Functional Analysis

Applications in Mechanics and Inverse Problems

2nd Edition

by

L.P. LEBEDEV

Professor, Department of Mechanics and Mathematics, Rostov State University, Russia & Department of Mathematics and Statistics, National University of Bogota, Colombia

I.I. VOROVICH[†]

Professor, Department of Mechanics and Mathematics, Rostov State University, Russia Fellow of the Russian Academy of Sciences

and

G.M.L. GLADWELL

Distinguished Professor Emeritus, Department of Civil Engineering, University of Waterloo, Canada Fellow of the Royal Society of Canada, and Fellow of the American Academy of Mechanics

KLUWER ACADEMIC PUBLISHERS

NEW YORK, BOSTON, DORDRECHT, LONDON, MOSCOW

eBook ISBN: 0-306-48397-1 Print ISBN: 1-4020-0667-5

©2003 Kluwer Academic Publishers New York, Boston, Dordrecht, London, Moscow

Print ©2002 Kluwer Academic Publishers Dordrecht

All rights reserved

No part of this eBook may be reproduced or transmitted in any form or by any means, electronic, mechanical, recording, or otherwise, without written consent from the Publisher

Created in the United States of America

Visit Kluwer Online at: and Kluwer's eBookstore at: http://kluweronline.com http://ebooks.kluweronline.com

Table of Contents

1	Introduction	1			
	1.1 Real and complex numbers	1			
	1.2 Theory of functions	9			
	1.3 Weierstrass' polynomial approximation theorem	14			
2	Introduction to Metric Spaces	19			
	2.1 Preliminaries	19			
	2.2 Sets in a metric space	25			
	2.3 Some metric spaces of functions	27			
	2.4 Convergence in a metric space	29			
	2.5 Complete metric spaces	30			
	2.6 The completion theorem	32			
	2.7 An introduction to operators	35			
	2.8 Normed linear spaces	40			
	2.9 An introduction to linear operators	45			
	2.10 Some inequalities	48			
	2.11 Lebesgue spaces.	51			
	2.12 Inner product spaces.	58			
3	Energy Spaces and Generalized Solutions				
5	3.1 The rod	65			
	3.2 The Euler–Bernoulli beam	74			
	3.3 The membrane	78			
	3.4 The plate in bending	83			
	3.5 Linear elasticity	85			
	3.6 Sobolev spaces				
	3.7 Some imbedding theorems	90			
	5.7 Some moduling medicinis	90			
4	Approximation in a Normed Linear Space	99			
	4.1 Separable spaces				
	4.2 Theory of approximation in a normed linear space	103			
	4.3 Riesz's representation theorem	106			
	4.4 Existence of energy solutions of some mechanics problems				
	4.5 Bases and complete systems	113			

	4.6	Weak convergence in a Hilbert space	120
	4.7	Introduction to the concept of a compact set	126
	4.8	Ritz approximation in a Hilbert space	128
	4.9	Generalized solutions of evolution problems	132
5	Eler	nents of the Theory of Linear Operators	141
	5.1	Spaces of linear operators	141
	5.2	The Banach–Steinhaus theorem	144
	5.3	The inverse operator	147
	5.4	Closed operators	152
	5.5	The adjoint operator	157
	5.6	Examples of adjoint operators	162
6	Con	npactness and Its Consequences	167
	6.1	Sequentially compact \equiv compact	167
	6.2	Criteria for compactness	171
	6.3	The Arzelà–Ascoli theorem	174
	6.4	Applications of the Arzelà–Ascoli theorem	178
	6.5	Compact linear operators in normed linear spaces	183
	6.6	Compact linear operators between Hilbert spaces	189
7	Spe	ctral Theory of Linear Operators	195
	7.1	The spectrum of a linear operator	195
	7.2	The resolvent set of a closed linear operator	199
	7.3	The spectrum of a compact linear operator in a Hilbert space	201
	7.4	The analytic nature of the resolvent of a compact linear operator	208
	7.5	Self-adjoint operators in a Hilbert space	211
8	App	plications to Inverse Problems	219
	8.1	Well-posed and ill-posed problems	219
	8.2	The operator equation	220
	8.3	Singular value decomposition	226
	8.4	Regularization	229
	8.5	Morozov's discrepancy principle	234
In	dex		241