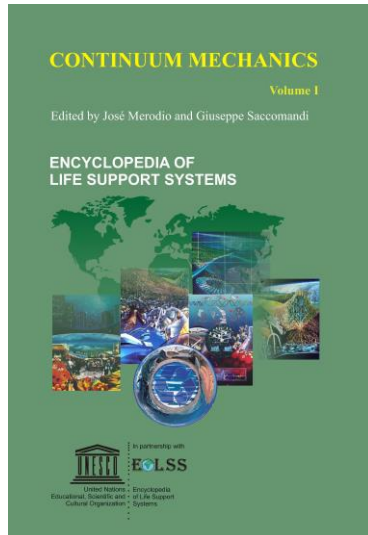


CONTENTS

CONTINUUM MECHANICS



Continuum Mechanics Volume 1

e-ISBN: 978-1-84826-372-7

ISBN : 978-1-84826-822-7

No. of Pages: 460

Continuum Mechanics Volume 2

e-ISBN: 978-1-84826-373-4

ISBN : 978-1-84826-823-4

No. of Pages: 446

Continuum Mechanics Volume 3

e-ISBN: 978-1-84826-374-1

ISBN : 978-1-84826-824-1

No. of Pages: 388

For more information of e-book and Print Volume(s) order, [please click here](#)
Or contact : eolssunesco@gmail.com

CONTENTS

Preface

xi

VOLUME I

General Overview of Continuum Mechanics

1

Jose Merodio, *Department of Continuum Mechanics and Structures, Universidad Politécnica de Madrid, Madrid, Spain*

Anthony D. Rosato, *Department of Mechanical Engineering, New Jersey Institute of Technology University Heights, Newark, NJ 0710, USA*

1. Preliminary concepts: Definitions and theoretical framework
2. Kinematics of deformation
 - 2.1. The continuum setting: Mathematical description
 - 2.2. Displacement, deformation and motion
 - 2.3. Stretch, shear and strain
 - 2.4. Change of reference frame and objective tensors
3. Balance laws
 - 3.1. Mass and conservation of mass
 - 3.2. Force, torque and theory of stress
 - 3.3. Euler's laws of motion
 - 3.4. Energy
 - 3.5. Summary of equations and unknowns
4. Constitutive behavior
 - 4.1. Basic concepts of constitutive theories
 - 4.2. Isothermal Solid Mechanics
 - 4.3. Isothermal Fluid Mechanics

Introduction to Continuum Mechanics

58

J. Merodio, *Department of Continuum Mechanics and Structures, E.T.S. Ing. Caminos, Canales y Puertos, Universidad Politécnica de Madrid, Madrid, Spain*

G. Saccomandi, *Dipartimento di Ingegneria Industriale, Via G. Duranti, Università degli Studi di Perugia, 06125 PERUGIA Italy*

1. Introduction
2. The Continuum Setting: Kinematics and Balance Equations
3. Mathematical issues
4. A primer on constitutive equations (solids)
 - 4.1. Entropic spring
 - 4.2. Phenomenological laws
5. More on constitutive behavior (fluids) and coupled fields
6. Rethinking basic issues

History of Continuum Mechanics

80

Robert W. Soutas-Little, *Professor Emeritus of Engineering Mechanics, College of Engineering, Michigan State University, USA*

1. History of general theories and fundamental equations
2. History of constitutive equations; rheology
3. Development of mathematical methods of solution of the equations

Kinematics**94**

Anurag Gupta, *Department of Mechanical Engineering, Indian Institute of Technology, Kanpur, UP 208016, India*

David J. Steigmann, *Department of Mechanical Engineering, University of California, Berkeley, CA 94720, USA*

1. Preliminaries
2. Body, configurations, and motion
3. Deformation gradient
4. Rotation tensors and rigid body motion
5. Singular surfaces

Balance Laws**120**

Anurag Gupta, *Department of Mechanical Engineering, Indian Institute of Technology, Kanpur, UP 208016, India*

David J. Steigmann, *Department of Mechanical Engineering, University of California, Berkeley, CA 94720, USA*

1. Integral theorems
2. Surface interactions
3. Balance laws and jump conditions

Thermodynamics**141**

L. Deseri, *D.I.M.S., Dept. of Mechanical and Structural Engineering Università degli Studi di Trento, Trento, Italy and visiting professor at the S.T.R.eG.A. Lab. University of Molise, Termoli (CB), Italy*

