

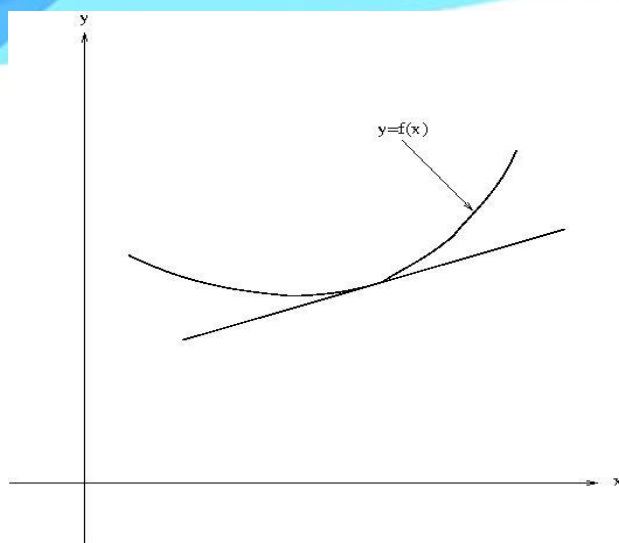
Calculus at crossroads: On either side of the fence

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Calculus has been in the forefront of Mathematics learning at the undergraduate levels probably since its inception itself. This branch of Mathematics was developed independently by two great souls: Sir Isaac Newton of Great Britain during 1665-66 and Gottfried Wilhelm von Leibniz of Germany during 1673-76. While Newton was the first scientist to apply Calculus to general Physics, Leibniz formalized the ideas into true Calculus of infinitesimals and developed much of the notions used in Calculus today.

In the list of favourite topics over the years during my course of teaching Mathematics to undergraduate level students, Calculus will always remain at the top this list. I have always enjoyed teaching Calculus because of its beauty, intrigue and the subtleness, which in turn has opened up many ways of presenting it to my students. However, the fun part of Calculus got assimilated into me owing to my own individual efforts after my college life; the seed was not sowed at the time I got introduced to the topic. Like most of the students in

India, my journey with Calculus started with learning its branch Differential Calculus at the 11th Standard. After meandering through the usual passage of function, limit and continuity, we had arrived at the doorstep of Calculus in the real sense: the definition of the **Derivatives**. Most of the stuffs were pretty mechanical, the only excitement we could extract was through working out the textbook problems to match our answers with the ones that could be found at the end of the book after plugging in the functions in the formula of derivatives. No visual effect of the derivatives taught in class was strong enough to linger on and make an imprint which I could cherish later on.



Our first introduction to the graphical interpretation of **derivatives** was the above figure. This was probably the fate of majority of the Indian undergraduate students being introduced to **Calculus** during our time. It ended just there: neither more, nor less was explained about the figure. Decades after I saw that figure for the first time, I have been able to realize the connection of the same figure with the history of Calculus only now. At that time we had no clue that Newton's tryst with Calculus originated in 1665 with his endeavour of developing an accurate method of finding tangent to a curve. Such curves were called crooked line during Newton's time and the above figure is exactly the picture of a tangent (the straight line here) touching the curve (the crooked line) at a point. The only thing we were

ensured was that drawing the above figure will earn us full marks if we are asked about the geometrical interpretation of the derivative in the exam. We were either too timid or the instructors were shrewd enough to create an aura of their own with a shield of unapproachability around them which prevented us from raising further query on the above figure. The limited number of reference and textbooks that we had access to also explained nothing further.

Derivative is the concept on which the foundation of Calculus is based on. In plain language Calculus is the mathematical study of continuous change: more precisely "Rate of change" or "Derivatives". It is an extremely important tool for Engineers and Scientists alike in their own trades. Unfortunately, during our undergraduate days, it was just another topic in the Mathematics curriculum. I didn't have any special attraction or attachment to this topic probably because our instructors were not able to generate enough interest by explaining how handy it is in our day to day life. During my formative years of teaching in Bajali College at Pathsala, where I was at the other side of the fence for the first time as a teacher, my students were no different from me in their attitude towards Calculus.

It was only during my stint as a visiting faculty at the George

Washington University in Washington DC, USA that my perception of Calculus underwent a drastic change. Mathematics had already been a dreaded subject amongst the students there (probably the same goes for the overall student community in India as well), Calculus as its branch even more so. I could immediately realize certain awe and awkwardness amongst the common students (not necessarily Math majors) towards Calculus. The very few students who opted for Calculus used to be looked at by the other members in their fraternity in high esteem. Contrary to the practice here in India where Calculus is exclusively taught only to Math students, crediting Calculus course was compulsory for Math, Engineering, Medical and Business students alike. As such, its utility part was more important for the students than the bookish approach we encountered during our undergraduate days. Because of these, the textbooks are also written in such a way that even a layman can understand the utility of it apart from its basic concepts. In the USA, many universities run pre-Calculus courses in order to facilitate an easy passage for students intending to take up Calculus. The irony in our own country, however is, while it is compulsory to credit at least two Calculus courses with high grades in order to get entrance in Medical schools in USA, Medical entrance

examinations do not have any portion of Mathematics here!

This brings us to another aspect of the textbooks accessible to us during our initial Calculus days. Most of them were mere collection of contents from some already existing materials devoid of any personal input accrued from the teaching experience of the author. On the other hand, majority of the textbooks prescribed to the students in USA are products of years of toils by the author in the classroom. It is an amalgamation of the class notes developed over many years. Their style is more of that of a storyteller and spontaneity of thoughts is very much obvious having originated from their own classroom experiences. On the other hand many of our own teachers were seen to teach from the same old class notes repeatedly throughout their entire career without making any addition/improvements: the worn out and yellowish colour of the pages from where they used to teach stood testimonials to that!

But time has changed over the years. With the development of technology in general, and also their mindset, the current crop of teachers have been forced to equip themselves with the changing trend. It is a kind of enforcement by the modern student: he/she does not accept things for the sake of accepting it. He/she will raise questions at every opportune moments and the teacher has to be

ready for that. Unlike our generation where the teacher could escape without having the obligation and commitment of answering questions, there is no escape for the current crop. Being a teacher myself, I feel that our generation was way too respectful towards their teachers, sometimes probably more than what they actually deserved. On the contrary, the current generation of students perceive their teachers more as mere facilitators; it is more of a client patron relationship. He/she demands to know every detail of the subject being taught: it could be

either because of his/her genuine curiosity for the topic being taught or the high expectation of the service in exchange of the fee being paid by him/her. The exposure of both the student and the teacher to the information highway has made the job of teaching and henceforth the relationship between the teacher and the students a more intriguing one. The teacher is more alert and has to be on his/her toes all the time. **In my opinion that is a huge development!**
