Engineering Mathematics

with Applications

is written for mathematics courses in engineering. Core concepts are presented through a large number of solved examples followed by unsolved exercise. This text deals with the basic applications in a simple and supported by a plethora of examples, practice exercises for self-evaluation and detailed theory. Also, the text has been supplemented through remarks and notes to clarify principality of the subject.

- Differential Calculus-I
- Differential Calculus-II
- Integral Calculus-I
- ✓ Integral Calculus-II
- Vector Calculus
- Differential Equations and Integral **Transform Methods**
- Numerical Methods
- **Complex Numbers**
- Appendix

Sudhir Kumar Pundir PhD

is Head, Department of Mathematics, SD (PG) College, Muzaffarnagar, UP. He has been a recipient of JRF and SRF of CSIR, New Delhi, during his research work. He has been teaching undergraduate and postgraduate classes for well over two decades. He also organized and attended a number of national and international conferences. Six students have been awarded PhD degree under



his supervision. He has to his credit more than 100 books for undergraduate, postgraduate and engineering students which are widely used by the students of various universities.











Useful for

■ BE/BTech and all other Engineering Courses



CBS Publishers & Distributors Pvt Ltd

Sudhir Kumar Pundir



ublishers & Distributors Pvt Ltd.

Bhopal | Bhubaneswar | Hyderabad | Jharkhand | Nagpur | Patna | Pune | Uttarakhand | Dhaka (Bangladesh) | Kathmandu (Nepal)



ENGINEERING MATHEMATICS

with APPLICATIONS

Useful for

■ BE/B Tech and other Engineering courses

Dr. SUDHIR KUMAR PUNDIR

M.Sc., M.Phil, NET (JRF), Ph.D. Head Department of Mathematics S.D. (P.G.) College Muzaffarnagar (U.P.)



CBS Publishers & Distributors Pvt Ltd

New Delhi • Bengaluru • Chennai • Kochi • Kolkata • Mumbai Bhopal • Bhubaneswar • Hyderabad • Jharkhand • Nagpur • Patna • Pune • Uttarakhand • Dhaka (Bangladesh) • Kathmandu (Nepal)

Disclaimer

Science and technology are constantly changing fields. New research and experience broaden the scope of information and knowledge. The author has tried his best in giving information available to him while preparing the material for this book. Although, all efforts have been made to ensure optimum accuracy of the material, yet It is quite possible some errors might have been left uncorrected, The publisher, printer and author will not be held responsible for any inadvertent errors or inaccuracies.

ENGINEERING MATHEMATICS with APPLICATIONS

ISBN: 978-93-89688-87-0 Copyright © Author and Publisher

First Edition: 2020

All rights reserved. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system without permission, in writing, from the author and the publisher.

Published by Satish Kumar Jain and produced by Varun Jain for

CBS Publishers & Distributors Pvt Ltd

4819/XI Prahlad Street, 24 Ansari Road, Daryaganj, New Delhi 110 002, India.

Ph: 23289259, 23266861, 23266867 Website: www.cbspd.com

Fax: 011-23243014 e-mail: delhi@cbspd.com; cbspubs@airtelmail.in.

Corporate Office: 204 FIE, Industrial Area, Patpargani, Delhi 110 092

Ph: 4934 4934 Fax: 4934 4935 e-mail: publishing@cbspd.com;

publicity@cbspd.com

Branches

• Bengaluru: Seema House 2975, 17th Cross, K.R. Road,

Banasankari 2nd Stage, Bengaluru 560 070, Karnataka

Ph: +91-80-26771678/79 Fax: +91-80-26771680 e-mail: bangalore@cbspd.com

• Chennai: 7, Subbaraya Street, Shenoy Nagar, Chennai 600 030, Tamil Nadu

Ph: +91-44-26680620, 26681266 Fax: +91-44-42032115 e-mail: chennai@cbspd.com

• Kochi: 68/1534, 35, 36, Power House Road, Opp KSEB Power House,

Ernakulam 682 018, Kochi, Kerala

Ph: +91-484-4059061-65 Fax: +91-484-4059065 e-mail: kochi@cbspd.com

• Kolkata: 6/B, Ground Floor, Rameswar Shaw Road, Kolkata-700 014, West Bengal

Ph: +91-33-22891126, 22891127, 22891128 e-mail: kolkata@cbspd.com

• Mumbai: 83-C, Dr E Moses Road, Worli, Mumbai-400018, Maharashtra

Ph: +91-22-24902340/41 Fax: +91-22-24902342 e-mail: mumbai@cbspd.com

Representatives

• Bhopal	0-8319310552	Bhubaneswar	0-9911037372	Hyderabad	0-9885175004
 Jharkhand 	0-9811541605	 Nagpur 	0-9421945513	• Patna	0-9334159340
• Pune	0-9623451994	 Uttarakhand 	0-9716462459	 Dhaka (Bangladesh) 	01912-003485

• Kathmandu (Nepal) 977-9181742655

Printed at: Glorious Printers, Daryaganj, Delhi

Preface

The book entitled 'ENGINEERING MATHEMATICS with Applications' is meant for the students of B.E., B.Tech. and all other engineering courses. The book covers almost the entire syllabi of various technical universities in India.

