

# MY EXPERIENCES AS AN UNDERGRADUATE STUDENT IN THE CMI PHYSICS DEPARTMENT

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ABSTRACT. In the following document I will give a short description of my experiences with each course in Physics at CMI. What follows is purely my experience and does not reflect any general opinion of the physics students at CMI.

## 1. THE OVERALL FEELING

At the end of three years of having gone through the 17 courses in Physics at CMI I find it to be an act of deliberation to find out those few positive things in this experience. There were about 3 to 4 courses which I liked but the the deeply negative effect of all the other courses is so overwhelming that it seems very artificial if I try to feel happy about those few courses. Barring those few, the general scenario with the other courses had the following typical characteristics:

- Over and above all factors the primary thing that depressed me most was the lack of fairness in the evaluation system in Physics in CMI. Never was adoption of unfair means in assignments and examinations detected. People could easily get away with mass copying in the examination and assignments. People could submit physics assignments by just blindly copying the answers from someone in the batch, a few minutes from the submission deadline, . In almost all cases the student who was copying had absolutely no idea of the subject and didn't even understand what he was copying and it was almost a mere replication of symbols from the source. This has been a rampant scenario across all courses over the three years and never has been any such thing been detected.

At a next level there never seemed to be any differentiation of marking between two solutions both of which are correct but one is a longer and cruder solution and the other which is more elegant or shorter or mathematically more rigorous proof. Till the final answer was correct the elegance and mathematical rigour of the process of getting that always seemed to be completely ignored.

The situation grieved me the most when the marking procedure democratically treated a copied answer and a sophisticated or unconventional solution. I felt a sense of moral disintegration around me.

- Across all courses I seemed to run into blind end whenever I asked “why?” for something. I felt very uncomfortable with the “black box” approach to physics where I seemed to be expected to know the subject like a set of thumb rules and an algorithm by which a crank could be turned to generate answers. Somehow neither could I morally accept this approach to science not could I adapt myself to doing physics like this.

- I felt a deep inconsistency between the mathematics used in the physics courses with the mathematics that I was learning through my interactions with Prof. Ramanujan or my other regular classes. I felt the mathematics being used in the physics classes were logically inconsistent with my mathematics courses.

The mathematics being used in the physics courses seemed too vague and the so-called definitions of the terms used were almost always inconsistent with their standard definitions in the mathematics textbooks.

Overall there seemed to be a general atmosphere of not using clean and correct mathematics and any attempt to do so seemed to be severely discouraged and looked down upon. The importance of correct mathematics seemed to be completely ignored in the physics courses. Except through self-study there seemed to be no possible way in which I could understand the mathematical frameworks of the physics theories or the mathematically sophisticated areas of physics. I felt terribly resource constrained in finding answers to my personal curiosities.

- In most courses I felt a huge communication gap between me and the professor. I found it extremely difficult to discuss anything with the instructor or to explain to him/her what I was thinking. The situation worsened when I was unable to understand something on my own. Almost always I could not communicate to the instructor as to where I was getting stuck and hence I felt a complete vacuum of help.
- Almost all the classes were thought of as a one way interaction process where the instructor would come to the class and deliver a preplanned lecture and any form of questions during the class seemed to be looked upon as a disturbance.
- There was almost no rapport between the instructors and the students. The fact that I as a student is a person of age 21 never seemed to be taken into account. I felt treated like school kids. I feel that 21 years of age is enough for a person to have matured thinking and probably cannot be expected to behave like children in primary school who are likely to nod their heads in agreement to whatever the teacher says. But I always felt that I was expected to behave in the same way and any attempt of independent thinking seemed to be looked upon as a form of misbehaviour on my part.

Precisely this is the point which I enjoyed during my mathematical interactions with Prof. Ramanujan. I felt being treated like a 21 year old man and not only did he let me express my weaknesses (from which he effectively helped me out) but also gave me that creative space suited for an adult where I could do my independent thinking.

- Before coming to CMI there were regions of physics in which I was weak in. Time and again whenever I found that a course in CMI comes close to those weak areas of mine I tried asking help from the instructors to recover my weaknesses. But somehow I never got the help to recover from those. Some of those weaknesses I could repair by independent efforts.
- Somehow the instructors saw a discrepancy between these two things that I was unable to follow the laboratory classes and some other such things in which apparently the others seemed to be performing better than me and that I was interested in understanding the mathematical structures in Physics. I don't know why but this conflict between my abilities resulted in kinds of responses from the instructors but which caused me a lot of psychological pressures and traumas. These further multiplied my weaknesses since it was becoming emotionally taxing to approach the instructors to help me out.

