



ENGINEERING ANALYSIS METHODS, by I. S. Habib, D. C. Heath & Co., Lexington, Mass.

REVIEWED BY ROBERT W. KOLKKA¹

The text *Engineering Analysis Methods* is a result of the author's teaching applied mathematics to senior and graduate students in engineering at the University of Michigan, Dearborn. The author's viewpoint is that applied mathematics should be presented with emphasis on the derivation of the governing equation, the method of solution and the physical interpretation of the resulting solution. As a result, the motivation of and the analysis of the validity of various mathematical operations is excluded.

The first three chapters consist of review material which the author feels is necessary for subsequent material on partial differential equations and integral equations contained in the remaining six chapters of the text.

The review material commences with a discussion of linear ordinary differential equations. The concepts of separable variables, exact equations, variation of parameter and the integrating factor are presented in view of first order differential equations. Constant coefficient second order equations are then treated and the ideas of characteristic equation, method of undetermined coefficients and variation of parameters are discussed in the usual manner. With respect to variation of parameters, the Wronskian is only mentioned and not given its due attention.

The second chapter deals with series solutions of ordinary differential equations. The method of Frobenius is conventionally discussed with good emphasis on the importance of the indicial equation and recurrence relation. Restrictions to ordinary and regular singular points are brought out but the reason for such restrictions is not. Linear independence is mentioned but given no detailed treatment. Bessel's equation, Bessel functions and modified Bessel functions are discussed in detail and sketches of $J_0(X)$, $J_1(X)$, $Y_0(X)$, $Y_1(X)$, $I_0(X)$, $I_1(X)$, $K_0(X)$ and $K_1(X)$ are given. It should be pointed out that the text contains 107 figures of functions, sketches and various diagrams, which in my opinion greatly enhances its presentation. An example on cylindrical heat flow is given. The chapter concludes with Legendre's equation and Legendre polynomials. Due attention is given to the Legendre function of the second kind which is unfortunately omitted in most texts on the subject. Rodrigués formula is given.

The third chapter is devoted to Fourier series. The usual definition on $[-\pi, \pi]$ is given and then rescaled to $[-l, l]$. The accuracy is discussed and shown in Fig. (3-3), but a treatment of Gibbs's phenomena, which is generally desirable, is omitted. Odd and even functions are defined. The idea of orthogonal functions is presented with a good transition from linear algebra. A thorough discussion of the Sturm-Liouville problem concludes the chapter with good emphasis on the physical interpretation of the boundary conditions.

The fourth chapter is an introduction to partial differential

equations. The definition and general form are written down. Some simple examples are then solved by direct integration. The chapter concludes with classification and transformation to canonical form. The clarity of the transformation to canonical form could be improved by saying something about the characteristics of the partial differential equation.

Chapter five treats hyperbolic equations in great detail. Several good explicit examples which reflect the method of solution and have an important physical application, are worked out. The chapter begins with the derivation of the equations for the vibrating string (with external forces and damping), longitudinal and transverse vibrations of a beam, transmission lines, acoustics and gravity water waves. The remainder of the chapter is devoted to the two basic methods of solution, separation of variables (bounded interval) and travelling waves (infinite, semi-infinite intervals). With respect to separation of variables, discussions of harmonics and overtones are given, techniques for nonhomogeneous equations and boundary conditions are presented and graphical techniques for obtaining eigenvalues are discussed. As for travelling waves, D'Alembert's solution is derived and interpreted and is followed by a section on reflection and transmission of waves. Extensions to two and three dimensions are discussed with the vibrating rectangular and circular membrane given as examples. In light of nonhomogeneous equations, Green's function is discussed but worked backwards. The solution is found first from which the Green's function is written. No method is given for finding the Green's function. Several good figures and schemes are included in this chapter.

Parabolic equations are the subject of chapter six. The author begins with an excellent development of the equations of heat transfer. Derivation of the momentum, diffusion and cable equations then follow. As in chapter five, the remainder is devoted to the methods of solution, separation of variables and the similarity solution (he does not use Fourier transforms). Separation of variables is put forth in much the same manner as in chapter five. Duhamel's superposition integral is presented in light of time dependent boundary conditions. The similarity solution is not entirely clear. The fundamental idea is that if a certain rescaling of the independent variables does not change the partial differential equation and the initial condition, then the problem is "similar" and the dependent variable θ remains unchanged, i.e. θ obeys the functional equation $\theta(\bar{x}, t) = \theta(L\bar{x}, L^2t)$ (for the diffusion equation) from which (via differentiation w.r.t. L) the similarity variable can be determined. None of the preceding is mentioned in his treatment. The chapter concludes with extension to two and three dimensions and a similar treatment of the Green's function as before.

Chapter seven concludes the material on partial differential equations with the treatment of elliptic equations. The equations for steady state heat flow, potential flow in fluids and electric potential are derived. Laplace's equation is solved by separation of variables and the resulting harmonic functions (rect., cylindrical, and spherical) and their properties are discussed in detail. Superposition of solutions is well stressed as it is throughout the book. Solution by conformal mapping is omitted. Poisson's equation is solved by transforming it to Laplace's equation.

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The final two chapters, eight and nine, derive and solve integral equations. Chapter eight serves as an introduction in which Fredholm and Volterra equations of the first and second kind, homogenous and nonhomogenous, are defined. The author shows the relation between integral and differential equations by transforming an initial value problem into a Volterra integral equation and a boundary value problem into a Fredholm integral equation.

Chapter nine is entirely devoted to the methods of solution of integral equations. The first part deals with the method of solution when the kernels are degenerate; some explanation of the linear algebra (Fredholm alternative) would have been helpful

here. The example of radiosity in an enclosure is worked out. Volterra equations are then solved by successive differentiation. Abel's equation is used as an example. The methods of successive substitution and approximation (Neumann series) are discussed in detail and the conditions for convergence of the series are very well explained. The chapter concludes with a discussion of Hilbert-Schmidt theory in which the necessity for symmetric kernels could have used some more discussion.

In my opinion, this book serves its purpose well and I would recommend it for use in an appropriate course. If one does use the book, one should be careful of the frequent misprints throughout the book.