

Studying calculus: some preliminary advice

I have included below a few tips that appear to have been useful for students in past courses over the years. I have kept them to a bare minimum. The different points are interdependent, but not entirely. So if you feel that some of them are difficult to follow, you should still try the others, and then eventually find a way to adjust the whole profile to match your mode of study.

1. Textbook

Read the textbook!!! Three times. The first time can be a rough overview, preferably before the material is covered in the lecture. The second time, you should read in detail the main body of the text *and the examples*. Make sure you understand each example very well, so that you can reproduce its calculation and argumentation. The third reading, a review, is intended to give you confidence, and an overall grasp of the most significant points.

2. Exercises

The most important advice is in item 1: **Read the textbook!!**. Most of the exercises are routine if you have read and understood the text and especially if you can reproduce the argument in the examples. Except for the most routine exercises, each problem should be solved twice. The first time to struggle your way through while working out the separate difficulties. The second time with smooth confidence. In particular, the assignments should be written twice: the first writing should be a 'draft' that still displays the hesitation and difficulties. But the submitted version should be written in a systematic and organized fashion that builds up your confidence with respect to the ideas involved. Give yourself plenty of room to write for each problem and use plenty of scratch paper (that should always be kept readily available). In particular, always work at a desk that doesn't inhibit your willingness to try out sample calculations.

Never do the following:

- Prepare a few pieces of paper.
- Write on the left at certain intervals the numbers of the problems you need to submit.
- Cram the sentences together in a haphazard manner in order to fit the solutions into the space you have needlessly allotted yourself.

In many cases, it is not unreasonable to use an entire page for a single problem. Whatever you end up doing, the way you eventually write things down will reflect the clarity of your understanding. If in doubt about the desirable degree of clarity, think about how you would feel if your writing were actually the one printed in the textbook. *Submit your assignments with a sense of completion.*

3. Lectures

Do not focus too much on taking notes. You may if it helps you to concentrate, but you should give most of your attention to understanding what is being said in class. My experience is that if you just jot things down that you don't understand, notes are either useless or misleading. That's why it's great conservation of time and energy to understand the important points when they are being made, and then to reinforce this understanding by reading the textbook and doing the exercises. Sit near the front of the class so that you can have actual human interaction with the lecturer. Ask questions when you get lost so you can follow the drift of the argument through the whole class from beginning to end. If you are not used to this, it might take practice over time. At first you might concentrate enough to follow the first fifteen minutes. With more practice, you keep up for thirty minutes. If you keep at it, eventually you will be able to understand every lecture from the beginning to the end. The key point, once again, is to **concentrate!** Training yourself in this way is a valuable investment that will serve you well over many years in many different situations. Do not miss lectures! College life can become sufficiently unstructured and chaotic as it is. No matter how little you feel is being gained, the physical discipline of keeping up with every lecture will help you organize your life in general. Even if you are entirely lost (or bored) just come to the lecture hall and meditate for 50 minutes. Meanwhile, remember that your instructor will never be able to cover

every detail of the material you are expected eventually to understand. Therefore, it is essential to complement the lectures with the other activities, especially, **reading the textbook!!**

4. Office hours

There is one important point to be made here. Interact with your instructor as one intelligent person to another. Be respectful and confident at the same time. What does confidence consist of in this context? **Do not be afraid to look stupid!** In practice, this means revealing your weaknesses honestly so that your instructor can help you with them. You are an intelligent and inquisitive adult, so that any reasonable instructor will welcome such openness and not penalize you for it. Here is one important example: Suppose you cannot solve a problem. You have tried various approaches but the answer comes out wrong. Then instead of letting your instructor explain the whole thing to you, go up to the board yourself and show him/her what you have been doing. Ask your instructor to point out what you are doing wrong. Carrying this through once with honesty (to yourself and to your instructor) can end up more useful than ten times of passive attempts at absorbing someone else's explanation. Prepare your questions with some care.

An example of a bad question is 'How do you do problem 7?' to which my reply always will be 'What have you tried?'

A better question is 'I've tried such and such with problem 7, but at step X, what should I do?' I will probably ask you to **reread the section of the textbook** the exercise appears in, and try to encourage you to come up with the procedure for yourself.

An even better question: 'This is how I solved problem 7. I feel uncertain about step X. It seems to me that procedure Y from the textbook is the relevant one, but it doesn't seem to work. What am I doing wrong?'

Here is one remark about answers that often surprises students: *You should eventually solve the problems with so much confidence that you do not need anyone to tell you if it's correct.* Think about addition, say, adding two digit numbers. If there is a person who needs someone else to check the correctness of each answer, would you say this person understands addition?

5. Self-study

A frequent question that needs to be faced is the number of study hours outside of class. It is hard to give a general answer. But one important method is to study many hours at a stretch. So 10 study hours spread out over seven days will be less efficacious than two chunks of 5 hours. This is because mathematics usually requires warm-up time just to get going. If you study for one hour, you will be stopping just when your attention is getting properly focussed. Discussing problems with friends can be fun and efficacious, but can be overdone. The bulk of study time must be spent alone in deep concentration.

6. Exams

After you have done all of the above, you don't need to worry about exams. But one point can be made: A good student is prepared enough to do tolerably well even one week in advance of the exam date. Equipped with that attitude, the last week can just be spent finalizing the details and building up confidence.