast way to do it. So, they kept trying. This is where P and NP comes in. Skipping a ton of details for a moment, P is a class that basically includes all the problems that can be solved by a reasonably fast program, like multiplication or alphabetizing a list of names(sorting). And then, around and including P we sort of discovered a class called NP. That's all the problems where, if you're given a correct solution you can at least check it in a reasonable amount of time. NP was totally maddening, because it contained a lot of important problems like vehicle routing and scheduling and circuit design and databases. And often, we get lucky and find that an NP problem was actually a part of P (finding primes) and we would have our fast program. But for a lot of them, that didn't seem to be happening.
So people started to wonder whether everything in NP would turn out to be in P or if there were some problems that were truly harder than the ones in P. That's the P vs NP question. If all the NP problems are really in P, a lot of important puzzles we have been struggling with are gonna turn out to be easy for computers to solve. Puzzles connected to biology, and curing cancer; puzzles in business and economics et cetera. We would have a lot of miracle answers almost overnight. And also, the encryption we use for things like online banking would be easy to crack, because it's based on NP problems.

I like to think of the problems in NP as being basically like "puzzles" because I think what makes a puzzle a puzzle is that it's a problem where you can give away the answer. And that's what NP means. Like with Sudoku. Sudoku Puzzles can take a long time to solve but if I give you a solved sudoku grid, checking it for mistakes is pretty quick. You might think that solving a Sudoku puzzle is not that hard at all, but your perspective is limited to the 9×9 grid sudoku only, try thinking about a 100×100 or 1000×1000 grid Sudoku.

Outside of NP there are problems where it's hard to even check an answer. For instance, what's the best move in any chess game? I could tell you the answer but how would you know whether I am right? Well, you wouldn't, because finding out requires a calculation so enormous that there's a pretty good argument we will never be able to build a computer that could do it. To me, that's not a very good puzzle. It's practically impossible to know whether you have solved it. On the other side, are all the reasonable solvable puzzles in P. These are clearly also on NP because

one way to check an answer is to go through the process of finding it yourself. Like if I tell you that the answer to
51×3 is 153, how would you check whether I'm right? You would probably just multiply 51 by 3 yourself because it's fast to do it.

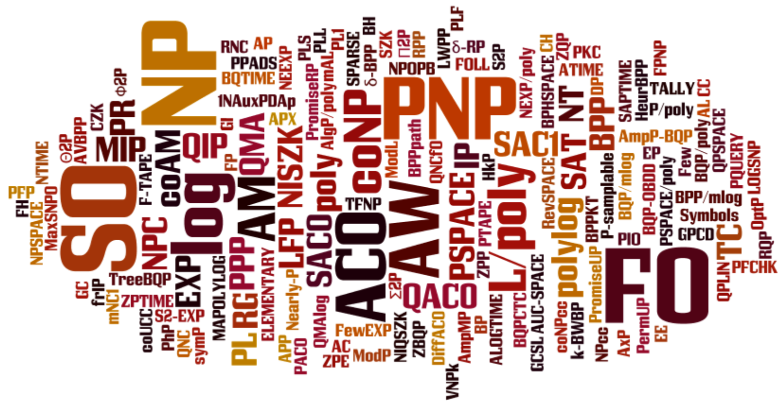
But Sudoku is different, or at least we think it is. It seems like solving a Sudoku grid is lot harder than checking a solution, but in fact nobody's been able to prove it yet. As far as we know, there could be a clever way of playing Sudoku, much much faster.

So that's the question. Does being able to quickly recognize correct answers mean there's also a quick way to find them? Nobody knows for sure, but either way, figuring out exactly how this works would teach us something important about the nature of computation.