These experiences were acting as large factors demotivating me from Physics and at times I thought of shifting to mathematics but then I love the subject Physics too much and nothing could shatter that passion.

## 2. COURSES

In the following sections I plan to give an account of my experiences with the physics courses at CMI that I had to do since *August* 2005 to *April* 2008. I shall leave out the one graduate physics course that I opted for at IMSc. (That was great course to say the least and the only time when I could interact with the instructor extensively about my own ideas and thoughts).

Along with the description of how the course went and how I felt about it, I also would try to suggest changes in those courses which could have made them more enjoyable and beneficial to me.

## 3. CLASSICAL MECHANICS-I

It was my first Physics course in CMI and my hopes and enthusiasm got badly shattered by this first course itself. The class atmosphere made it impossible to share thoughts and analysis with the instructor and the whole atmosphere was completely discouraging towards any kind of approach other than what the instructor demonstrated on the board. I found the course content highly incoherent and superficial and the approach too strict about following the exact process as shown by the instructor and also highly rigid about following the exact same notation!

Mathematical structures were being introduced through out the course which seemed to be treated like some notation to be followed blindly. Much later I studied their proper theories from the mathematics text-books. But ultimately the entire course turned out to be a process of introducing these symbols! Except at the fag end of the course I could not see any Physics any where and even then things were taught were too murky and superficial for me to follow.

As per the syllabus the course was supposed to teach me theory of collisions, scattering and motion in central force and special relativity. (as per the course on the web-page). But almost nothing of these things were taught and no other course in CMI ever taught me these things. Ultimately I have a huge vacuum of understanding in these topics except for some of those topics on which I independently worked hard later or fortunately some other course spent some time repeating these. But even then since the focus of those later courses was not to teach these basic things the treatment remained fairly introductory.

Hence my understanding in some very basic topics got damaged badly and I am desperately hoping to repair the damage done during my graduate school.

## 4. CLASSICAL MECHANICS-II

This course too turned out to be almost the same case as Classical Mechanics-I. As usual I went into the course with an expectation like what is stated in the CMI webpage (which seems to be a very good plan) but somehow except a few basic definitions almost nothing was taught that pertained to the core topics of this course. Instead the course completely focussed on topics in Classical Mechanics like theory of dynamical systems, non-linear dynamics and chaos theory which probably one would want to know only if one tried to specialize in it and probably of no large consequence if one doesn't choose a career in these branches. The entire course seemed to have gotten reduced to a mundane

exercise in solving all sorts of differential equations. Almost never was I shown any physical or practical application of whatever formalism was developed in the class.

At the end of two Classical Mechanics courses I was never formally taught basic things in this subject like theory of harmonic and an-harmonic oscillations, rigid body dynamics, nutation, precession, gyroscopes, motion of tops etc. Things *not* taught in the two courses in Classical Mechanics forms about 95% of any standard book in this topic.

I did read up these left out topics on my own but there are various points in these theories which I didn't understand and they remain as gaping holes since I haven't yet found any help in these topics to repair them.

Some of these left out topics were left to the students as presentations to be given and most people just copied down on the board some equations from the book which they couldn't themselves explain!

Hence again some of my basics got damaged at the end of this course.

## 5. STATISTICAL PHYSICS-I

This course was another disaster of sorts. I can barely think of a topic that was taught completely in this course. Had I not self-studied the topic from the standard texts I would have probably learnt nothing from the course. Interestingly the course started off with great motivations and insights and I was excited about the course. But then it turned out that the motivations formed the larger fraction of the course and the course never really got down to the detailed theories! The entire course seemed to be like a sequence of story telling sessions.

But of course the mathematics seniors who were doing the course with us were greatly overjoyed since it was one of those courses which is called a *free course* in the CMI student lingo. One could get a great grade by never studying! And that is more or less what motivated many of the maths seniors to take up this course.

Hence in Statistical Physics too my understanding is probably crude in some aspects since all that I know is self-studied and I have never studied it under the guidance of any expert in the topic.

## 6. ELECTROMAGNETISM-I

This was probably the first decent course in Physics. It was a neat course and it covered the basics well. But I feel that its level could have been raised a lot higher by doing the basic things a bit faster.

But this course left me unsatisfied at the usual count which I found uniformly missing from all CMI Physics courses. It was mathematically very basic and all mathematical sophistications and subtleties were ignored. In retrospect I feel that there were many mathematically exciting approaches in electrodynamics that could have been introduced in this course which are central to modern theoretical physics like theory of magnetic monopoles and interpreting Maxwell's Equations in differential forms and then looking at Maxwell's Equations as a geometric statement about curvature. The theory of gauge fields and the exotic topological issues in it were completely left out.