G. Marcari, *College of Engineering, University of Molise, Italy*

G. Zurlo, *D.I.C.A. Politecnico di Bari, Bari, Italy*

1. Introduction
2. Basic Notions of Thermodynamics
 - 2.1. A Few Definitions
 - 2.2. More about Systems, States and Processes
 - 2.3. A Few Words about Extended Thermodynamics
3. Balance and Thermodynamic Laws
 - 3.1. State Functions.
 - 3.2. Some consequences of the Second Law of Thermodynamics.
4. Thermodynamics of Non-Reacting Mixtures
 - 4.1. Material and Geometric Phases
 - 4.2. Types of Phase Transitions
 - 4.3. Equilibrium of Non-Reacting Mixtures: Chemical Potentials and the Gibbs' Phase Rule
 - 4.4. The Gibbs-Duhem Equations
 - 4.5. Geometrical Interpretation of the Gibbs-Duhem Equation
 - 4.6. Equilibrium between Different Phases: The Common Tangent Rule
 - 4.7. Ideal Solution Theory
 - 4.8. Non Ideal Solution Theory: Bragg-Williams and Flory-Huggins Approximations
 - 4.9. An Example of Binary Mixtures Encountered in Biological Systems: Lipid-Lipid and Lipid-Cholesterol Mixtures
5. Continuum Thermodynamics of Mixtures: Coupling with Mechanical Effects
 - 5.1. Preliminary Definitions and Basic Laws
 - 5.2. Consequences of the Laws of Thermodynamics in Mixture Theory
 - 5.3. The Variational Problem for a Non-Reacting Mixture

Constitutive Theories: Basic Principles**198**I-Shih Liu, *Instituto de Matemática, Universidade Federal do Rio de Janeiro, Brazil*

1. Introduction
2. Frame of reference, observer
3. Motion and deformation of a body
4. Objective tensors
5. Galilean invariance of balance laws
6. Constitutive equations in material description
7. Principle of material frame-indifference
8. Constitutive equations in referential description
9. Simple materials
10. Material symmetry
11. Remarks on material models
12. Elastic materials
13. Viscous fluids
14. Thermodynamic considerations

Simple Constitutive Models for Solids and Fluids**246**Manuel Doblaré, Estefanía Peña, and Jose F. Rodríguez, *Group of Structural Mechanics and Materials Modelling, Aragón Institute of Engineering Research (I3A), Universidad de Zaragoza, Spain*

1. Basic Results in Continuum Mechanics
 - 1.1. Kinematics
 - 1.2. Stress Tensors and Balance of Momenta
 - 1.3. Energy Balance Principle and Entropy Inequality
 - 1.4. Fundamental Principles of Constitutive Models
2. Elastic and Hyperelastic Materials
 - 2.1. Isotropic Hyperelastic Materials
 - 2.2. Constitutive Models for Fiber-Reinforced Hyperelastic Materials
 - 2.3. Examples of Numerical Applications
3. Elastoplasticity and Viscoplasticity
 - 3.1. Classical Rate-Independent Infinitesimal Strain Plasticity
 - 3.2. Phenomenological Plasticity in Large Deformation Problems
 - 3.3. Viscoplasticity
4. Viscous fluids And Solids
 - 4.1. Uniaxial Models
 - 4.2. General 3D Viscoelastic Constitutive Models
 - 4.3. Examples of Numerical Application
5. Continuum Damage Models
 - 5.1. Principles of Continuum Damage Mechanics
 - 5.2. Constitutive Models For Continuum Damage Mechanics of Hyperelastic Materials
 - 5.3. Examples of Numerical Application

Linear Elasto-Statics**344**J.R. Barber, *Department of Mechanical Engineering, University of Michigan, USA*

1. Introduction
2. Traction and Stress
3. Transformation of Coordinates
4. Hooke's Law
5. Loading and Boundary Conditions
6. Strain Energy and Variational Methods
7. Two-Dimensional Problems
8. Solution of Boundary-Value Problems

9. The Prismatic Bar under Shear and Torsion
10. Three-Dimensional Problems
11. Concentrated Forces and Dislocations
12. Asymptotic Fields at Singular Points
13. Anisotropic Materials

Index	395
About EOLSS	403

VOLUME II

Linear Elastodynamics And Waves	1
<i>M. Destrade, School of Electrical, Electronic, and Mechanical Engineering, University College Dublin, Belfield, Dublin 4, Ireland</i>	
<i>G.Saccomandi, Dipartimento di Ingegneria Industriale, Università degli Studi di Perugia, 06125 Perugia, Italy.</i>	