Actually pretty much everybody thinks it's obvious that NP contains more problems than P. It's just that we haven't been able to prove it. The bad news for fast solutions came in the early 1970s where complexity researchers realized that dozens of those NP Problems they were struggling with were essentially all the same problem! (with some easy polynomial time complications thrown in here and there). These are called "NP-complete" problems, and since that first batch in the 70s, we have added Sudoku and protein folding and problems underlying puzzles like Battleship, FreeCell, Master Mind, Tetris, Minesweeper, and making up crossword puzzles. Even classic video games like Super Mario Bros. and Metroid turn out to be connected to NP Complete level traversal problems. NP-complete is yet another Math phrase meaning that these problems include all the really hard parts of every NP problem. A fast program for solving any NP-complete problem could be used to solve every problem in NP. The whole class would instantly collapse. So yeah, amazingly, sudoku is hard because it involves, literally, the same NP-complete task that makes protein-folding hard. If you come up with a profoundly faster way to play sudoku, let somebody know, okay? Because fast protein folding would help us cure cancer. But the fact that a bunch of smart people have all been unsuccessful in coming up with fast programs to solve what turned out to be, essentially, the same problem, looks like pretty good clue that the fast programs just aren't out there.

So why has it been so hard to prove P vs NP one way or other? Well, fun fact, proving things is an NP problem. The P vs NP problem *is* one of these problems. So this might be difficult, or not? We don't know.

As the field of computational complexity has developed, we have discovered a lot of complexity. The P vs NP question turns out to just the main attraction in a huge and complicated "zoo" of complexity classes. Beyond NP there are even harder classes of problems like "EXP"—the class of problems including figuring out the best move in chess, that takes exponential time to even check. This whole upper area of problems that are at least as hard a s NP-complete is called "NP-hard". There's also "Co=NP"—the class of problems where instead being easy to check right answers, it's easy to exclude wrong answers, which may or may not be the same as NP. And then there's "P-SPACE", the class of problems that can be solved given unlimited time, but using only a polynomial amount of space for memory. There are also problems that can be solved probabilistically in polynomial time. That class is called "BPP", and it may or may not be the same as P. And then there's a quantum computing analog of BPP called BQP. All over the places in here there are complicated little classes that would take a lot of explaining. And, actually some of these turn out to be infinite branches of problems that are slightly more difficult from the ones beneath them. We know there's an exponential hierarchy and there's probably a polynomial hierarchy. And beyond all of this are problems that are just not solvable by any computer in any amount of time or space (e.g. Turing's Halting Problem).



To me, the amazing thing about this whole complexity zoo is that we are talking literally about what can be computed in a given amount of space and time. We are not just looking at the nature of computation here, we are looking at the nature of time and space themselves. This mess of computational complexity classes, I think, ultimately has implications for physics, chemistry, biology and basics understanding of everything. As an example of those implications, here's how Scott Aaronson, a complexity researcher at MIT, explain his intuition about P vs NP:

"If P=NP, then the world would be a profoundly different place than we usually assume it to be. There would be no special value in 'creative leaps', no fundamental gap between solving a problem and recognizing the solution once it's found. Everyone who could appreciate a symphony would be a Mozart; everyone who could follow a step-by-step-argument would be Gauss"

In a very real way, something connected to P vs NP shows up in the struggle of scientists and artists. Chopin once said: “*Simplicity is the final achievement. After one has played a vast quantity of notes and more notes, it is simplicity that emerges as the crowning reward of art*”

And Jack Kerouac put it like this:

T **O N E** U **D A Y** D T R **I** N G C H U R

I C **W I L L** H B F **F I N D** C O O K L P

T H E E V I N L T **R I G H T** F B Q P Q

W O R D S N P U B **A N D** E **T H E Y** L

W I L L H B **B E** M A **S I M P L E** E P S

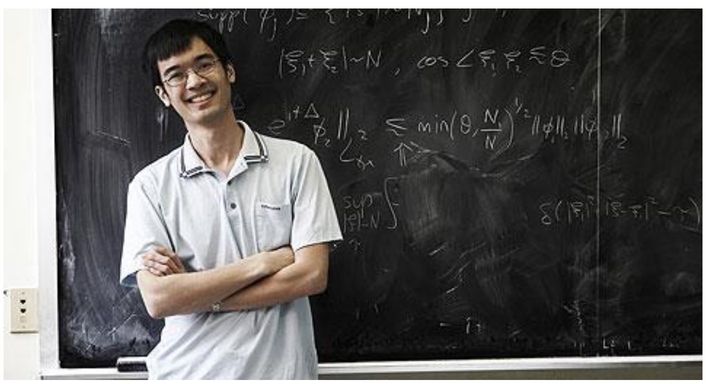
THE LEGEND OF QUESTION 6

It's a secret to no one that math is hard, so when you start talking about the hardest maths problems ever, things start to get a little crazy. Take the innocuously named Question 6, which is so complex, it can bring mathematicians to tears.