Of course this course seemed far better than all previous courses since it at least taught me the basics well but it left me unsatisfied since no exotic topics were introduced. As an opposite extreme of the other courses I felt that it followed the standard texts a bit too closely.

## 7. ELECTROMAGNETISM-II

This was one of those courses from which I gained nothing and everything taught in the class looked either vague or superficial and many times even dangerously incorrect. It was one of those courses where I went in with great expectations since I am deeply interested in the topic and the course fell flat with almost no content.

I had expected to learn a lot of the complicated applications of electrodynamics in the spirit of the standard texts like that by Jackson and Landau and my expectations were substantiated by the kind of things my seniors were taught in their corresponding course. But what happened for us left me highly disillusioned.

My understanding is that instructors were from a totally experimental physics background and they channelled the course into teaching the approximate and watered down version of the standard theories in the form that the experimental physicists use as thumb rule in their daily work. But given that we were never taught the full fledged detailed theories the approximate theories made little sense to me and they anyway seemed to be presented like just a set of symbols with no explanation.

Anyway nothing was proved rigorously and I seemed to hit a dead end whenever I tried asking the instructors for some clarification about the detailed theories.

Also the evaluation process for the course left me deeply dissatisfied. All kinds of solutions and presentations irrespective of their depth and clarity and elegance seemed to be treated democratically.

On my own I tried to pick up the full theory from the books by Jackson and Landau but my progress was very slow and I felt that these are things which are difficult to self-study unless there is some expert guidance.

Hence my basics in various things in electrodynamics also got damaged and again I am desperately waiting to repair this void from hopefully a detailed and advanced course in electrodynamics in my graduate school.

## 8. MATHEMATICAL PHYSICS

This course was very much like the Electrodynamics-I course. It was a neat and simple course. It seemed to cover a wide range of basic topics and gave me a lot of practice in doing some basic kinds of things.

As in the Electrodynamics-I course this too left me dissatisfied on the count of mathematical rigour. I somehow felt that all the various things topics taught seemed to be disjoint from each other and the larger mathematical structures in which they fit together was not emerging in the lectures.

Further given that the course followed a standard text very closely, I felt that the course was devoid of many of the more exciting and advanced topics in mathematical physics.

The course seemed too biased towards differential equations and there was very little geometry. The applications of advanced forms of topology and geometry in physics was completely left out. Given that the course is officially called “Mathematical Physics” and not “Application of differential equations in Physics” I felt that the course was not doing justice to this huge area of current interest that is topological and geometric approaches in physics.

On a different note I feel that we need at least 3 Mathematical Physics courses so that the following topics in mathematical physics can also be covered in these courses which are altogether left out from all other courses:

- Theory of spinors and twistors and writing of General Relativity and Yang-Mill’s theory in this framework. Like the mathematical structures which lead to use of Einstein-Carter connection in General Relativity and eventually to the Palatini formulation of gravity.
- Applications of conformal mapping in electrodynamics and field theory.
- Theory of Green’s functions and Strum-Liouville theory.
- Theory of functional differentiation and integration (like for matrix valued functions).
- Using the structure of Principle Bundles to write Yang-Mill’s field theory.
- Grassmann calculus for doing Feynman path integral for fermionic fields.
- Application of algebraic topology in condensed matter physics to understand phase transitions.

## 9. PROPERTIES OF MATTER

This course was yet another fiasco of sorts. The instructor planned and somehow managed to cover quite a large range of topics. But I don’t think I gained anything from attending the classes. I felt that the topic was being presented in too muddled up ways and that the mathematics being used was too crude and naive. There were obvious improvements that could be done with the mathematical framework which could have made the equations much more cleaner and easier to read and the essential ideas would have been clearer to follow.

I feel that the topic naturally requires a more sophisticated approach but the mathematical machinery being used was very elementary. I felt that an exorbitant amount of class hours got wasted in fixing up and solving equations. The messy equations could have been altogether avoided had a more elegant mathematical structure been adopted.

Because personally I was very interested in the subject, I studied most of it from the standard texts on fluid dynamics and elasticity by Landau. Given that the presentation of these books of the same topics was so much more elegant than what was being done in the class and that it could be almost completely self-studied , very soon there was a lack of motivation to go for the classes.

Further the examinations in this course also left me depressed. Some of the questions set in the paer were of level incommensurate with the level at which the course was being taught or involved such large calculations that it was almost impossible to complete them in 3 hours.

