



Mathematical Physics: With Applications, Problems & Solutions. V. Balakrishnan. Ane Books Pvt Ltd, 4821, Parwana Bhawan, 1st Floor, 24 Ansari Road, Darya Ganj, New Delhi 110 002. 2018. xxvi + 852 pages. Price: Rs 2495.

This is a very unusual book, 852 pages long with 32 chapters. The author, V. Balakrishnan is an eminent theoretical physicist who has inspired a generation of students at IIT Madras over more than three decades. Bala, as popularly known amongst friends, is well known for his breadth of knowledge in various areas of theoretical physics. There are very few theoretical physicists who have written important papers in widely different areas like high energy physics, condensed matter physics, equilibrium and non-equilibrium statistical mechanics and nonlinear dynamics as Bala has done. So when I heard of a book on mathematical physics by Bala, I was curious about its contents. After carefully going through it, I can only compare it with some of the classics of mathematical physics like *Methods of Theoretical Physics*, vols I and II by Morse and Feshbach, and *Methods of Mathematical Physics*, vols I and II by Courant and Hilbert. And I am happy to note that it is of similar level, but very different from the other two books. It is not only different in its content (which is to be expected since many new topics have become important in the last 50 years or so), but more important in its emphasis. In particular, this book assigns a prominent role to the applications of the relevant mathematics to different areas of physics ranging from fluid dynamics, electromagnetic theory, quantum mechanics, special theory of relativity, quantum optics, random processes, linear response theory, and so on. The emphasis in the

book is not on formal proofs but rather on motivating and elaborating the results and even more important, discussing the relevance of the results in different areas of physics. Bala knows very well that one can never learn mathematical physics (actually even theoretical physics) without solving problems. With this in mind, he has given about 370 problems, many of them with several parts and sub-parts. He has made the problems contiguous with the text and has provided solutions to them either in the outline or in detail at the end of each chapter. This I consider as an important aspect of the book. I believe that over the years this book will occupy a place similar to the other classics in the field, like the two books mentioned above.

What are the broad topics that have been covered in the book? Apart from the chapters on topics which one would expect in any mathematical physics book like complex variables, orthogonal polynomials, matrices, vectors and tensors, vector spaces, Fourier and Laplace transforms, integral equations, Green's functions, etc. it has chapters on both discrete and continuous probability distributions and stochastic processes, as well as Möbius transformations, which points at Bala's taste. Another novel aspect of the book are the chapters on fluid dynamics, and electromagnetism and special relativity which provide an elegant illustration of several aspects of vector calculus. Besides, there are chapters on operator algebras and identities, diffusion equation, etc. underlying the relevant mathematics from which these topics follow. I consider this to be the strong point of the book. Whenever Bala discusses a topic in mathematical physics, he almost immediately discusses the role it has played in different areas of physics. For example, while discussing error function, he points to its connection with cumulative probability distribution function of a so-called normal or Gaussian distribution function discussed in chapter 20 dealing with continuous probability distributions. Similarly Bala highlights the role of delta function in electrostatics and other fields, of tensors in the theory of elasticity, in electrostatics, of Gauss's theorem and Stoke's theorem in electrostatics and magnetostatics, of infinite dimensional vector spaces in quantum mechanics, and so on. I would like to make special mention of the detailed discussion about coherent states as an example of operator algebras. Equally impressive has been the discussion about squeezed states and the group $SU(1,1)$.

The one obvious question is, to whom is this book addressed? I believe that it will serve as a useful reference book for teachers, research students and bright M Sc physics students, but I do not see it as being used as a textbook. Majority of the treatment assumes that the students have taken at least one course in most of the core subjects like classical electrodynamics, quantum mechanics, statistical mechanics, etc.

The book already is rather long (852 pages). However, I still wish that Bala had covered basics of group theory, differential geometry and partial differential equations. He has only discussed solutions to few but important partial differential equations like Laplace equation, Poisson's equation, Helmholtz equation and the diffusion or heat equation by determining the corresponding Green's function.

Finally, I think there are two glaring omissions in the book. Bala talks about Madhava–Leibniz formula as well as Hemachandra–Fibonacci sequence without giving any reference or adding any footnote to the work of not so well-known Indians, Madhava and Hemachandra. I must admit that I was ignorant of their work till I read about them in the book. I am sure that not many Indians (and surely foreign scientists) have heard of Madhava or Hemachandra or their works. However, these are minor omissions and overall Bala has done a great job in writing such a masterpiece on mathematical physics.

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