The Legend of Question 6 spawned from a maths competition for *high-schoolers* held in Australia in 1988. (Yep, they make them tough down there.)

The competition was the International Mathematical Olympiad, which is held every year in a different country, and only six kids from every country are selected to compete. Points are scored on how each 'mathlete' performs on six different questions.

In 1988, the Australian Olympiad officials decided to throw a massive curveball to the kids on the final day of competition, and it's gone down in history as one of the toughest problems out there.



Just to give you an idea of how tough it was, the prodigal Australian-American mathematician Terrence Tao - recipient of the 2006 Fields Medal (the mathematician's 'Nobel Prize') - scored a 1 out of 7 when he attempted it although he had scored 7 out of 7 in the remaining 5 questions. But, you know, he was 13 at the time, so let's cut the man some slack.

What made Question 6 so hard is that it actually tried to pay mind games with you as you solved it.

Question 6 was actually submitted to the Australian Olympiad officials by a mathematician from West Germany, and the officials gave themselves SIX HOURS to solve it to see if it should be included in the event.

Not one official could solve Question 6 within the time limit. Some of the best mathematicians in the world at the time.

But they put it on a test for kids anyway, and only gave them about 90 minutes to solve it, because mathematicians have a great sense of humor. Out of the 260 mathletes that competed at this math Olympics, only 11 people solved it perfectly and only one person solved it awesomely. And he was Emanouil Atanassov from Bulgaria. Apart from getting a silver medal, he received a special prize for solving question number 6 awesomely.

So, you just want to know what this problem is, right? Okay, here it is:
“Let a and b be positive integers such that ab + 1 divides $a^2 + b^2$. Show that $a^2 + b^2$ / ab + 1 is the square of an integer.”

Oh, the irony! A problem statement so small and simple to understand, baffled mathematicians to uncomfortable proportions. I know you are looking for its solution. Let’s just say that it is beyond the scope of this magazine. But after all this time, you can always google it.

RAMANUJAN’S MAGIC SQUARE

22	12	18	87
88	17	9	25
10	24	89	16
19	86	23	11

This square might look like a normal magic square. But it ain’t one. It’s more special than that. This magic square was formed by the great mathematician of our country: Srinivasa Ramanujan

What’s so great in it?
1.Sum of numbers of any row is 39
2.Sum of numbers of any column is 139
3.Sum of numbers of any diagonal is 139

But every magic square has these properties. What makes this square special?

22	12	18	87
88	17	9	25
10	24	89	16
19	86	23	11

Sum of corner numbers is also 139!

22	12	18	87
88	17	9	25
10	24	89	16
19	86	23	11

Sum of Identical Colored boxes is also 139!

