BOOK REVIEWS

Engineering Mathematics, Volume 2, by R. S. L. Srivastava. Tata McGraw-Hill, New Delhi 110 002, 1980, Pp. xi + 314, Rs. 24.

The present book is a continuation of Volume 1 with the same title. It contains 7 chapters with headings Fourier Series and Orthogonal Functions ; Partial Differential Equations; Complex Analytic Functions ; Expansions in Series : Zeros and Singularities ; The Calculus of Residues; Conformal Transformation; Probability and Statistics. In addition, Bibliography, Answers to Problems, and Index are included. Few sections are marked with asterisk and the author states that they may be omitted in the first reading without loss of continuity.

In the first volume, it was stated that the book contained those branches of mathematics which are of practical value to the analytical engineer. In the present volume, it is stated that it deals with some advanced topics in engineering mathematics usually covered in a degree course and that the two volumes together meet the complete requirements of undergraduate engineering students, without making any mention to analytic engineers. It would have been useful if the contents of the first volume are also enumerated in the present one.

The treatment of topics in the theory of functions of a complex variable in this book is generally good, though it needs some cleaning up at the following places: (1) In the line preceding eqn. (14) on p. 128, the author writes : 'Since the partial derivatives are continuous, we obtain...'. Actually the continuity of the partial derivatives has already been used in the first part of the paragraph itself when the functional increments are written. It is redundant and hence confusing to write it again as it gives the wrong impression that the continuity of partial derivatives is employed once again. Actually it is only the limit process that gives eqn. (14). It may be remarked that what one needs[1] [for both necessary and sufficient conditions for the analyticity of $f(z)$] are the C–R conditions and the 'differentiability' of the functions $u(x, y)$ and $v(x, y)$ as functions of two real variables in the domain D (This concept is discussed in § 5.3 of Vol. 1), though it has become the conventional practice in many text books to write theorem 6 as stated by the author. (2) In respect of the discussion in (*d*) on p. 195, it must be pointed out that in order to classify the singularity at $z = a$, one cannot take the Laurent expansion in any annulus about $z = a$ (as done by the author), but must take it in a punctured disc (or deleted r-neighbourhood of a) $\{z \mid 0 < |z - a| < r\}$, in which it is analytic. After all, the nature of the singularity at $z = a$ is determined by how the function behaves in a neighbourhood of $z = a$ and not by how it behaves in any annulus centered at a. Unless the author emphasizes that $r_1 \to 0$, students will not appreciate that for classifying the singularity at $z = a$, we have to consider the special case of Laurent's theorem when $r_1 \to 0$. This becomes particularly important when one tries to classify (using L–T) the singularities of a function having more than one isolated singularity.

On p. 100 (in the chapter of PDE), harmonic functions are defined as the solutions, of Laplace's equation, that have continuous partial derivatives, while on p. 129 (in the chapter on Complex Analytic Functions) they are defined merely as solutions of Laplace's equation without the qualifying phrase. This discrepancy will keep the student wondering whether the definitions differ from one branch of mathematics to the other.

The treatment of Mechanics in Mathematics Curricula in this country was dominated by the books of Loney for many years. This situation is being corrected in recent years. Similarly, the treatment of partial differential equations (PDE) is even now influenced by the book of Sneddon and this situation also needs to be corrected. The treatment of PDE in the book under review is on the old orthodox line. The main aim of PDE curricula should be to introduce the Initial value and Boundary value problems associated with PDE and the methods to tackle them. To this end, it is necessary to introduce the concepts of characteristics and Cauchy problem for first order equations also. Such a treatment is lacking in this book; hence the students will get a wrong perspective of PDE. It is possible to introduce briefly a discussion of existence and uniqueness of solutions for first order equations in a book of this type. Attention should have been paid to this aspect.

In the definition of linear first order PDE on p. 61, R in (15) could be allowed to be a linear function of z as well, instead of restricting it to be independent of z as is done by the author. It is necessary to point out that $u = \alpha v + \beta v^2$, etc. (α, β being arbitrary constants) also become complete solutions of (15). Why does the author introduce $u = \alpha v + \beta$ only as complete solution of (15) ?

It is necessary to mention as to why we assume the solution (38) on p. 70 in the variable separable form, if we want the student to know 'why' and under what conditions the method should be adopted and not only 'how' to use it mechanically.

In order that the students understand the motivation of change of variables in the beginning of § 2.3.2 on p. 76, it would have been better if the author had chosen to write about reducible equations. It is better to call (56) on p. 76 as D'Alembert's general solution of the wave equation as the solution (of IVP) in the form

$$u(x, t) = \frac{1}{2}\left[r(x - ct) + r(x + ct) + \frac{1}{c}\int_{x-ct}^{x+ct} s(\sigma)\, d\sigma\right]$$

is generally known as D'Alembert's solution of the wave equation.