**9.1. The forgotten assignment!** The most depressing incident in this course which has left an indelible negative memory for me is the incident of a forgotten assignment.

In general the assignments and the homeworks in Physics courses always turned out to be some sort of mundane trickery or jugglery with complicated differential equations. I never felt that there was ever anything creative or interesting about any of the Physics assignments in CMI. Whereas in the Mathematics courses there have been quite a few exciting questions in the assignments, memories of solving which still bring a sense of joy and satisfaction. They were deep learning experiences.

But in this course of Properties of Matter generally the assignments were more creative than the other courses and once the instructor came up with a slightly off-beat idea where he said that the student would have to submit some sort of a original analysis of some phenomenon where the topics taught in the course could be used. I was excited about such an open-ended assignment and I immediately got down to work. Within 2 weeks I had something worked out and it was probably the first time I designed a question on my own and created a technique of solving it. I felt that the idea was somewhat original since I haven't yet seen it in any book.

But most interestingly I turned out to be the only one to submit it! Even the instructor forgot to collect that assignment and the course ended without any further mention of this assignment! The grades for this course had not been given till the next semester and one day during the next semester I went to the instructor to ask him about his evaluation of the project that I had submitted.

I was shocked and depressed to see that he had almost forgotten that he had ever given such an assignment and he had to search through his room to finally recover my papers that I had submitted to him during the last semester.

Eventually the grades were given out and the grading completely ignored that assignment and the fact that no one else had submitted the project work was not reflected anywhere. People seemed to have gotten grades based on everything else but that project work!

This and various other factors made me feel that the evaluation process in this course was extremely unfair.

## 10. QUANTUM MECHANICS-I AND ATOMIC AND MOLECULAR PHYSICS

I am clubbing these two courses together since they were taught by the same instructor and were consecutive courses. So effectively it looked like a single 2 semester long course in Quantum Theory. The second course took off precisely where the first course ended and hence they were contiguous. It was one of the most satisfying of all courses in CMI and the clarity of exposition was way above all other courses and the central reason why I believe my basics in Quantum Theory is much more stronger than all other subjects except for General Relativity in which too I feel that I have equal strength.

These 2 courses stand out as strong exceptions to the general scenario with most other CMI Physics courses. It was probably a stroke of luck that lady luck thought I was worth!

During this course I had a lot of free time for myself since the course was not at all demanding in terms of assignments and since during my first year I had independently studied almost all that was taught in Quantum Mechanics I and III and some parts of

the Atomic and Molecular Physics. So much of the material in these courses was familiar to me beforehand.

During this extra time that I got for myself, I started studying Topology and Differential Geometry on my own and aspects of Physics like theory of Magnetic Monopoles and Gauge Fields where there are exotic geometrical issues intertwined with Quantum Theory. It was this free time that I could generate, which got me the opportunity to start studying under Prof.Ramanan and I started my geometric journey under his guidance.

The course was very beautifully paced and although it started off pretty slowly it soon picked up speed and ultimately in 8 months we comfortably covered an amount of Quantum Theory which probably is not covered in the entire MSc. programs of other institutes. It had a very good balance of basic things, advanced topics and mathematical subtleties. Various advanced concepts got introduced but at the same time we got adequate grounding in basics and various mathematical subtleties were taken care of.

But like every other course at CMI, in this course too I felt a complete vacuum of topics in Physics which have deep geometrical and topological issues connected to it.

## 11. QUANTUM MECHANICS -II

This course is the single largest reason among the whole spectrum of reasons why when I look back at my entire CMI Physics life, it looks like a long dark nightmare. Before this course I never knew that classes can be so intimidating. Even if there was anything to be gained out of the course it seemed impossible to do so given the terrorizing atmosphere in the class. There was almost no possibility of any interaction or discussion with the instructor. After the first few classes not only did I feel completely disinterested to go to the classes, I also felt scared at the thought of going to this class. It was a semester long psychological trauma for me and even an year after the course is over images of the classes haunt my memories.

Every class seemed to be a deliberate process of belittling the CMI Physics program and of humiliating the student for his faults and shortcomings. Almost for every question that I asked, the reply had more sarcasm and criticism in it than scientific content or the answer. Every attempt seemed to be made to make sure that no mathematical issue in the subject is discussed or is brought up in class. It almost seemed as if discussing or mentioning mathematics is a grave crime.