22	12	18	87
88	17	9	25
10	24	89	16
19	86	23	11

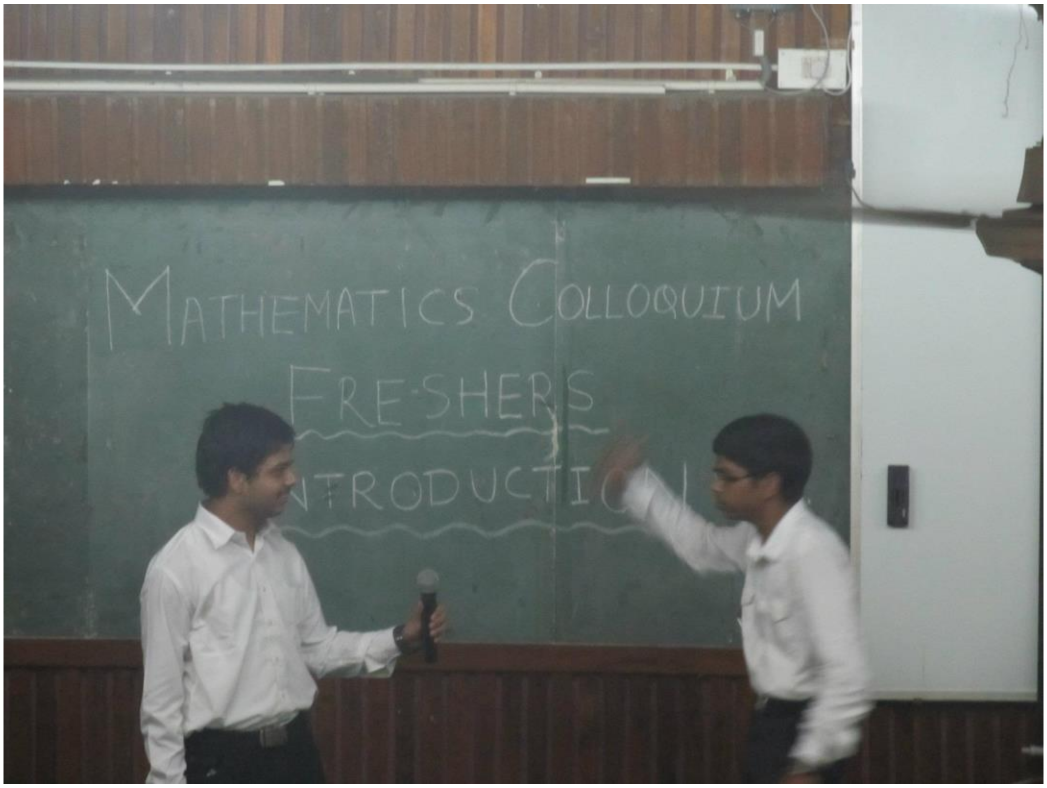
The magic is repeated.

22	12	18	87
88	17	9	25
10	24	89	16
19	86	23	11

Look at these central squares!

Now, here's some cake on the icing!
Do you know when Ramanujan was born?
Check out the first row of the square -
22 December 1887!

GALLERY



FRESHER’S WELCOME

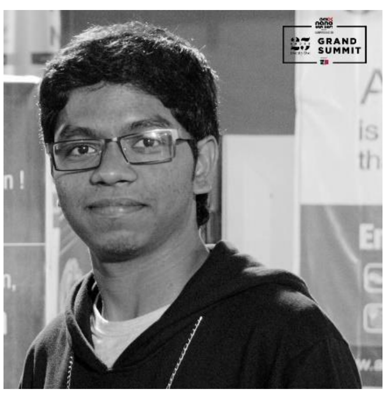
FAREWELL

INTRA DEPARTMENT CRICKET MATCH

GOODBYE KGP!

Well, the last 5 years my life, I call it my Honeymoon. The shortest yet the most memorable & enjoyable part of my life. KGP to me has been about Friends/Family, E-Cell, Department, Hall, Hult, Cooking, Travelling, Reading, Internships, Poltu. I recommend you to explore yourself. Don't ever do things for your resume, instead do what pleases/interests you but take it slow, one step at a time. Exploring a new thing every semester or vacations will give you plethora of experiences for life. And also, a fresh perspective. Ask yourself 'What would you do if you weren't afraid?' and then Just do it. The question which has always baffled people is 'List out things that you've done in life out of curiosity!'. Make sure you get this one. ;)

-Anush Gupta



Live these 5 years to your fullest because you are not going to get them again. The freedom, time and space you get here in kgp will never show themselves to you, at least not in the near future. Kgp is known for its exposure to extra academic activities, no wonder there are so many societies and hobby groups out there. The advantage with the department is that you have the funda of a CS(almost) guy and time way more than any others in the institute, USE it well. Also, keep in touch with your seniors because you never know where they might show up next. Last but not the least, if you have a healthy CGPA good, else do not panic as there is more to life than CGPA. CGPA is just another metric to say about what you are, don't let it be the only one. All the best for all your future endeavors and keep in touch!

