Preface

A good postgraduate curriculum in engineering must have a core course in applied mathematics. And, given that, in an engineering curriculum, enough specialized engineering courses need to be accommodated, the curriculum can afford to have *at most* one compulsory subject on mathematics! Thus,

> a good postgraduate engineering curriculum will have exactly one compulsory course in applied mathematics.

The purpose of this course is to arm the student with the necessary ideas and methods, so that when mathematical elements appear in other courses and research work, one can tackle them with confidence, possibly with further independent study into specialized areas. Its major role is to summarize, crystallize, enhance and give a forward orientation to the mathematical methods taught in undergraduate curriculum, with projections to future requirements.

While teaching such a course to postgraduate students, registered for master's and doctoral degrees, I noted that most existing books on applied mathematics are so voluminous, with necessary and avoidable topics intertwined in presentation, that selection of course material and problems from a book and then supplementing them with other vital topics not covered in it is a Herculean task, requiring constant care on issues of completeness and consistency. Finding the primary subject matter of the course in several books is a painful experience for the student as well. The difficulty is compounded in the case of those learners who need to develop the background for their profession or research, but do not have the constant guidance of a course instructor. No wonder, few people outside a 'course' pick up a book of applied mathematics to brush up their mathematical skills: those who did might have found themselves grounded in the third chapter of the book. Most books tend to do justice to the topics they cover, and justice to the students or readers often gets relegated to the second priority.

After teaching the course twice, and putting in an effort to assort and order material that is relevant and possible to cover in a single course, I envisioned this textbook with a difference: to do justice to the students and instructors, even if it means some injustice to some or all the topics covered. Interestingly, the actual plan to write the book was triggered by the suggestion from some of the students that a nice book can be carved out of the material organized for the course. This is the genesis of the present book.

The major sections of targeted audience include

(a) postgraduate students in their master's or doctoral programme, possibly studying a similar course of applied mathematics,

(b) teachers of applied mathematics who are looking for suitable material for a semester course, that would appropriately fit with the students' needs,

(c) senior undergraduate students or fresh graduates who plan to review and brush up their mathematics background, possibly for facing the imminent competition, and

(d) scientists and engineers in research laboratories and industry who are likely to be involved in serious level of mathematical modelling and computational analysis in their work.

The pedagogical approach of the book particularly supports a self-motivated learner away from a classroom and takes over the instructor's task to an extent.

In a way, the present book is an attempt to extend the borders of a classroom. As such, the text has been written in a style of lectures or discourses. In place of the usual blunt statements of theorems and lemmas, with their dry proofs following, an ambience of appreciation is attempted. For most of the topics, the ideas and concepts are first developed to prepare the mind-set for the arguments, and the actual proof is mostly worked out in the form of mere derivations. It is assumed that the reader is not an adversary, cross-examining the author in a court; rather the reader and the author are colleagues trying to develop the subject and work out the problems together, checking out the correctness at every step. This keeps the proofs rigorous enough, surrendering some crispness in favour of smoother understanding.

Some of the themes are left to the reader to establish *before* they appear in the discourse, in the form of exercises over previous topics, with hints and step-by-step procedures, wherever necessary. This strategy encourages readers (students) to develop some 'theory' ahead of time, so that in their proper contexts there is an opportunity for the author to consolidate on the reader's work. Even if the reader did not succeed in establishing a particular result, this pre-orientation would have sensitized him/her regarding the problem to an extent that on the appearance of the topic in its primary context, he/she is in a more comfortable position to appreciate the topic and the author's arguments to establish or derive it. The author has found that this approach is very successful in teaching mathematics. Even average students in the class, assigned the task of developing non-trivial results with the help of easy steps enumerated in the problem statement, came up with clear algorithms and constructive proofs, which appeared later in the lectures mostly for consolidation.

With the tone of dialogue and discussion adopted in this book, the reader is more likely to get encouraged to perform the steps and exercises to see the validity of the results directly, rather than just being convinced by argument that the author's claims are correct. The number of so-called 'solved examples' have been kept intentionally small. Experience shows that too many solved examples inculcate a damaging tendency among students to 'read' the solutions and get a false sense of satisfaction that they have grasped the subject. Instructing them, rather, to 'perform' the steps ensures actual learning.

To keep the sense of balance among different topics, each chapter is designed to be equivalent to a lecture or 'lesson'. The subject matter to be covered is arranged in small modules, retaining the continuity across chapters but refraining from loading individual chapters. This would help the reader in progressing with the book at a steady pace and being conscious in not getting grounded in one complicated chapter for too long. It would also assist an instructor in planning his/her lectures in a balanced manner.

The necessity of progressing ahead and completing the course, on the part of the student, has been kept in focus in the framing of exercises as well. Repetitive practice of similar problems is well recognized as an important factor in the learning of a subject. But, confounded with an enormously long list of exercises, a student typically finds it difficult to make a good selection of problems which would give a reasonable maturity in a limited time-frame. Therefore, rather than setting records of number of exercises, I have endeavoured to concentrate on *selection* and proper direction, so as to instil conceptual clarity.

With concentrated effort, one should be able to complete this 'course' in three weeks. With a lot of other things to do, one may take it with partial effort during a longer period of four months, i.e. as the postgraduate students originally did as part of the semester load. A few chapters and sections of the book are marked with asterisks as indicators for the students and the instructors. These are not necessarily advanced or less important. If, due to lack of time, it becomes necessary to omit some sections, then these are the probable candidates.

Even though the selection and presentation of the subject matter for effective transmission was quite a trying task, the experience of writing this volume has been exhilarating. If the reader finds the presentation and style of the book beneficial in his/her learning process, the efforts spent in its compilation will be deemed successful. I warmly welcome comments and constructive criticisms from readers. Please send your feedback to the address dasgupta@iitk.ac.in.

Bhaskar Dasgupta