Even when I try to look at the absolute content of the course minus all the above factors, I see a complete lack of coherence and relevance. The content seemed completely unmotivated and disconnected from the rest of the courses. Almost everything seemed to be a case of name dropping and terms seemed to be getting introduced at almost a completely random fashion. Every class the topic seemed to change from one pole to the other or even during a single class. I felt completely dissatisfied with how the topics were treated and everything seemed sketchy and all strings were left hanging loose. And the so-called “definitions” that were given for the mathematical terms used, seemed dangerously inconsistent with the standard definitions and any attempt to clarify them again met with sarcastic remarks.

From a long shot I feel that the topics attempted were just too obscure and only those people who do research in it are interested in it. During the entire course there was a lot of difficulty in finding resources to study the topics from. Some research monographs

and highly specialized books were the only source to study it from and they were very difficult to follow and things were made more worse by the fact that there was a complete vacuum of help to explain me the things which I got stuck with.

Lastly the examinations seemed completely disproportionate and un-standardized. Given that for the above factors my understanding of the topics was already very low, I found the questions either impossibly difficult to do or extremely long to be able to complete in a 3-hour exam. Eventually the grading system also seemed unfair to me.

This course not only damaged my career in quantitative terms but also alienated me from these topics and also I lost my faith in CMI Physics program.

## 12. QUANTUM MECHANICS -III

This was yet another course which left me deeply dissatisfied. Of course I didn't go into the course with any great expectation since it was being taken by the same instructor as who had taken our Classical Mechanics-I. History simply repeated itself. The same kind of a non-interactive and one-sided atmosphere where I seemed to be expected to nod my head in agreement with whatever the instructor said. I as a student seemed to be treated like a life-less entity who has no right to have either an opinion or a suggestion or thoughts but was expected to follow the whatever was being said like kindergarten kids.

Most time of the course was spent on Special Relativity and that too seemed to be a very superficial treatment for 3<sup>rd</sup> year students. Almost everything seemed routine and whatever slightly advanced topics were started seemed to be left as open strings or left as a set of vague statements.

Somehow the main topic of the course i.e Dirac Equation got relegated to the fag end and what was done was extremely elementary in nature. It was simply a set of symbols getting drawn on the blackboard with almost no insight or applications. Various basic issues about the Dirac Equation seemed to be completely ignored.

As in most courses here too I felt that the mathematics used was too crude and almost all the subtle and interesting issues were swept under the carpet. The instructor decided to devote some classes only to explain the mathematical structures and I felt that they were greater fiascoes than the usual classes since there were so very obvious discrepancies between whatever was being said and whatever exists in the standard mathematical literature.

I lost all motivation to go for the classes and I started bunking.

But I got a lot of free time to devote to other pursuits since I had studied most of these topics in my first year and the course was almost completely devoid of any non-trivial content and it was not at all demanding.

I am sure that for those students for whom this was the first experience with the Dirac Equation they were left completely deprived of almost everything that is beautiful about this equation.

### 13. STATISTICAL PHYSICS-II

This course effectively vanquished whatever hopes I had of recovering my Statistical Physics, after the fiasco of Statistical Physics-I. A major part of the course turned out to be a revision of the topics in Statistical Physics-I and the treatment seemed superficial and vague to say the least. Each of the classes seemed to be a process where some standard derivations and equations found in the standard books seemed to be copied down on the black-board. Everything was routine and not a single topic ever seemed to be ones that would be difficult to grasp on one's own.

Everything that was said was so basic that I am sure everything could be studied on one's own without any assistance. And I seemed to run into a dead end every time I tried asking questions about the issues which interest me and issues which I find to be challenging and exciting in this topic. There was never a convincing answer for any question.

What depressed me further was the crudeness of mathematics used in the course. It was almost a sledge hammer treatment of the subtle mathematical structures that are involved in Statistical Physics. Again it was a dead end that I faced whenever I asked clarifications for anything.

Among the repeated topics there was not a single exciting or exotic topic that could have motivated me to come to the classes. Eventually I started bunking classes since I saw not a zilch of a reason to come to the classes.

Given the kind of course that our seniors got, I expected the following topics to have been covered in a second course in Statistical Physics like a detailed discussion of Ising Model (like Onsager's solution) and theory of phase transitions and critical phenomenon and theory of superconductors and superfluids and may be some introduction to the topological issues in Statistical Physics. But our course never came anywhere close to such topics and what was dished out to us was too watered down and elementary to say the list notwithstanding the completely cavalier approach to the background mathematics.

At the end of two courses of Statistical Physics my understanding was limited only to its basics. Here again I am anxiously looking forward to recovering my Statistical Physics in my graduate school.