1. Introduction
2. Bulk waves
 - 2.1. Homogeneous Waves in Isotropic Solids
 - 2.2. Homogeneous Waves in Anisotropic Solids
 - 2.3. Slowness Surface and Wavefronts
 - 2.4. Inhomogeneous Waves in Isotropic Solids
3. Surface waves
 - 3.1. Shear Horizontal Homogeneous Surface Waves
 - 3.2. Rayleigh Waves
 - 3.3. Love Waves
 - 3.4. Other Surface Waves
 - 3.5. Surface Waves in Anisotropic Media
4. Interface waves
 - 4.1. Stoneley Waves
 - 4.2. Slip Waves
 - 4.3. Scholte Waves
 - 4.4. Interface Waves in Anisotropic Solids
5. Concluding remarks

Elementary Fluid Dynamics	32
<i>G. Bergeles, Department of Mechanical Engineering, Nat. Technical University of Athens, Greece</i>	

1. Fundamental concepts of Fluids
 - 1.1. What is Fluid Mechanics?
 - 1.2. What is a Fluid?
 - 1.3. Continuum
 - 1.4. Physical Properties of a Fluid
 - 1.5. System of Units and Equation Homogeneity
2. Fluid Statics
 - 2.1. Hydrostatic Equation
 - 2.2. Hydraulic Mechanisms
 - 2.3. Pressure Measuring Instruments
 - 2.4. Forces on Submerged Surfaces
 - 2.5. Forces on Submerged Bodies-Buoyancy Force
 - 2.6. Stability of Floating Bodies
3. Hydrodynamics

- 3.1 Kinematics of the Fluid
- 3.2. Lagrangian and Eulerian Description of the Flow
- 3.3. Rate of Deformation of the Fluid Element
- 3.4. Irrotational flow
- 3.5. Forces Acting on Moving Fluids
- 3.6. Conservation of Mass
- 3.7. Conservation of Linear Momentum
- 3.8. Euler's Equations
- 3.9. The Velocity of Sound Propagation or Speed of Sound
- 3.10. Bernoulli's equation
4. Laminar and Turbulent Flow
 - 4.1. Two flow regimes, Laminar and Turbulent.
 - 4.2. Flow Separation
 - 4.3. Analytic Solutions for Laminar Flow
 - 4.4. Flows in Ducts
 - 4.5. Flows in Porous Media
 - 4.6. Flow around Bodies
5. Aerodynamics-gas dynamics of the inviscid Fluid
 - 5.1. Introduction
 - 5.2. The energy equation for inviscid flows
 - 5.3. Flow in Convergent-Divergent Nozzle
 - 5.4. Stream Function and Velocity Potential Function
 - 5.5. The Principle of Superposition
 - 5.6. Parallel Flow around Non Lifting Slender Bodies
 - 5.7. Parallel Flow around Airfoils
6. Fluid Mechanics in energy machines
 - 6.1. Fans
 - 6.2. The Pelton Hydraulic Turbine
 - 6.3. Pumps
 - 6.4. Wind Turbines
 - 6.5. The Propeller

Thermoelasticity**142**

D. Ieşan, Department of Mathematics, "A.I. Cuza" University and Institute of Mathematics, Romanian Academy, Iaşi, Romania

1. Introduction
2. Preliminaries
3. Constitutive Equations
4. Equations of the Nonlinear Thermoelasticity
5. Linear Theory
6. Dynamic Theory. Uniqueness and Continuous Dependence Results
7. Reciprocal Theorem. Applications
8. Variational Theorem
9. Homogeneous and Isotropic Bodies
10. Thermoelastic Waves
11. Equilibrium Theory. Thermoelastic States
12. Homogeneous and Isotropic Bodies
13. Thermoelastic Plane Strain
14. Thermal Stresses in Beams
15. Special Problems

Nonlinear Elasticity and Its Role in Continuum Theories**270**Alan Wineman, *Department of Mechanical Engineering, University of Michigan, Ann Arbor, Michigan USA*

