
Contents

Preface	xi
Noël CHALLAMEL, Julius KAPLUNOV and Izuru TAKEWAKI	
Chapter 1. Optimization in Mitochondrial Energetic Pathways	1
Haym BENAROYA	
1.1. Optimization in neural and cell biology	1
1.2. Mitochondria	3
1.3. General morphology; fission and fusion	5
1.4. Mechanical aspects	9
1.5. Mitochondrial motility	13
1.6. Cristae, ultrastructure and supercomplexes	14
1.7. Mitochondrial diseases and neurodegenerative disorders	15
1.8. Modeling	16
1.9. Concluding summary	17
1.10. Acknowledgments	18
1.11. Appendix	18
1.12. References	19
Chapter 2. The Concept of Local and Non-Local Randomness for Some Mechanical Problems	23
Giovanni FALSONE and Rossella LAUDANI	
2.1. Introduction	23
2.2. Preliminary concepts	24
2.2.1. Statically determinate stochastic beams	24
2.2.2. Statically indeterminate stochastic beams	26

2.3. Local and non-local randomness	29
2.3.1. Statically determinate stochastic beams.	31
2.3.2. Statically indeterminate stochastic beams	32
2.3.3. Comments on the results	36
2.4. Conclusion	36
2.5. References	37
Chapter 3. On the Applicability of First-Order Approximations for Design Optimization under Uncertainty	39
Benedikt KRIEGESMANN	
3.1. Introduction	39
3.2. Summary of first- and second-order Taylor series approximations for uncertainty quantification	41
3.2.1. Approximations of stochastic moments.	42
3.2.2. Probabilistic lower bound approximation.	43
3.2.3. Convex anti-optimization	44
3.2.4. Correlation of probabilistic approaches and convex anti-optimization	45
3.3. Design optimization under uncertainty	46
3.3.1. Robust design optimization	46
3.3.2. Reliability-based design optimization.	47
3.3.3. Optimization with convex anti-optimization	48
3.4. Numerical examples.	48
3.4.1. Imperfect von Mises truss analysis	48
3.4.2. Three-bar truss optimization	50
3.4.3. Topology optimization	52
3.5. Conclusion and outlook	56
3.6. References	57
Chapter 4. Understanding Uncertainty.	61
Maurice LEMAIRE	
4.1. Introduction	61
4.2. Uncertainty and uncertainties.	61
4.3. Design and uncertainty	63
4.3.1. Decision modules	63
4.3.2. Designing in uncertain	66
4.4. Knowledge entity	67
4.4.1. Structure of a knowledge entity	67

4.5. Robust and reliable engineering	70
4.5.1. Definitions.	70
4.5.2. Robustness.	71
4.5.3. Reliability	72
4.5.4. Optimization.	72
4.5.5. Reliable and robust optimization	73
4.6. Conclusion	74
4.7. References	75
Chapter 5. New Approach to the Reliability Verification of Aerospace Structures	77
Giora MAYMON	
5.1. Introduction	77
5.2. Factor of safety and probability of failure	78
5.3. Reliability verification of aerospace structural systems	84
5.3.1. Reliability demonstration is integrated into the design process.	86
5.3.2. Analysis of failure mechanism and failure modes	87
5.3.3. Modeling the structural behavior, verifying the model by tests.	87
5.3.4. Design of structural development tests to surface failure modes	88
5.3.5. Design of development tests to find unpredicted failure modes	88
5.3.6. “Cleaning” failure mechanism and failure modes	88
5.3.7. Determination of required safety and confidence in models	89
5.3.8. Determination of the reliability by “orders of magnitude”	89
5.4. Summary	92
5.5. References	93
Chapter 6. A Review of Interval Field Approaches for Uncertainty Quantification in Numerical Models	95
Matthias FAES, Maurice IMHOLZ, Dirk VANDEPITTE and David MOENS	
6.1. Introduction	95
6.2. Interval finite element analysis	97
6.3. Convex-set analysis	99
6.4. Interval field analysis	100
6.4.1. Explicit interval field formulation	101
6.4.2. Interval fields based on KL expansion	103
6.4.3. Interval fields based on convex descriptors	105
6.5. Conclusion	105
6.6. Acknowledgments	106
6.7. References	106

