DIFFERENTIAL EQUATIONS

Dr. B.D. SHARMA

01712

Kedar Nath Ram Nath

DIFFERENTIAL EQUATIONS

(Complete Theory and All Examples Fully Solved) for

Honours and Post-Greekente Classes

BHU DEV SHARMA M.Sc. Ph. D.

Reader in Mathematics University of Delhi.



MATHEMATICS AND STATISTICS PUBLICATIONS (For M.A., M.Sc., B.A., B.Sc., (Hons.) and Competitive Examinations)

Dr. P.P. Gupta, Dr. R.P.S. Yadav G.S. Malik

- Advanced Engineering Mathematics :
 - Dr. P.P. Gupta Statics
- 2. 3. Integral Transforms Dr. M.D. Rai Singhania
- Mathematical Methods 4.
- **Special Functions** 5. A.R. Vasishtha & Vipin Vasishtha
- Numerical Analysis 6. **Differential Equations** 7. Tyagi, Nand & Dr. Sharma
- Integral Calculus 8.
- Spherical Harmonics and Partial 9. **Differential Equations** Dr. B.D. Sharma
- **Differential Calculus** 10.
- 11. **Differential Equations**
- Hydrostatics 12.
- Spherical Trignometry 13. Tyagi, Nand & Dr. Sharma
- Co-ordinate Geometry of 3-Di-14. mensions (Solid Geometry)
- Attraction and Potential 15.
- Theory of Probability 16.
- Dynamics of Rigid Bodies 17. Brahma Nand Raj Kumar Sharma
- Basic Programming in computer 18. Science
- Dr. Sharma, Sachdeva **Elementary Hydrodynamics** 19.
- J.N. Sharma, Dr. Goel Matrics
- 20.
- Modern Algebra 21.

22. Linear Algebra Dr. B.D. Gupta & O.P. Gupta Mathematical Statistics 23. Dr. B.D. Gupta 24. Topology 25. Viva Voce in Mathematics J.N. Sharma, A.R. Vashishtha 26. Differential Geometry Dr. Gupta & Malik 27. Vector Calculus Dr. Gupta, Malik & Mittal 28. Measure Theory G.S. Malik Dynamics of a Particle 29. Spherical Astronomy 30. Dr. S.D. Sharma 31. **Operations Research Operations Research & Statistical** 32. Analysis Linear Programming and the 33. Theory of Games 34. Non-Linear and Dynamic Programming 35. An Introduction to Operations Research Dr. S.D. Sharma, Dr. Kalthia and Dr. Sharma Basic Elements of Fortran IV 36. Programming with Applications . Dr. S.S. Chaudhary, O.P. Gupta & M.A. Ansari **Applied Statistics** 37. Dr. P.P. Gupta & R.K. Gupta

Dr. S.N. Goel

- 38. Complex Variable Dr. R.K. Gupta
- Dynamics of a rigid Body 39.

All Rights Reserved DIFFERENTIAL EQUATIONS Price Rs. 80.00 Only

Published by

KEDAR NATH RAM NATH 132, R.G. College Road, Mcerut - 250 001 (U.P.) Phones : 543375, 543376, 7466555 Branch : G-2/3834/XI, Pataudi House Road, Daryaganj, New Delhi-110 002

Printed at : Durga Offset Printers Meerut The book has been written to provide the students with the material in a systematic and easy to understand way.

In a book of this character there will not be found much that is new or original. An attempt has been made to explain all the articles with clarity and to give model solutions of as many examples as were available. To attain this object many treatises on this and allied subject have been consulted. Numerous examples from examination papers of various Indian Universities have been taken. Examples which require special attention from the examination point of view have been marked with an asterisk (*).

The author is confident that this book, like this other books, will be liked and appreciated.

My thanks are due to the Publishers and Printers for their keen interest in the book.

Every suggestion to improve the book will be gratefully acknowledged.

-Bhu Dev Sharma

PREFACE OF THE NEW EDITION

This edition is practically a reprint of 11th edition. Misprints have been removed as far as possible, University references have been made upto-date.

I am thankful to large number of studentks and teachers who have written to me in admiration of the book.

Suggestions for improvement will be thankfully received.

