

Table of Contents

Preface

vii

Part I Three-Dimensional Analysis of Rectangular Plates Made of Functionally Graded Materials 1

Introduction 1

1. Elastic Plates 3

 1.1 Bi-dimensional theories 4

 1.1.1 The CPT 4

 1.1.2 Shear deformation theories: First-order
 deformation theory 7

 1.1.3 Shear deformation theories: Third-order
 deformation theory 8

 1.2 Three-dimensional theory 9

 1.3 Some remarks 12

2. Introduction to Functionally Graded Materials 13

 2.1 Fabrication methods 15

 2.2 Modelling of the effective material properties 15

 2.2.1 The rule of mixtures 16

 2.2.2 The Mori–Tanaka model 17

 2.2.3 Self-consistent model 21

 2.3 Some remarks 22

3.	Dynamic Analysis of Plates Made of Functionally Graded Materials	23
3.1	Statement of the problem	25
3.1.1	Basic definitions	25
3.2	Three-dimensional analysis	27
3.2.1	Strain energy	27
3.2.2	Kinetic energy	28
3.2.3	Dissipation functional	28
3.2.4	Work done by the external forces	29
3.3	Ritz method: Displacement representation	29
3.3.1	Chebyshev polynomials	31
3.3.2	Boundary functions	32
3.4	Solution methodology	33
3.5	Numerical results	37
3.5.1	Free vibrations	37
3.5.2	Forced vibrations	57
3.6	Some remarks	71
4.	Static Analysis of Plates Made of Functionally Graded Materials	73
4.1	Statement of the problem and solution methodology . .	74
4.2	Numerical results	77
4.3	Some remarks	85
Part II	Vibration Tailoring of Inhomogeneous Beams and Circular Plates	87
5.	Beams Made of Functionally Graded Material	89
5.1	Euler-Bernoulli beam equation	90
5.2	Method of solution of uniform beam vibrations	90
5.2.1	Determination of natural frequencies and mode shapes	92

6.	Vibration Tailoring of Inhomogeneous Elastically Restrained Vibrating Beams	97
6.1	Background	97
6.2	Analysis	99
6.3	Comparison between closed-form solutions of inhomogeneous vibrating beam and homogeneous beam	105
6.4	Vibration tailoring: Numerical example	106
7.	Some Intriguing Results Pertaining to Functionally Graded Columns	107
7.1	Background	107
7.2	Formulation of the problem	108
7.3	Dependence between Ω^2 and P	118
7.4	Numerical example	125
7.5	Conclusion	127
8.	Design of Heterogeneous Polar–Orthotropic Clamped Circular Plates with Specified Fundamental Natural Frequency	129
8.1	Background	129
8.2	Derivation of governing differential equation	130
8.3	Semi-inverse method of solution	132
	8.3.1 Parabolic mode shape	134
	8.3.2 Two cubic mode shapes	138
	8.3.3 Two alternative quartic mode shapes	145
8.4	Discussion	152
8.5	Vibration tailoring: Numerical example	153
9.	Vibration Tailoring of Simply-Supported Polar Orthotropic Inhomogeneous Circular Plates	155
9.1	Introduction	155

9.2	Analysis	156
9.2.1	Semi-inverse method of solution associated with $m = 1$	157
9.2.2	Semi-inverse method of solution associated with $m = 2$	159
9.2.3	Semi-inverse method of solution associated with $m = 3$	163
9.2.4	Semi-inverse method of solution associated with $m = 4$	167
9.3	Vibration tailoring: Numerical example	174
10.	Vibration Tailoring of Clamped–Clamped Polar Orthotropic Inhomogeneous Circular Plates	177
10.1	Analysis	177
10.1.1	Semi-inverse method of solution associated with $m = 1$	178
10.1.2	Semi-inverse method of solution associated with $m = 2$	180
10.1.3	Semi-inverse method of solution associated with $m = 3$	184
10.1.4	Semi-inverse method of solution associated with $m = 4$	186
10.2	Vibration tailoring: Numerical example	192
11.	Vibration Tailoring of a Polar Orthotropic Circular Plate with Translational Spring	193
11.1	Analysis	193
11.1.1	Boundary conditions	194
11.1.2	Method of solution	194
11.1.3	Vibration tailoring: Numerical example	210
12.	Conclusion	213
Appendix A: A Novel Formulation Leading to Closed-Form Solutions for Buckling of Circular Plates		215

Appendix B: Inverse Vibration Problem for Inhomogeneous Circular Plate with Translational Spring	227
Appendix C: Apparently First Closed-Form Solutions for Non-Symmetric Vibrations of Inhomogeneous Circular Plates	241
Appendix D: Closed-Form Solution for Axisymmetric Vibration of Inhomogeneous Simply-Supported Circular Plates	251
<i>References</i>	265
<i>Author Index</i>	309
<i>Subject Index</i>	319