- Anuj Menta

COLLOQUIUM YEAR ROUNDUP

Another eventful year comes to an end. As we take a trip down the memory lane we behold the hardships encountered and the memories shared. Few blurred patches might have tried to discolor our colorful enthusiasm, but we succeeded in ending the academic session on a high note. We would like to share the year-long experiences of the Colloquium office bearers with the readers. The following is a short account of what all Colloquium did this year.

Freshers' Welcome:

The year started with another fresh group of students joining the Institute, fulfilling the long dream of clearing the JEE. The freshers were given a welcome note from the Colloquium on the registration day itself which included a brief introduction of the Department such as courses offered, achievements, prominent faculties and alumni and of course about the Colloquium and its activities followed by the speech of HOD. Later in August, the Department of Mathematics organized a Freshers' Welcome event to welcome the newcomers in the family. The ceremony started with formal introductions of the freshers, followed by performances which ranged from a group skit, to singing, drawing etc. The night wrapped up on a high-glutton note – a lavish feast wherein freshers involved in a casual interaction with their seniors.

Teachers' day:

Later this academic year, commemorating the birthday of Sarvepalli Radhakrishnan, Teachers' day was celebrated with great vigor and enthusiasm. Quiz was the highlight of the day. Professors and Students teamed up together for one last duel. Puzzles and General Mathematical questions were showered upon them. Finally, the event concluded with presenting the professors with the mementos.

Interactive Session with pre-final and final year Students:

Is it going to be finance for me? What about Data Science? Oh my! How could I possibly forget about Competitive Coding! All the doubts were sort of sorted out when a casual conversation ensued between the 2nd year students and the 4th & 5th year Students.

Xponent:

Of course, we cannot forget the sugar cube you are currently holding in your hands. It took time, for it was worth it.

If you have any suggestions, do not hesitate to mail us at contact.maths@gmail.com.
The sugar lumps need more sweetening!

Farewell:

Nostalgia Level 9000! To conclude the year-long activities, the Colloquium manages yet another event, and an indispensable one that is the Farewell. This sugar cube goes in every last cup of tea. The tea, that this kgp-kettle had preserved for 5 years. We bid adieu to the final year students and wish them luck in their future endeavors.

PLACEMENT 2017

ROLL NO.	NAME	PLACED AT
12MA20001	ABHINABA MONDAL	ACCENTURE
12MA20014	GAURAV PURVA	ACCENTURE
12MA20051	VUSIRIKALA NITHIN NATARAJ	ACCENTURE
12MA20002	ABHIPSA SAHU	J P MORGAN
12MA20017	HARSH GUPTA	J P MORGAN
12MA20004	ADITYA KESHARWANI	GOLDMAN SACHS STRATS GROUP
12MA20037	RISHAL RAJ	GOLDMAN SACHS STRATS GROUP
12MA20052	KUMAR KRISHNA AGARWAL	GOLDMAN SACHS STRATS GROUP
12MA20054	NAMAN NISHESH	GOLDMAN SACHS STRATS GROUP
12MA20005	AJAY KUMAR BRAHMA	QUANTIPHI ANALYTICS
12MA20009	AYUSH PANDEY	SPRINKLR INDIA PVY LTD
12MA20029	MUNAGALA ALEKHYA	SPRINKLR INDIA PVT LTD
12MA20012	CHANDRA SHEKHAR MEENA	CAPILLARY TECHNOLOGIES
12MA20034	PRIYANKA JAYASWAL	CAPILLARY TECHNOLOGIES
12MA20020	KESHAV AGARWAL	MICROSOFT
12MA20023	MANISH GOYAL	SAP LABS
12MA20025	MANU KASHYAP	TESCO BENGALURU
12MA20027	MD MODASSIR AKHTAR	GE DIGITAL
12MA20030	NAMAN BHATIA	CREDIT SUISSE
12MA20045	SUNIL KUMAR	CREDIT SUISSE
12MA20031	SUSHMITA PANDULA	SOCIETE GENERALE
12MA20038	SABYASACHI MANDAL	C-DOT
12MA20039	SANDEEP MOHANTY	DIRECTI
12MA20043	SOURAV KUMAR	DELOITTE CONSULTING
12MA20044	SUMIT KUMAR	ZS ASSOCIATES
12MA20047	VAIBHAV SAVALA	Power2SME
12MA20049	VENGALA HARINI	WALMART LABS
12MA20050	VISHAL TRIVEDI	MENTOR GRAPHICS

