Theory Of Linear Poroelasticity With Applications To Geomechanics And Hydrogeology

This book provides a unified framework for subsurface imaging based upon asymptotic and trajectory-based methods, with online software applications.
A full account of thermo-poroelasticity and thermo-poromechanics with derivations to problems, for both experienced and novice researchers.
Porous media are broadly found in nature and their study is of high relevance in our present lives. In geosciences porous media research is fundamental in applications to aquifers, mineral mines, contaminant transport, soil remediation, waste storage, oil recovery and geothermal energy deposits. Despite their importance, there is as yet no complete understanding of the physical processes involved in fluid flow and transport. This fact can be attributed to the complexity of the phenomena which include multicomponent fluids, multiphasic flow and rock-fluid interactions. Since its formulation in 1856, Darcy’s law has been generalized to describe multi-phase compressible fluid flow through anisotropic and heterogeneous porous and fractured rocks. Due to the scarcity of information, a high degree of uncertainty on the porous medium properties is commonly present. Contributions to the knowledge of modeling flow and transport, as well as to the characterization of porous media at field scale are of great relevance. This book addresses several of these issues, treated with a variety of methodologies grouped into four parts: I Fundamental concepts II Flow and transport III Statistical and stochastic characterization IV Waves The problems analyzed in this book cover diverse length scales that range from small rock samples to field-size porous formations. They belong to the most active areas of research in porous media with applications in geosciences developed by diverse authors. This book was written for a broad audience with a prior and basic knowledge of porous media. The book is addressed to a wide readership, and it will be useful not only as an authoritative textbook for undergraduate and graduate students but also as a reference source for professionals including geoscientists, hydrogeologists, geophysicists, engineers, applied mathematicians and others working on porous media.
Mechanics of Fluid Saturated Rocks presents a current and comprehensive report on this emerging field that bridges the areas of geology and mechanics. It is of direct interest to a wide spectrum of earth scientists and engineers who are concerned with upper-crust mechanics and fluid movements, the most important fluids being oil and water. This authoritative book is the result of a collaborative effort between scientists in academic institutions and industry. It examines important issues such as subsidence, geological fault formation, earthquake faulting, hydraulic fracturing, transport of fluids, and natural and direct applications. Mechanics of Fluid Saturated Rocks provides a unique interdisciplinary viewpoint, as well as case studies, conclusions, and

recommendations for further research. Covers the physical, chemical, and mechanical analysis of porous saturated rock deformation on both large and small scales Discusses the latest developments of importance to engineers and geologists Examines natural and direct applications Includes extensive bibliographies for each chapter

This second part of Continuum Thermodynamics is designed to match almost one-to-one the chapters of Part I. This is done so that the reader studying thermodynamics will have a deepened understanding of the subjects covered in Part I. The aims of the book are in particular: the illustration of basic features of some simple thermodynamical models such as ideal and viscous fluids, non-Newtonian fluids, nonlinear solids, interactions with electromagnetic fields, and diffusive porous materials. A further aim is the illustration of the above subjects by examples and simple solutions of initial and boundary problems as well as simple exercises to develop skills in the construction of interdisciplinary macroscopic models.

This book examines the differences between an ideal and a real description of wave propagation, where ideal means an elastic (lossless), isotropic and single-phase medium, and real means an anelastic, anisotropic and multi-phase medium. The analysis starts by introducing the relevant stress-strain relation. This relation and the equations of momentum conservation are combined to give the equation of motion. The differential formulation is written in terms of memory variables, and Biot's theory is used to describe wave propagation in porous media. For each rheology, a plane-wave analysis is performed in order to understand the physics of wave propagation. The book contains a review of the main direct numerical methods for solving the equation of motion in the time and space domains. The emphasis is on geophysical applications for seismic exploration, but researchers in the fields of earthquake seismology, rock acoustics, and material science - including many branches of acoustics of fluids and solids - may also find this text useful. * Presents the fundamentals of wave propagation in anisotropic, anelastic and porus media * Contains a new chapter on the analogy between acoustic and electromagnetic waves, incorporating the subject of electromagnetic waves * Emphasizes geophysics, particularly, seismic exploration for hydrocarbon reservoirs, which is essential for exploration and production of oil

This book furnishes state-of-the-art knowledge about how earthquake faulting is coupled with fluid flow. The authors describe the theoretical background of modeling of faulting coupled with fluid flow in detail. Field and laboratory evidence to suggest the fluid involvement in earthquake faulting is also carefully explained. All of the provided information constitutes together a basic framework of the fault modeling for a comprehensive understanding of the involvement of fluids in earthquake ruptures. Earthquake generation is now widely believed to be significantly affected by high-pressure fluid existing at depths. Consequently, modeling study of earthquake faulting coupled with fluid flow is becoming increasingly active as a field of research. This work is aimed at a wide range of readers, and is especially relevant for graduate students and solid-earth researchers who wish to become more familiar with the field.