In this book special and conscious efforts have been made to keep the writing style simple. It is a collection and compilation work from various sources and has been endeavoured to include as much as information as could be possible. Different concepts have been explained with the help of detailed theory and examples. There is a plenty of scope in the form of exercise for the readers to try and solve the problem on his own.

I express my gratitude to the authors and publishers of various books, I consulted during the preparation of the book.

I wish sincerely thank **Sh. S.K. Jain** and **Sh. Varun Jain**, Managing directors, CBS publishers and Distributors, New Delhi for their encouragement and help in bringing out this publication in a present nice form.

My special thank to Sh. Y.N. Arjuna, Senior director, publishing, editorial and publicity and Smt. Ritu Chawla, publishing head, CBS publishers and distributors, New Delhi whose encouragement and unstinted support enabled me to complete my book. Sh. Sunil Dutt and Sh. Suresh Sharma, CBS publishers and distributors deserve special mention for their kind help and support. Mr. Peeyush Goel, M/s Dreamshapers also deserve special mention for nice typesetting.

I must also record my appreciation due to my wife **Dr. Rimple**, daughter **Rijuta** and son **Shrish** for their understanding and love during the long period that I have taken to complete this book. I am indebted to my colleagues and research students who generously shared their views on the need of a comprehensive book on ENGINEERING MATHEMATICS.

Above all I am thankful to 'The Almighty God' without whose grace nothing is possible for anyone.

Further suggestions and comments for improvement of the book will be thankfully received and duly incorporated in the next edition.

DR. SUDHIR KUMAR PUNDIR

email: skpundir05@yahoo.co.in

Contents

Ch. 1	ALGEBRA	1-112
1.1	Introduction	1
1.2	Type of Matrices	1
	Operation on Matrices	
	Multiplication of Matrices	2 5
	Determinant of a Square Matrix	6
	Minor and Cofactors	13
1.7	Singular and Non-Singular Matrix	14
	Transpose of a Matrix	14
1.9	Symmetric and skew-symmetric Matrix	15
1.10	Complex Matrix	16
1.11	Submatrix of a Matrix	19
1.12	Rank of a Matrix	19
1.13	Elementary Transformations (or E-Transformations) of a Matrix	22
1.14	Inverse of a Matrix	30
1.15	System of Linear Equations	36
1.16	Homogeneous Linear Equations	38
1.17		42
	Gauss-Elimination Method	46
1.19	Eigenvalue and Eigenvectors of a Matrix	48
1.20	Diagonalization of a Matrix	59
1.21		65
	Solutions of Equations	77
	Number of Roots of any Equation	77
	Relation between the Root and Coefficients	77
	Transformation of Equation	79
	Descarte's Rule of Signs	88
	Cardan's Method to find the roots of a Cubic Equation	101
	Reduction of Biquadratic Equation into Euler's Cubic and Reducing Cubic	106
	Descarte's Method for finding the Roots of a Biquadratic	108
1.30	Ferrari's Method for finding the roots of a Biquadratic Equation	109
Ch. 2	DIFFERENTIAL CALCULUS-I	113-208
2.1	Successive Differentiation	113
2.2	Mean Value Theorems and Expansion of Functions	125
2.3	Indeterminate Forms	142
2.4	Tangent and Normal	150
2.5	Curvature	157
2.6	Envelopes and Evolutes	169
	Asymptotes	176
2.8	Curve Tracing	188
Ch 3	DIFFERENTIAL CALCULUS-II	209-266
3.1	Partial Differentiation	209
3.2	Change of Variables	222
	Expansion of Function of Several Variables	230
3.4		236
3.5	Concepts of Maxima and Minima	246
	Error and Approximations	262

Ch. 4	INTEGRAL CALCULUS-I	267-312
4.	2 Definite Integrals 3 Rectification of Curves 4 Area of Curve	267 278 286 294 300
Ch. 5	INTEGRAL CALCULUS-II	313-346
5. 5. 5.	Dirichlet's Theorems Liouville's Extension of Dirichlet's Theorem Change of Variables Change of Order of Integrations Gamma Functions Beta Function	313 322 324 327 329 331 333 337
Ch. 6	VECTOR CALCULUS	347-406
6. 6. 6. 6. 6. 6. 6.1		347 353 357 360 361 362 367 370 370 371 371
Ch. 7	SERIES	407-456
7. 7. 7. 7. 7. 7.1 7.1 7.1 7.1 7.1 7.1 7	Fundamental Results for the Convergence of Positive Term Series Comparison Tests Cauchy's Root Test D'Alembert's Ratio Test Raabe's Test Logarithmic Test Some Modified Forms Gauss's Test Cauchy's Integral Test Cauchy's Condensation Test Rearrangement of Terms Different Types of Convergence Leibnitz's Test More about Conditional and Absolute Convergence Summary of the Tests	407 409 411 414 414 419 419 420 424 424 424 425 426 428 430 433 442 444 448 452 454