PRE-PLACEMENT OFFERS

ROLL NO.	NAME	PPO AT
12MA20003	ADITI SINHA	FIDELITY
12MA20006	ANMOL GULATI	GOOGLE
12MA20007	ANUJ MENTA	AMERICAN EXPRESS
12MA20008	ANUSH GUPTA	ACCENTURE
12MA20010	BALLA SUREKHA	SAMSUNG BANGALORE
12MA20026	MAYANK SINGH	ADOBE SYSTEMS
12MA20053	SHUBHAJOY DAS	ADOBE SYSTEMS
12MA20042	SHUBHAYAN GHOSH	GOLDMAN SACHS
12MA20046	SUPRIT SHARAD DHOBLE	EDGEVERVE

FACULTY AT A GLANCE

Prof. Mahendra Prasad Biswal
Research Interest: Operations Research, Computational Statistics & Stochastic Programming, Fuzzy and Convex Optimization, Game Theory and Applications, Analytic Hierarchy Process (AHP), Interior Point Methods (IPM), Multi-Objective Multi-Level & Multi-Choice Programming, Decision Sciences.

Prof. Umesh Chandra Gupta
Research Interest: Statistics, Stochastic modelling, Queueing Theory.

Prof. Vasudeva Rao Allu
Research Interest: Complex Analysis, Univalent Function Theory, Harmonic Mappings (in the Plane).

Prof. Bibhas Adhikari
Research Interest: Applied Linear Algebra, Complex Networks, Quantum Entanglement.

Prof. Somnath Bhattacharyya
Research Interest: Computational Fluid Dynamics, Micro-/nanofluidic Modeling.

Prof. Bappaditya Bhowmik
Research Interest: Geometric function theory (Complex Analysis), Harmonic and Quasiconformal Mappings, Several Complex Variables.

Prof. Debapriya Biswas
Research Interest: Functional Analysis, Lie Groups Lie Algebras and their Representation theory, Complex Analysis, Harmonic Analysis, Hyper-Complex Analysis including Clifford Algebras.

Prof. Debjani Chakraborty
Research Interest: Fuzzy Optimization, Fuzzy logic and its applications.

Prof. Asish Ganguly
Research Interest: Mathematical & Theoretical Physics, Quantum Mechanics, Non-linear Evolution Equation in Real & Complex Domain, Soliton Theory and Inverse Scattering Transformation, Ordinary and partial differential equations.

Prof. Ratna Dutta
Research Interest: Functional Encryption and Attribute Based Cryptosystems, Elliptic Curves and Pairing based Cryptography Oblivious Transfer and Private Set Intersection,
Lattice-Based Cryptography, Multilinear maps and Obfuscation. Secure Multiparty Computation, Broadcast Encryption and Traitor Tracing.

Prof. Rupanwita Gayen
Research Interest: Linear water waves, Integral equations.

Prof. Koeli Ghoshal
Research Interest: Mathematical Modelling of sediment-laden turbulent flow, Grain-size distribution in suspension, Secondary current, Study on different parameters of sediment transport.

Prof. Adrijit Goswami
Research Interest: Operations Research, Data Mining, Cryptography and Network Security.

Prof. Dharmendra Kumar Gupta
Research Interest: Numerical Analysis and Computer Science, Constraint Satisfaction Problems.

Prof. Nitin Gupta
Research Interest: Numerical Analysis Applied Probability, Mathematical Statistics, Reliability Theory and Computer Science, Constraint Satisfaction Problems.