### 14. CONDENSED MATTER PHYSICS

This course was yet again a disaster of all sorts. At the end of the course there is not a single topic that I can confidently say that "Yes, I understand it". The entire course seemed to be a set of terms introduced arbitrarily with none of the topics explained. A huge plethora of topics across a huge spectrum was picked up arbitrarily and brushed through without doing justice to any of them. Everything was unclear.

Somehow I felt that it was a highly mistimed course. Most people were not even familiar with Quantum Statistics and what this course was trying to do was using Quantum Statistics at every step. I had studied Quantum Statistics on my own but even then I found my self uncomfortable since it seems there exists many different formulations of this theory and the instructor was using a completely different formulation. The situation worsened when the instructor started finding it difficult to follow my answers in which I used a formulation different from the one taught in class. The way I do Quantum Statistics

is by using the technique of what is called the “Partition Function” and somehow it seems that the instructor was not familiar with this technique.

It was a long time by when this discrepancy was realized and even then the instructor didn’t seem to make any attempts to do the basics so that everyone could be using the same language.

I was extremely depressed with the tremendous superficiality and lack of thoroughness of the classes. As with most other CMI courses here too I found no answers to any question that I raised in the class. As a result my doubts and confusions kept piling up and there seemed no help in sight to explain me the huge number of things that I was stuck with.

Towards the end of the course things became very difficult when the instructor started picking up topics pertaining to modern technology (like GMR and Spin Valves) and these topics are completely absent from most books accessible to us. They only exist in some specialized monographs. The classes kept getting more and more vague and full of hand-waving and there was a complete vacuum of literature to read the topics from after the class.

I tried finding out some of these monographs at the IMSc library but these were far from being written for a novice to learn from but were fast reviews for professionals. Hence I was understanding almost nothing of the topics taught towards the end. Towards the beginning of the course the classes were equally devoid of clarity or consistency or detail but at least there was enough literature to fall back on and study on one’s own.

I simply fail to see the justification for introducing such a large spectrum of topics in 4 months when none of them were explained reasonably and probably the class didn’t have much of background to grasp even if they had been explained.

Once again with yet another topic I am eager to get a firm hold on during my graduate school since the CMI course turned out to be devoid of any content.

## 15. GENERAL RELATIVITY-UNDERGRADUATE COURSE

Had I been a first timer to General Relativity like in my first year of BSc.(Hons.) then probably I would have liked such a course which was in the spirit of story telling. But since I had been already been studying General Relativity for quite sometime and I had already done a graduate course in this (which was undoubtedly my best course in CMI..it was a graduate course at IMSc that I did), I didn’t see anything especially attractive about this course. But I did gain some bits and pieces of things in this course by way of doing the assignments.

Even if I take an objective look at the course minus the fact that I had already done an advanced course before hand, I still don’t see anything in this course that can set it apart from the other typical Physics courses in CMI which seemed like fiascoes to me like Classical Mechanics I and II, Quantum Theory II and III, Statistical Physics I and II etc etc

Given that the topic is General Relativity which is so highly geometric in its content and has so much deep rooted mathematics associated to it, I am not sure whether I am very wrong in expecting at least this course to have been mathematically consistent. But on mathematical count this course fell as flatly as others. Concepts like metric, connection,

covariant derivative, Riemannian Curvature, pull backs etc etc were used in the utmost of cavalier ways with no regard for their proper definitions and their systematic exposition as found in any standard text in these topics.

These geometric notions were used in ways which seemed completely bizarre, crude and sometimes even looking to be dangerously incorrect and the “motivations” that were given towards these concepts seemed to me to be too old fashioned with complete disregard to the modern mathematical machinery that exists today for these topics. Neither the exact theorems regarding them were ever stated nor were the definitive results at least ever quoted.

The course always seemed to revolve around some special cases with no intention ever to get to the global structure of the theory and to get an understanding of the general theorems that exist for it.

Even basic concepts like “What is a Space-Time?” were never addressed. I felt that the course had too much of hand-waving and everything non-trivial was ignored. In general the course seemed to have de-prioritized elegance of the theory and sophistication was completely compromised. For almost everything that was done on the black-board it was possible to give an alternative method which would be more elegant (at least in the sense of being basis free) and more neat. I felt that all the methods demonstrated were too clumsy and crude.

Like any other course in this course too all topological issues were completely ignored. I had initially expected that this course might have some discussion of the interesting mathematical structures that arise if we do Einstein’s Gravity on 2-dimensional Space-Time. But the course had so coarse an approach and so less content that it never came anywhere close to these special topics.

## 16. COMPUTATIONAL PHYSICS

There were times when I wondered whether at least the CMI life would end with a good course so that I can at least console myself by saying “All’s well that ends well”. But this course removed every shred of such optimism that I had about a happy ending.