-Bhu Dev Sharma



Chapters

Pages

Part I

I.	INTRODUCTION	1.
11.	EQUATIONS OF FIRST ORDER AND FIRST DEGREE	6
	(i) Variable separable	6
248	(ii) Homogeneous differential equations	10
5.5	(iii) Linear Differential equations	18
	(iv) Bernoulli's equation	22
14 A	(v) Problems of curves leading to differential equation	32
Ш.	EQUATIONS OF FIRST ORDER AND FIRST	
0	DEGREE [CONT.]	36
N _N ¹	(i) Exact differential equations	(36)
1	(ii) Working rule	37
•	(iii) Integrating factors	41
IV.	TRAJECTORIES	54
·V.	LINEAR DIFFERENTIAL EQUATION WITH	
	CONSTANT COEFFICIENTS	60
	(i) Auxiliary equation	61
	(ii) Particular integrals in some special cases	67
5	(iii) Exceptional cases	70
VI.	HOMOGENEOUS LINEAR EQUATION	95
	(i) Equations reducible to homogenous form	109
/II.	EQUATIONS OF THE FIRST ORDER BUT NOT OF	109
12	THE FIRST DEGREE	115
	(i) Equations solvable for p	
	(ii) Equations solvable for y	115
	(iii) Equations solvable for x	122
	(iv) Clairaul's equation	127
781.	SINGULAR SOLUTIONS	130
	(i) Tac locus, nodal locus, cusp locus	139
	(ii) General procedure	140
	PART II	141
50 36.4	EXACT DIFFERENTIAL EQUATIONS AND EQUA-	
	TIONS OF PARTICULAR FORMS	
el.	(.) Dependent variable absent	3
	(ii) Equations in which x is absent	3
12	(iii) Condition of exactness	8
	(iv) Integrating factor	13
	(v) Non-linear equations Exactness	22
	A standar equations Exaciness	28

Chapt	ers	Pages
п.	LINEAR EQUATIONS OF SECOND DEGREE	45
*	(i) One Integral of C.F. Known	45
	(ii) Removal of first derivative (Normal form)	62
- 8	(iii) Changing the independent variable	74
	(iv) Method of variation of parameters	85
	(v) Method of operational factors	97
III.	SIMULTANEOUS DIFFERENTIAL EQUATIONS	99
a	(i) Different methods	99
	(ii) Number of arbitrary constants ,	. 99
	(iii) Method of solving $dx/P = dy/Q = dz/R$	113
	(iv) Geometerial interpretations	114
IV.	TOTAL DIFFERENTIAL EQUATIONS	122
	(i) Condition of integrability	122
· · · ·	(ii) Methods of Solving $P dx + Q dy + R dz = 0$	123
	(iii) Orthogonality of integral surface of	100 million (100 m
	P dx+Q dy+R dx=0, dz/P=dy/Q=dz/R	138
	(iv) Non-Integrable Equations	139
¥.V.	INTEGRATION IN SERIES	141
. · · ·	(i) Solution near an ordinary point	142
	(ii) Solution when origin is a regular singular point	143
	(iii) Indical equation has unequal roots not differing by	
•	an integer	144
	(iv) Indical equation having equal roots	146
	(v) Roots of the indical equation differing by an	
	integer	149
	(vi) General theory (Forbenious Method)	152
VI.	NUMERICAL SOLUTIONS	157
	(i) Picard's method	157
	(ii) Taylor series method	162
: VII.	LEGENDER'S EQUATION	165
	(i) Legendre's Polynomials $P_n(x)$, $Q_n(x)$	167
	(ii) Generating Function for $P_n(x)$	168
	(iii) Rodrigue's formula	170
	(iv) Recurrence formula	170
VIII.	BESSEL'S EQUATION	193
	(i) Definition of $J_{\perp}(x)$	193
	(ii) Recurrence formulae	
51 (SEC	(iii) Generating function	196
19	(iv) Bessel's Integral	199 202
	() second integrat	202

¢.

(v)

Chapters	· · · · · · · · · · · · · · · · · · ·	Pages
	PART III	
I. L	INEAR PARTIAL DIFFERENTIAL EQUATIONS	
C	FORDER ONE	3
(i) Origin of Partial Differential Equations	4
(i	i) Lagrange's method for $Pp+Qq=R$	6
(i	ii) Lagrange's method for more than two independen	t
	variables	14
(i	v) Integral surfaces through a given curve	16
HI. N	ION-LINEAR PARTIAL DIFFERENTIAL	-
E	QUATIONS OF ORDER ONE	18
(i) Classification of integrals	18
(i	i) Charpit's method	22
` (i	ii) Particular methods : For $f(p,q)=0$	31
(i	(v) For $z=px+qy+f(p,q)=0$	33
(V) For f(z, p, q) = 0	35
((i) For $f_1(x,p) = f_2(y,q)$	37
(vii) Use of transformations	39
(viii) Solutions satisfying given conditions	44
III. L	INEAR PARTIAL DIFFERENTIAL EQUATIONS	8223
(i) Homogenous linear partial differential	
	equation with constant coefficients	46
(i	i) Solution when auxiliary equations has distinct roo	ts 47
(i	ii) When auxiliary equation has repeated roots	48
(i	v) Particular Integral	54
(v) Exceptional case	55
(vi) Exceptional case	55
(vii) A general method of finding the P.I.	59
IV. S	ECOND ORDER PARTIAL DIFFERENTIAL	
E	QUATION WITH VARIABLE COEFFICIENTS	84
(1	Monge's method for $Rr+Ss+Tt=V$	84
(i	ii) Monge's method for $Rr+Ss+Tt+U(rt-s^2)V$	104
(iii) Canonical forms	112
1	-	

(vi)