1. Introduction
2. Nonlinear Elasticity
 - 2.1. Kinematics
 - 2.2. Field Equations
 - 2.3. Constitutive Equations for Nonlinear Elastic Response
 - 2.4. Constraints
 - 2.5. Some Forms for Strain Energy \tilde{W}
 - 2.6. Heat Flux Vector – Constitutive Equation
 - 2.7. Some Basic Deformations
 - 2.8. Concluding Comments for this Section
3. Nonlinear Viscoelastic Solids
 - 3.1. Kinematics
 - 3.2. Field Equations
 - 3.3. Constitutive Equations for Nonlinear Viscoelastic Solids
 - 3.4. Constraints
 - 3.5. Isotropic Materials
 - 3.6. Some Proposed Constitutive Equations for Nonlinear Viscoelastic Solids
 - 3.7. Some Basic Deformations
 - 3.8. Concluding Comments for This Section
4. Mixtures, Interacting Continua
 - 4.1. Kinematics
 - 4.2. Field Equations
 - 4.3. Volume Additivity Constraint
 - 4.4. Constitutive Equations
 - 4.5. Special Topics
5. Concluding Comments

Fundamental Applications: Solid Mechanics**309**M. Elices, V. Sánchez-Gálvez, A. Valiente, J. LLorca and G.V. Guinea, *Departamento de Ciencia de Materiales, Universidad Politécnica de Madrid, Spain*

1. Introduction
2. Application to Metals
 - 2.1. Plasticity models
 - 2.2. Damage and fracture models
 - 2.3. Fatigue models
 - 2.4. Creep models
3. Application to Composite Materials
 - 3.1. Introduction
 - 3.2. Homogenization models
4. Application to Biological Materials
 - 4.1. Characteristics of Biological Materials
 - 4.2. Macroscopic Models

Applications to Fluid Mechanics: Water Wave Propagation**336**I. J. Losada and J. A. Revilla, *Environmental Hydraulics Institute “IH Cantabria”, Universidad de Cantabria, Spain*

1. Introduction
2. Classification of Wave Models
3. Phase-Averaged Models

4. Phase-Resolving Models
 - 4.1. Introduction
 - 4.2. Governing Equations for Water Waves
 - 4.3. Linear Wave Theory
 - 4.4. Depth Integrated Models
 - 4.5. Boussinesq equations. General formulation
 - 4.6. Energy Dissipation in Depth Integrated Models
5. Models Based On Navier Stokes-Equations
 - 5.1. Introduction
 - 5.2. Reynolds Averaged-Navier Stokes Equations Models
 - 5.3. Large Eddy Simulation Models
 - 5.4. Applications
6. Concluding Remarks

Index **381**

About EOLSS **389**

VOLUME III

Turbulence **1**

*P. Cinnella, Laboratoire de Simulation Numérique en Mécanique des Fluides,
Ecole Nationale Supérieure d'Arts et Métiers, PARIS, France*

1. What is turbulence?
 - 1.1. Phenomenology
 - 1.2. Some Notions in Hydrodynamic Stability and Transition
 - 1.3. Properties of Turbulent Flow
 - 1.4. Brief Historical Survey
2. Energy cascade and dissipation
 - 2.1. A “Simple” Example: The Burgers Equation
3. Vorticity dynamics and energy cascade
4. Turbulence scales
5. Turbulence modeling
 - 5.1. Need for Turbulence Modeling
 - 5.2. Modeling Strategies
6. Reynolds averaged approach
 - 6.1. The Reynolds-averaged Navier-Stokes equations
 - 6.2. Eddy Viscosity Turbulence Models
 - 6.3. Beyond the Boussinesq Approximation: Reynolds Stress Models, Nonlinear Models
7. Large eddy simulation
 - 7.1. The Filtered Navier-Stokes Equations
 - 7.2. Subgrid-Scale Models
8. Future research directions

Nonlinear Electro- and Magnetoelastic Interactions **41**

*A. Luis Dorfmann, Tufts University, USA
Ray W. Ogden, University of Glasgow, UK*

1. Introduction
2. Electrostatics
 - 2.1. Coulomb's Law
 - 2.2. Charge Conservation
 - 2.3. The Field of a Static Charge Distribution