Prof. Swanand Ravindra Khare
Research Interest: Numerical Linear Algebra, Chemometric.

Prof. Pawan Kumar
Research Interest: Graph Theory.

Prof. Somesh Kumar
Research Interest: Statistical Decision Theory, Estimation Theory, Quantum Information and Computation, Statistical Data Analysis, Experimental Designs, Entropy Estimation, Reliability Estimation, Estimation under Constraints, Estimating Parameters of Directional Distributions, Classification under Restrictions, Robust Estimation, Reliability Ordering, Dependent Trials.

Prof. Sourav Mukhopadhyay
Research Interest: Algebraic Cryptanalysis on Symmetric Cipher., Digital rights management, Key pre-distribution for, Wireless Sensor Networks, Time/Memory Tradeoff Cryptanalysis, Cloud Computing.

Prof. P V S N Murthy
Interest: Bio-fluid Mechanics, Convective Heat and Mass Transfer in nanofluid.

Prof. Gnaneshwar Nelakanti
Research Interest: Inverse and ill-posed problems, Spectral approximation of integral operators, Approximate solutions of operator equations.

Prof. Chandal Nahak
Research Interest: Variational and Complementarity problems, Fractional Calculus, Numerical Optimization, Set Valued optimization, Frame Theory in Semi Inner Product Spaces, Applied Functional Analysis and Optimization, Optimization Problems on Manifolds.

Prof. Ramakrishna Nanduri
Research Interest: Commutative Algebra.

Prof. Geetanjali Panda
Research Interest: Portfolio Optimization, Numerical Optimization, Optimization with uncertainty, Convex Optimization.

Prof. Rajnikant Pandey
Research Interest: Differential Equations (Ordinary), Theoretical Numerical Analysis, Singular Boundary Value Problems.

Prof. Raja Sekhar G P
Research Interest: Boundary integral methods for viscous flows, Hydrodynamic and thermocapillary study of viscous drops, Applications of binary mixture theory to biological tissues.

Prof. T. Raja Sekhar
Research Interest: Quasilinear Hyperbolic System of Conservation Laws, Lie Group Analysis for Quasilinear Hyperbolic System of Partial Differential Equations, Symmetry Integration Methods for Differential Equations.

Prof. Parmeshwary Dayal Srivastava
Research Interest: Functional Analysis & Cryptography, Fuzzy Sequence Space.

Prof. Mousumi Mandal
Research Interest: Combinatorial Commutative Algebra and Algebraic Geometry.

Prof. Pratima Panigrahi
Research Interest: Algebraic and Spectral Graph Theory, Irreducible No-hole Colorings, Self-centered Graphs, Existence of Strongly Regular Graphs.

Prof. Rajesh Kannan
Research Interest: Matrix theory, Spectral graph theory and Functional analysis.

Prof. Shirshendu Chowdhury
Partial Differential Equations, Fluid Mechanics, Control Theory: Linear and Nonlinear Partial Differential Equations, Fluid Mechanics, Compressible Navier-Stokes equations, Viscoelastic flow of Maxwell and Jeffrey's fluid, Control of PDE (Controllability, Stabilizability, Optimal control problem for Compressible Navier-Stokes equations and Viscoelastic fluid model).

THE COLLOQUIUM BODY

SUSHMITA PANDULA (PRESIDENT)

HAREESH KULAKARNI (VICE PRESIDENT)

MANISH KUMAR (VICE PRESIDENT)

VINAY CHANDIL
(WEB HEAD)

YAJUVENDRA SINGH
(GENERAL SECRETARY)

YAJUVENDRA SINGH
(TREASURER)

HEMACHANDRA KOLISETTY
(EVENT HEAD)

2nd YEAR REPRESENTATIVES

BHUVNESH BHUWAN

SIDDHARTH JINDAL

NITIN CHOUDHARY

NUPUR GUNWANT

PRASANNA KUMAR MULAGALAPALLI

NAMAN GUPTA

HARSHIT CHOUHAN

ONCE BEST FRIENDS
NOW STRANGERS,
WITH MEMORIES!