Provides a quantitative introduction to the physics, application, interpretation, and hazard aspects of fluid-induced seismicity, with many real data examples.

This book summarizes, defines, and contextualizes multiphysics with an emphasis on porous materials. It covers various essential aspects of multiphysics, from history, definition, and scope to mathematical theories, physical mechanisms, and numerical implementations. The emphasis on porous materials maximizes readers' understanding as these substances are abundant in nature and a common breeding ground of multiphysical phenomena, especially complicated multiphysics. Dr. Liu's lucid and easy-to-follow presentation serve as a blueprint on the use of multiphysics as a leading edge technique for computer modeling. The contents are organized to facilitate the transition from familiar, monolithic physics such as heat transfer and pore water movement to state-of-the-art applications involving multiphysics, including poroelasticity, thermohydro-mechanical processes, electrokinetics, electromagnetics, fluid dynamics, fluid structure interaction, and electromagnetomechanics. This volume serves as both a general reference and specific treatise for various scientific and engineering disciplines involving multiphysics simulation and porous materials.

Poromechanics is the mechanics of porous materials and is now a well established field in many engineering disciplines, ranging from Civil Engineering, Geophysics, Petroleum Engineering to Bioengineering. However, a rigorous approach that links the physics of the phenomena at stake in porous materials and the macroscopic behaviour is still missing. This book presents such an approach by means of homogenization techniques. Rigorously founded in various theories of micromechanics, these up scaling techniques are developed for the homogenization of transport properties, stiffness and strength properties of porous materials. The special feature of this book is the balance between theory and application, providing the reader with a comprehensive introduction to state-of-the-art homogenization theories and applications to a large range of real life porous materials: concrete, rocks, shales, bones, etc.

Bringing together basic ideas, classical theories, recent experimental and theoretical aspects, this book explains desiccation cracks from simple, easily-comprehensible cases to more complex, applied situations. The ideal team of authors, combining experimental and theoretical backgrounds, and with experience in both physical and earth sciences, discuss how the study of cracks can lead to the design of crack-resistant materials, as well as how cracks can be grown to generate patterned surfaces at the nano- and micro-scales. Important research and recent developments on tailoring desiccation cracks by different methods are covered, supported by straightforward, yet deep theoretical models. Intended for a broad readership spanning physics, materials science, and engineering to the geosciences, the book also includes additional reading especially for students engaged in pattern formation research.

This book treats the mechanics of porous materials infiltrated with a fluid (poromechanics), focussing on its linear theory (poroelasticity). Porous materials from inanimate bodies such as sand, soil and rock, living bodies such as plant tissue, animal flesh, or man-made materials can look very different due to their different origins, but as readers will see, the underlying physical principles governing their mechanical behaviors can be the same, making this work relevant not only to engineers but also to scientists across other scientific disciplines. Readers will find discussions of physical phenomena including soil consolidation, land subsidence, slope stability, borehole failure, hydraulic fracturing, water wave and seabed interaction, earthquake aftershock, fluid injection induced seismicity and heat induced pore pressure spalling as well as discussions of seismoelectric and seismoelectromagnetic effects. The work also explores the biomechanics of cartilage, bone and blood vessels. Chapters present theory using an intuitive, phenomenological approach at the bulk continuum level, and a thermodynamics-based variational energy approach at the micromechanical level. The physical mechanisms covered extend from the quasi-static theory of poroelasticity to poroelastodynamics, poroviscoelasticity, porothermoelasticity, and porochemoelasticity. Closed form analytical solutions are derived in details. This book provides an excellent introduction to linear poroelasticity and is especially relevant to those involved in civil engineering, petroleum and reservoir engineering, rock mechanics, hydrology, geophysics, and biomechanics.

The theory of linear poroelasticity describes the interaction between mechanical effects and adding or removing fluid from rock. It is critical to the study of such geological phenomena as earthquakes and landslides and is important for numerous engineering projects, including dams, groundwater withdrawal, and petroleum extraction. Now an advanced text synthesizes in one place, with one notation, numerous classical solutions and applications of this highly useful theory. The introductory chapter recounts parallel developments in geomechanics, hydrogeology, and reservoir engineering that are unified by the tenets of poroelasticity. Next, the theory's constitutive and governing equations and their associated material parameters are described. These equations are then specialized for different simplifying geometries: unbounded problem domains, uniaxial strain, plane strain, radial symmetry, and axisymmetry. Example problems from geomechanics, hydrogeology, and petroleum engineering are incorporated throughout to illustrate poroelastic behavior and solution methods for a wide variety of real-world scenarios. The final chapter provides outlines for finite-element and boundary-element formulations of the field's governing equations. Whether read as a course of study or consulted as a reference by researchers and professionals, this volume's user-friendly presentation makes accessible one of geophysics' most important subjects and will do much to reduce poroelasticity's reputation as difficult to master.