- 2.4. Gauss's Theorem
- 3. Magnetostatics
 - 3.1. Scalar Magnetic Potential
 - 3.2. Ampère's Circuital Law
 - 3.3. The Biot-Savart Law and the Vector Potential
 - 3.4. Force and Couple on a Dipole in a Magnetic Field
- 4. Faraday's Law of Induction
 - 4.1. Electromotive Force
 - 4.2. Flux of Magnetic Field through a Moving Circuit
 - 4.3. Faraday's Law
- 5. Maxwell's Equations
 - 5.1. Polarization and Magnetization in Materials
- 6. Boundary Conditions
 - 6.1. Boundary Conditions for \mathbf{E} and \mathbf{D}
 - 6.2. Boundary Conditions for \mathbf{B} and \mathbf{H}
- 7. Deformable Electromagnetic Materials
 - 7.1. Continuum Kinematics
 - 7.2. Maxwell's Equations for a Deforming Continuum
 - 7.3. Lagrangian Formulation
- 8. Nonlinear Magnetoelastic Interactions
 - 8.1. Equilibrium, Stress and Constitutive Laws
 - 8.2. Material Symmetry Considerations
- 9. Representative Boundary-Value Problems
 - 9.1. Application to Circular Cylindrical Geometry
 - 9.2. Helical Shear
 - 9.3. Extension and Inflation of a Tube

Liquid Crystals

112

Paolo Biscari, *Department of Mathematics, Politecnico di Milano, Italy*

- 1. The liquid crystalline phase
- 2. Frank director theory
- 3. Nematic displays: Freedericksz transition
 - 3.1. The Variational Origin of Freedericksz' Threshold
 - 3.2. Freedericksz Transitions
- 4. Dynamics
- 5. Landau-de Gennes order tensor theory
- 6. Topological defects
 - 6.1. Nematic Defects
- 7. Nematic elastomers
 - 7.1. Soft Elasticity and Striped Domains

Configurational Forces

144

G rard A. Maugin, *Institut Jean Le Rond d'Alembert (UMR 7190 CNRS), Universit  Pierre et Marie Curie, Paris, France*

- 1. Introduction
- 2. Concepts of Piola stress and configurational stress
- 3. Configurational force
- 4. Pseudo-inhomogeneity and pseudo-plastic effects
 - 4.1. Materially Homogeneous Thermoelasticity
 - 4.2. Other Cases
- 5. Inhomogeneous pure elasticity: conservation laws
 - 5.1. A Sufficiently General Variational Formulation
 - 5.2. Definitions of Various Systems

- 5.3. The Case of Hyperelasticity
- 5.4. Dissipation: Elementary Approach
- 6. General continuum mechanics: canonical conservation laws
 - 6.1. Reminder
 - 6.2. Canonical Balance Laws of Momentum and Energy
- 7. Configurational forces acting on field singularities
 - 7.1. Introductory Remark
 - 7.2. The Case of a Progressing Crack
 - 7.3. The Case of a Dissipative Phase Transition Front (Singular Surface I)
 - 7.4. The case of thermo-mechanical shock waves (singular surface II)
 - 7.5. Continuously Distributed Singularities
- 8. Configurational forces and numerics
 - 8.1. Computing Configurational Forces for their own sake
 - 8.2. Exploiting Configurational Forces as Numerics Criteria
- 9. Conclusion: the World of configurational forces

Implicit Constitutive Relations**190**K. R. Rajagopal, *Texas A&M University, USA*

- 1. Introduction
- 2. A Simple Implicit Model
- 3. More General Implicit Theories for Fluids
- 4. Implicit Theories for Elastic Solids
- 5. More General Implicit Theories
- 6. Concluding Remarks

Introductory Topics In The Mathematical Theory Of Continuum Mechanics**206**R J Knops, *School of Mathematical and Computer Sciences, Heriot-Watt University, UK*R. Quintanilla, *Department of Applied Mathematics II, UPC Terrassa, Spain***I. GENERAL PRINCIPLES**

- 1. Introduction
- 2. The well-posed problem

II. BASIC CONTINUUM MECHANICS

- 3. Introduction
- 4. Material description
- 5. Spatial description
- 6. Constitutive theories

III. EXAMPLE: HEAT CONDUCTION

- 7. Introduction. Existence and uniqueness
- 8. Continuous dependence. Stability
- 9. Backward heat equation. Ill-posed problems
- 10. Non-linear heat conduction
- 11. Infinite thermal wave speeds

IV. CLASSICAL THEORIES

- 12. Introduction
- 13. Thermoviscous flow. Navier-Stokes Fluid
- 14. Linearized and linear elastostatics
- 15. Linearized Elastodynamics
- 16. Linearized and linear thermoelastostatics
- 17. Linearized and linear thermoelastodynamics
- 18. Viscoelasticity
- 19. Non-linear Elasticity
- 20. Non-linear thermoelasticity and thermoviscoelasticity

V. NON-CLASSICAL THEORIES

- 21. Introduction
- 22. Isothermal models
- 23. Thermal Models

Index 325

About EOLSS 331