In the discussion of the Laplace equation, a reference to mean value theorem should have been made. In fact, having obtained the Gauss Mean Value theorem, the maximum modulus principle, and the Poisson integral formula in a circle for an analytic function (§. 3.8, pp. 159–163), and having a chapter on PDE in which the author talks about two-dimensional harmonic functions, it would have taken just a few more lines of writing to connect these results (by giving cross references) to get these properties of harmonic functions. Such a unified treatment should be expected. As it stands now, it looks as though these chapters are disconnected. A section on Green's function could have been included in the chapter on PDE.

In the treatment of Probability, the term random variable is used (on p. 281) without defining it earlier. It is not advisable to do this even in an elementary treatment because even though random variable is really a function, a student will mistake it as a type of variable and this is suicidal from the point of view of his grasping the subject in real sense of the term. This was one of the aspects in the mind of one of us when the comment was made about the treatment of the concept of function in the first volume of this book, a review of which appeared earlier in this journal.

Thus such old-style treatment will not make the groundwork of the student conceptually sound and clear, even though he will be able to make some calculations and solve some examples mechanically.

Some of the printer's devils are the following : On p. 185, the text calls the concentric circles as γ_1, γ_2, while the figure indicates them as r_1, r_2. Index cites page 126 for harmonic function. Actually pages 125 and 129 should have been mentioned. On p. 62, ' $= dz/R$ ' is missing in stating the system of ordinary differential equations in 4th line before example 4.

On p. 196, in (*e*) it should have been 'from Theorem 15' instead of 'from Theorem 16', and the last statement in that para should have been 'Since by theorem 16, it is not a pole, it is an isolated essential singularity'.

Reference :

1. J. E. Marsden : *Basic Complex Analysis*, Freeman and Co., 1973, p. 48.

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Wave scattering from statistically rough surfaces, by F. G. Bass and I. M. Fuks (translated and edited by Carol B. Vesecky and John F. Vesecky), Pergamon Press Ltd., 1979, Pp. 536, $ 75.

Diffuse scattering of light and sound plays a far more important role in nature than the specular reflection of these waves. We see objects by the light scattered by them. We are constantly surrounded by sound waves which are scattered by the walls and furniture in the rooms. In the open air the uneven ground and the many objects that surround us scatter sound. In the sea, the sound transmission between the transmitter and the receiver is influenced by sound scattered by marine organisms, temperature fluctuations, internal waves and the uneven sea bottom and sea surface. Specular reflection, in contrast, does not provide information about the object reflecting the waves. Instead we merely see the source of light or hear the source of sound. Our knowledge of the external world, therefore, depends to a large extent upon scattered waves that we receive from different objects. Hence the importance of scattering phenomena in electromagnetic and acoustic radiation.

The earliest studies on scattering and diffraction of light and sound waves date back to the work of Kirchoff and Lord Rayleigh. Often the scattering surfaces do not have simple geometrical shapes and can be described only in statistical terms. The study of scattering from such irregular surfaces consists in determining the statistical characteristics of the scattered field (distribution functions, moments, correlation functions, etc.), given the statistical properties of the surface.

There are two basic methods which are most frequently used in the study of scattering by statistically rough surfaces, *viz.*, the perturbation method and the Kirchoff method. The exposition of the scattering phenomena in this book is based upon these two methods and their derivatives. The basic concepts of wave propagation and the theory of random processes as applied to rough surfaces and to wave fields are developed in the first two chapters. In the third chapter the average field scattered by rough surfaces is considered. The fourth chapter is devoted to the calculation of the characteristics of the fluctuation field, *viz.*, second moments and phase fluctuations. Wave scattering from random moving surfaces is investigated in the fifth chapter. Special correlation characteristics in the approximation of small perturbations are studied in the sixth chapter. The seventh chapter is devoted to scattering from large-scale irregularities. The scattered intensity and the extent of shadowing are calculated. In the eighth chapter the mean field and scattered intensity over an infinite rough surface are determined. In chapter nine the notion of effective cross-section of a body is introduced and its statistical properties investigated. Chapter ten introduces the so-called two-scale model in which a statistically rough surface is assumed to be composed of large scale irregularities covered with fine ripples. This type of combined model well describes the properties of signals scattered by real objects, *e.g.*, the ocean surface. The eleventh chapter deals with the problem of multiple scattering such as occurs in rough wave guides by means of Green's functions.