Ch. 8	DIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORM METHODS	457-734
8.	An Introduction to Ordinary Differential Equations	457
8.3	2 Linear Differential Equation with Constant Coefficients	485
8.3	B Homogeneous Linear Differential Equations	505
8.4	1 Ordinary Simultaneous Linear Differential Equations	513
	5 Linear Differential Equation of Second Order with Variable Coefficients	523
8.	Applications of Ordinary Differential Equation to Engineering Problems	537
	7 Series Solution of Second Order Differential Equations	567
	B Legendre and Bessel's Functions	575
	The Laplace Transform	600
	The Inverse Laplace Transform	617
	Applications of Laplace Transform to Solution of Ordinary Differential Equation	629
	2 Partial Differential Equations	639
	3 Linear and Non-Linear Partial Differential Equations	648
	Partial Differential Equations of Second Order	660
	5 Applications of Partial Differential Equations to Engineering Problems 6 Fourier Transforms	674
	7 Z-Transforms	709 722
Ch. 9	STATISTICAL METHODS	735-850
9.		735
	2 Statistical Averages	747
	3 Correlation and Regression	786
9.		794
	5 Probability and Distributions	799
	Random Variables and Probability Distribution	809
9.	1 0	825
	Analysis of Variance (ANOVA)	839 844
Ch. 10	Coefficient of Contingency	851-1004
	NUMERICAL METHODS	
10.	ļ	851
	2 Bisection Method	852
	3 Secant Method 4 Iteration Method	854 855
	5 Regula-Falsi Method (or Method of False Position)	858
	Newton-Raphson's Method	862
	7 Complex Roots	866
	3 Lin-Bairstow's Method	868
	9 Graeffe's Root Square Method	871
	Gauss Elimination Method	875
	LU Decomposition Method or Method of Factorization	875
	2 Jordan's Method	877
10.1	3 Iterative Methods	881
10.1	Relaxation Method	885
10.1	5 Eigenvalue and Eigenvectors	887
10.10	6 Difference Schemes	891
	7 Factorial Notation	894
10.1	3 Fundamental Theorem of Difference Calculus	896
	Divided Difference	901
) Interpolation	905
	Newton's Formulae for Interpolation for Equal Intervals	906
	Newton's Divided Difference Formula	912
	3 Lagrange's Interpolation Formula	915
	Hermite's Interpolation Formula	920
	5 Central Differences Interpolation Formulae	922
10.20	S Numerical Differentiation	930

	10.27	Numerical Quadrature	937
		The Trapezoidal Rule	937
		Simpson's 1/3 Rule	938
		Simpson's 3/8 Rule	939
		Weddle's Rule	939
		Romberg's Method	940
		Newton-Cote's Formula	940
		Gauss' Quadrature Formula	943
		Higher Order Rules	950
	10.36	Difference Equations	955
	10.37	Numerical Solution of Ordinary Differential Equations	969
	10.38		970
		Euler's Modified Method	971
	10.40	Solution by Taylor Series	973
	10.41	Picard's Method of Successive Approximations	975
		Runge-Kutta Method	977
		Simultaneous Differential Equations	981
		Second Order Differential Equations	982
	10.45	Milne's Methods	984
	10.46	Numerical Solution of Partial Differential Equations	986
Ch. 11		COMPLEX NUMBERS	1005-1132
	11.1	Complex Numbers	1005
		Limits and Continuity	1010
		Functions of a Complex Variable	1011
		Branch Line and Branch Point	1014
		De-Moivre's Theorem	1014
	11.6	Expansions of $\cos n\theta$ and $\sin n\theta$ in powers of $\cos \theta$ and $\sin \theta$ (n being positive integer)	1018
		Circular Function of Complex Quantities	1026
		Hyperbolic Functions	1028
		Separation into Real and Imaginary Parts	1031
		Inverse Circular Function of Complex Quantities	1034
		Logarithm of Complex Quantities	1038
		Gregory's Series	1043
		Summation of Trigonometrical Series	1046
		Calculus of Complex Functions	1059
		Conformal Representations	1071
		Complex Integration	1083
		The Zeros of an Analytic Function	1104
		The Calculus of Residues	1114
0		APPENDIX	1133-1140
0		INDEX	1141-1144