Chapter 7. Convex Polytopic Models for the Static Response of Structures with Uncertain-but-bounded Parameters	111
Zhiping QIU and Nan JIANG	
7.1. Introduction	111
7.2. Problem statements	114
7.3. Analysis and solution of the convex polytopic model for the static response of structures	116
7.4. Vertex solution theorem of the convex polytopic model for the static response of structures.	119
7.5. Review of the vertex solution theorem of the interval model for the static response of structures.	122
7.6. Numerical examples.	127
7.6.1. Two-step bar	127
7.6.2. Ten-bar truss	130
7.6.3. Plane frame	135
7.7. Conclusion	141
7.8. Acknowledgments	141
7.9. References	141
Chapter 8. On the Interval Frequency Response of Cracked Beams with Uncertain Damage	145
Roberta SANTORO	
8.1. Introduction	146
8.2. Crack modeling for damaged beams	148
8.2.1. Finite element crack model	148
8.2.2. Continuous crack model	149
8.3. Statement of the problem	150
8.3.1. Interval model for the uncertain crack depth	151
8.3.2. Governing equations of damaged beams	152
8.3.3. Finite element model versus continuous model	154
8.4. Interval frequency response of multi-cracked beams	162
8.4.1. Interval deflection function in the FE model	162
8.4.2. Interval deflection function in the continuous model	165
8.5. Numerical applications	167
8.6. Concluding remarks	173
8.7. Acknowledgments	173
8.8. References	173

Chapter 9. Quantum-Inspired Topology Optimization	177
Xiaojun WANG, Bowen NI and Lei WANG	
9.1. Introduction	177
9.2. General statements.	180
9.2.1. Density-based continuum structural topology optimization formulation.	180
9.2.2. Characteristics of quantum computing	181
9.3. Topology optimization design model based on quantum-inspired evolutionary algorithms	183
9.3.1. Classic procedure of topology optimization based on the SIMP method and optimality criteria	183
9.3.2. The fundamental theory of a quantum-inspired evolutionary algorithm – DCQGA.	186
9.3.3. Implementation of the integral topology optimization framework	189
9.4. A quantum annealing operator to accelerate the calculation and jump out of local extremum.	191
9.5. Numerical examples.	195
9.5.1. Example of a short cantilever	195
9.5.2. Example of a wing rib	196
9.6. Conclusion	198
9.7. Acknowledgments	198
9.8. References	199
Chapter 10. Time Delay Vibrations and Almost Sure Stability in Vehicle Dynamics	203
Walter V. WEDIG	
10.1. Introduction to road vehicle dynamics	203
10.2. Delay resonances of half-car models on road	205
10.3. Extensions to multi-body vehicles on a random road	209
10.4. Non-stationary road excitations applying sinusoidal models	212
10.5. Resonance reduction or induction by means of colored noise	215
10.6. Lyapunov exponents and rotation numbers in vehicle dynamics.	218
10.7. Concluding remarks and main new results.	221
10.8. References	222
Chapter 11. Order Statistics Approach to Structural Optimization Considering Robustness and Confidence of Responses	225
Makoto YAMAKAWA and Makoto OHSAKI	
11.1. Introduction.	225

11.2. Overview of order statistics	226
11.2.1. Definition of order statistics	226
11.2.2. Tolerance intervals and confidence intervals of quantiles	227
11.3. Robust design.	229
11.3.1. Overview of the robust design problem	229
11.3.2. Worst-case-based method.	230
11.3.3. Order statistics-based method	230
11.4. Numerical examples	231
11.4.1. Design response spectrum	231
11.4.2. Optimization of the building frame considering seismic responses	232
11.4.3. Multi-objective optimization considering robustness	236
11.5. Conclusion	239
11.6. References	240
List of Authors	243
Index	245
Summaries of Volumes 1 and 2	249