Despite the formidable appearance the book presents at first glance, the persistent reader will find that this is a well-written book. Any one with a good training in the fundamentals of electromagnetic and acoustic wave propagation and a working knowledge of modern probability theory can read the book with profit and equip himself for solving many interesting scattering problems encountered today in the broad fields of radar and sonar.

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The mathematical understanding of chemical engineering systems (Selected papers of Neal R. Amundson) edited by Rutherford Aris and Arvind Varma. Published by Pergamon Press, New York, 1980, Pp. 830, $ 113.

Amongst the traditional engineering disciplines, chemical engineering is perhaps the youngest, having had a history of perhaps only a century. Coincident with the rapid development of chemical industries in the US since the first World War, there came a realization that many of the chemical industries were characterised by a set of common operations termed " Unit Operation ". These were physical in nature and formed the nucleus for the growth of chemical engineering as a separate engineering discipline. The earliest attempts to systematize the design of equipment for carrying out these operations through the understanding of the basic principles were first discussed in the classical book entitled " Principles of Chemical Engineering " by Walker, Lewis and McAdams published in 1923. Until the 1940's these unit operations formed the basis of instruction and research in most of the US universities. Sherwood, Colburn, Lewis, McAdams are but a few notables amongst the many who dominated the field of transfer operations during these decades. While the analysis of physical transfer operations like mass and heat transfer was not particularly difficult, it was left to the genius of Hougen at the University of Wisconsin to initiate studies in applied chemical kinetics, a vital area in chemical engineering which rightly focussed urgent attention on the study of catalytic reactions influenced by convective and diffusion effects. At the same time, Byron Bird and his colleagues at Madison developed a comprehensive analytical treatment of transport phenomena and to this date, the pioneering work of Hougen and Bird represents classical contributions in chemical engineering science and this provided a face lift to the discipline of chemical engineering in early 1950's when it was plagued by correlation mania. During these years, it was realized that industrial equipment including chemical reactors hardly operated under steady state modes and the study of process dynamics and control became necessary and formed an important addition to the discipline of chemical engineering. The advent of high speed computers and the influence of techniques of applied mathematics that permeated engineering disciplines allowed a high degree of sophistication to be achieved in the analysis of several complicated chemical engineering phenomena considered unsolvable in the earlier decades. A new breed of chemical engineers having a strong foundation in engineering analysis started to dominate the chemical engineering discipline. The one man who made this possible is Neal Amundson who since 1949 and until 1977 was the Head of the Chemical Engineering Department at the University of Minnesota and who is now Cullen Professor of Chemical Engineering at the University of Houston. Incidentally, it is these two schools of Chemical Engineering—University of Wisconsin and University of Minnesota—that rank foremost amongst the US universities for the past several years. Neal Amundson brought to the Chemical Engineering discipline a unique scientific status equalled by few other disciplines. The analytical insights he himself possessed (with a Ph.D. in Mathematics, he was briefly the Head of the Department of Mathematics) and the diverse and powerful talents of his colleagues like Dahler, Aris, Scriven, Davis, Fredrickson, etc., provided a cross fertilization of biology, chemistry, material science and applied mathematics in teaching and research thus providing the chemical engineering discipline an overall omniscience that is rarely found in other engineering disciplines. The earliest application of matrices and finite difference equations to study processes like binary distillation, the first ever use of digital computer to solve distillation problems, analysis of dispersion in packed bed reactors, analysis of chromatography and ion exchange, stability and control of lumped as well as distributed chemical reactors, polymerization reactors are but a few of apparently diverse areas in which Neal Amundson showed his genius of providing research leadership. To recite the honours and the awards he received would be like decorating a voyageur's buckskins with boy-scout badges. The Walker (1961), Vincent Bendix (1970), Lewis (1971), and Wilhelm (1973) are but a few of the many honours he received and which indicate the deep and lasting influence that his work has had on contemporary research in chemical engineering. Neal Amundson built the lasting framework of mathematical analysis and modelling within which observed reacting systems behaviour could be understood. To borrow the tribute paid by Rutherford Aris " For Goldsmith, the immortal Johnson wrote the epitaph that there was almost no type of writing in which he did not engage and of those he touched, there was not one that he did not adorn ". With little change this might be applied to Amundson; not indeed as an epitaph but as a living tribute.

This valuable volume of 800 pages which is representative of the 2000 pages of published work of Neal Amundson is a tribute to a great man who over three decades of dedicated leadership and influence has brought distinction to an young engineering discipline through intelligent application of mathematical modelling to a variety of chemical engineering systems. The material presented in this volume could be a valuable source of information for the engineering scientists in general and chemical engineers in particular. For the applied mathematician, it serves to present a wide terrain within which lurks many an equation worthy of capture and further study. This volume would certainly adorn the shelves of any library devoted to the cause of professional progress in engineering and science.

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