I really can’t find out a single thing that was taught in the very few classes that were held, that was non-trivial or that which I couldn’t have understood just by flipping through the books. The course started out with grand promises of grand topics and extensive laboratory sessions and ultimately what I was dished out was probably the basic motivational lectures that are found in popular science text books.

Effectively I had to learn everything I needed on my own with absolutely no help available. The assignments were non-trivial and hence incommensurate with the course and the utterly basic things that were said in class were highly insufficient to do them. Effectively I had to do extensive studies in the subject on my own and with no one around to explain me the difficult and the subtle points where I was getting stuck at times.

I was excited about the project that we had to do and I studied certain aspects of General Relativity which are not generally emphasized in the courses. Issues which arise if one tries to write computer programs for General Relativity. I derived out a few small results in this theory which I have not yet found in any text-books and then used them to write a program.

But somehow I was deeply depressed when the instructor almost called my whole effort as trivial. Somehow I could not make him see that the small results in General Relativity that I had to derive for the project were not very obvious and that they require some effort and thinking. I agree that the program that I wrote wasn't anything great but the background results that I had to develop for the program was not very simple, at least I have not seen it in the standard General Relativity books I have studied till now.

Finally the root shock came when at the end of the semester the instructor asked me "Have you submitted all your assignments?" !!!!!

I was left wondering as to why I had been working day in and day out to get the assignments done before deadline and to submit them on time. To whom was I submitting the assignments through out the semester??

One more course got added to the list of fiascoes in CMI. One more level of disillusionment.

## 17. LABORATORY COURSES

Consider the following situation where a student of class 5 is given a question in integration to solve and he/she replies back that he/she doesn't understand the symbols or anything. Then the person gives that class 5 student a copy of the analysis book by Rudin and tells him/her to read up the subject and then do the integration. Now when the student says that he can't study that book on his own and then the giver of the question expresses doubts and lack of confidence in the student's abilities.

Is it expected that a class 5 student will be able to read Rudin's book on his/her own and then do the integration unless probably if that student is some prodigy?

This is precisely what I felt about the experimental physics course. Almost always I felt like being left with an apparatus of which I understood nothing and neither did I know the background theory! As a guidance I was given a write up or the manual of the machine!

I always felt like that hypothetical class 5 student who was asked to do the integration after reading up the theory from Rudin's book.

In such circumstances I completely crashed in the experimental physics courses and at the end of my CMI career I don't think I have understood much of anything of the experiments that were there as a part of the course.

I felt that given that I had almost no knowledge of even basic apparatuses and basic skills and techniques of taking measurements, the course looked to me to be too disproportionate where each experiment required a synthesis of various skills which I had never been trained in. It was almost like trying to learn calculus and analysis by starting with Differential Geometry.

The major problem that I perceive about the experimental Physics course in CMI is that it is highly mistimed. I have never ever studied electronics and I couldn't make much progress with the subject by reading on my own. In this situation what is the logic in making me do so many experiments in electronics? How am I supposed to be able to do it without having any training in the theory whatsoever? At times I was asked to do some experiment in electronics for which the background theory was in Page 616 of

the standard electronics book by Malvino. I simply don't have the ability to study 616<sup>th</sup> page of a book without knowing what all exists before it. I felt myself to be in a weird trap where I had to meet deadlines of completion of experiments and I didn't know the background theory and there was no one to help me out.

There was never a single clear explanation for anything that I asked or got stuck with. Especially w.r.t electronics I felt completely in the dark. Even w.r.t the other experiments I felt that very often even the instructor was not very familiar with the apparatus and couldn't give me any explanation when I asked about its functioning. There was never any help or explanation available from the instructor when I was unable to do an experiment or was getting anomalous behaviour when it was not expected. It seemed that it was always my fault or lack of intelligence or skill that I can't do the experiment whereas others can.

It always seemed that I was expected to do things like using a black-box and thumb rules without understanding what is the internal mechanism and logistics of the thing. Lot of times people got credit just for having gotten the theoretically expected results irrespective of whether or not they understood the details of the apparatus and the theory behind it. But on the other hand there was never any credit for detecting abnormal behaviour with the system or anomalous behaviour which was not theoretically expected. Most people generally avoided doing the experiments at those limiting cases of the parameters where non-typical behaviour would be seen. There was no reward system in the process of having done things at the limiting cases and having detected abnormalities. Instead there was a chance of getting penalized for not getting the ideal answers.

I simply couldn't take this approach and it never seems to me to be consistent with the very idea of scientific education.

There was rampant corruption in this course w.r.t data forging and copying and superficially copied reports etc and somehow like in all other courses here too nothing seemed to get detected. I was left very unsatisfied with the grading schemes.

## 18. PARTICLE AND NUCLEAR PHYSICS

This course looked just like the Condensed Matter Physics course. Lots of information getting dumped incoherently and a million terms getting introduced at completely random fashion with neither detail nor clarity nor thoroughness nor the pre-requisite.

First of all it is not logically clear to me as to why there exists this course without a thorough Quantum Field Theory course! Any attempt at this topic without a background in QFT is seems meaningless to me and the students can only keep fooling themselves into believing that they are understanding Particle Physics whereas actually no one is probably getting anything. The course seemed to be creating an imaginative paradise in which the student is being invited to believe in.

Apart from the problem of no QFT background there was also the problem of complete lack of understanding of the Dirac Equation in the batch since the Quantum Mechanics-III course was almost devoid of any content. Without a thorough grounding of the Dirac Equation, Particle Physics is probably inaccessible. Further since classical field theory had never been taught every technique might have looked unmotivated to me but I escaped this problem since earlier I had on my own rigorously studied classical field theory.

Secondly the mathematics level in this course was probably the lowest among all courses. Everything was fuzzy, unclear and unexplained. Even the notation used was bizarre and any attempt on my part to get it clarified only met with hurtful sarcasm from the instructor. It was always being made to appear as if I am some kind of a big fool ever born who can't understand these "obvious" things. Others kept trying to make an impression that they understand everything but when I asked help from them to explain me stuff the response was so shaky and muddled that it was obvious that no one had understood anything.

The black board seemed to have become a drawing board on which the instructor kept "drawing" lots of stuff and I had to keep copying them down with absolutely no understanding of what was going on. Every time I asked questions what came back was biting sarcasm at my stupidity. Later when I explore the subject on my own I see that there are deep mathematical structures in the theory which justify the thumb rules that the course was trying to force feed. But every time I asked questions about the equations I was getting rebuked for trying to distract the class from the core issue and the correct mathematical structures were completely ignored. Everybody else was into blindfolded usage of the thumb rules and that was upheld as the success of the course. A little tapping would have revealed the big hollow inside the class.

Never did I have such a frustrating and depressing course where everything was unclear and as usual in CMI there is no help available to explain me the things. Later I started getting some help with this subject from the instructor who taught me Quantum Theory-I and then I started recovering slightly. But even now it is perfectly clear to me that there are intricate structures of representation theory and principle bundles that are intertwined into this theory and no one is being able to explain me the correct things.

Had I not been intrinsically interested in this topic from before I would have surely developed an antagonism for this subject as an aftermath of this course. At the end of every such demoralizing class I seemed to start regretting taking up Physics. It was again my deep love for Physics that sailed me across such thoughts which most Physics courses in CMI provoke.

I think there are 3 things that can be done with this course for the better:

- Completely scrap the course. I don't see any reason why an undergraduate student should be forced to study this unless he/she is professionally interested. It is not really a very basic topic.
- Have a rigorous course in QFT before doing this course. There doesn't seem to be any substance in Particle Physics without QFT. It is just like a magic story without QFT.
- Gauge Field Theory is the central idea behind all of particle physics and that is a much general framework and is not tied to QFT. So this course can be made into a rigorous course in Gauge Field Theory and other related exotic topics in classical field theory like Monopoles and Solitons. A good course in Gauge Field Theory is likely to benefit lots of people since its concepts are of deep ramifications in all of Physics and not just Particle Physics.

Finally CMI Physics came to a close with a course which had all the typical elements of a generic Physics course in CMI.

## 19. FINAL REMARKS

The effectiveness of the supposedly very theoretical course of Physics at CMI can be seen from the fact that only 1 student qualified to the Department of Theoretical Physics at TIFR .

Sometimes it is best to say the harsh truth straight without any diplomacies so that the problem is detected fast and solutions are found out soon. That was the major aim of this document. The damage done to my career by the CMI Physics program cannot be undone. Now its on me to repair all my shortcomings in graduate school but I hope that the repair work for CMI Physics Program is started so that future batches don't have to go through this nightmare as I had to or for more fundamental reasons like ensuring the existence of this program for any more time.

But of course it is not clear to me why a student should take a risk of his/her career by joining the Physics program at CMI when it is this unstable (as it seems to me). It is not clear why fresh batches of students should submit their careers to this experiment. It doesn't seem to be the responsibility of the physics aspirants of high-school to ensure that CMI Physics program reaches a decent level.