This book presents selected papers from the 7th International Field Exploration and Development Conference (IFEDC 2017), which focus on upstream technologies used in oil & gas development, the principles of the process, and various design technologies. The conference not only provides a platform for exchanging lessons learned, but also promotes the development of scientific research in oil & gas exploration and production. The book will benefit a broad readership, including industry experts, researchers, educators, senior engineers and managers.

F.K. Lehner: A Review of the Linear Theory of Anisotropic Poroelastic Solids. - J.W. Rudnicki: Eshelby's Technique for Analyzing Inhomogeneities in Geomechanics. - Y. Gueguen, M. Kachanov: Effective Elastic Properties of Cracked and Porous Rocks - an Overview. - J.L. Raphanel: 3D Morphology Evolution of Solid-Fluid Interfaces by Pressure Solution. - Y.M. Leroy: An Introduction to the Finite-Element Method for Linear and Non-linear Static Problems. The mechanical behaviour of the earth's upper crust enters into a great variety of questions in different areas of the geological and geophysical sciences as well as in the more applied geotechnical disciplines. This volume presents a selection of papers from a CISM course in Udine on this topic. While each of these chapters will make for a useful contribution in its own right, the present bundle also illustrates, by way of examples, the variety of theoretical concepts and tools that are currently brought to bear on earth deformation studies, ranging from reviews of poroelastic field theory to micro-mechanical and homogenization studies, chemomechanics and interfacial stability theory of soluble solids under stress, and finally to an introduction to the finite element method.

This monograph focuses on the numerical methods needed in the context of developing a reliable simulation tool to promote the use of renewable energy. One very promising source of energy is the heat stored in the Earth's crust, which is harnessed by so-called geothermal facilities. Scientists from fields like geology, geo-engineering, geophysics and especially geomathematics are called upon to help make geothermics a reliable and safe energy production method. One of the challenges they face involves modeling the mechanical stresses at work in a reservoir. The aim of this thesis is to develop a numerical solution scheme by means of which the fluid pressure and rock stresses in a geothermal reservoir can be determined prior to well drilling and during production. For this purpose, the method should (i) include poroelastic effects, (ii) provide a means of including thermoelastic effects, (iii) be inexpensive in terms of memory and computational power, and (iv) be flexible with regard to the locations of data points. After introducing the basic equations and their relations to more familiar ones (the heat equation, Stokes equations, Cauchy-Navier equation), the "method of fundamental solutions" and its potential value concerning our task are discussed. Based on the properties of the fundamental solutions, theoretical results are established and numerical examples of stress field simulations are presented to assess the method's performance. The first-ever 3D graphics calculated for these topics, which neither requiring meshing of the domain nor involving a time-stepping scheme, make this a pioneering volume.

Poroelasticity is a continuum theory for the analysis of a porous media consisting of an elastic matrix containing interconnected fluid-saturated pores. In physical terms the theory postulates that when a porous material is subjected to stress, the resulting matrix deformation leads to volumetric changes in the pores. This book is devoted to the analysis of fluid-saturated poroelastic beams, columns and plates made of materials for which diffusion in the longitudinal direction(s) is viable, while in the perpendicular direction(s) the flow can be considered negligible because of the micro-geometry of the solid skeletal material. Many microstructures and fabrication schemes could be imagined, which would produce bulk materials with the postulated behavior. The book provides a methodology and a theoretical basis for investigating the mechanical behaviors of the structural elements made of such materials. It is recognized that the response of the poroelastic structural element to loading is sensitive to the properties of the fluid and to the diffusion boundaries, which can be easily altered in practice. Therefore, such structural elements and thus their features are potentially controllable. In other words, it could be possible to convert such elements into intelligent or smart structures. If this is so, it would be interesting that such structural elements could work as both sensors and actuators, e.g. the fluid can "feel" the change of the temperature by changing its viscosity and this results in a change of the behavior of the structure. The present book is the first of its kind; there does not exist in the professional literature any book which deals with this subject. Chapter 1 is a general introduction and overview. The governing equations for beams are presented in Chapter 2. Chapter 3 then presents analytical solutions for the quasi-static bending problem. Series solutions are found for normal loading with various mechanical and diffusion boundary conditions. The finite element method is developed and employed for the quasi-static beams and columns with small deflections in Chapter 4. In Chapter 5 solutions are found for free and forced vibrations of poroelastic beams. Chapter 6 deals with large deflections of beams. The stability of poroelastic columns is investigated in Chapter 7. Three problems are considered: buckling, post-buckling, and dynamic stability. Formulations are found in Chapter 8 for fluid-saturated poroelastic plates consisting of a material, for which the diffusion is possible in the in-plane directions only, both for bending and for in-plane loading. This book attempts to constitute a reasonably self-contained presentation of a wide spectrum of problems related to the analysis of the type of poroelastic structure considered.

This volume constitutes the refereed proceedings of the 11th International Conference on Applied Parallel and Scientific Computing, PARA 2012, held in Helsinki, Finland, in June 2012. The 35 revised full papers presented were selected from numerous submissions and are organized in five technical sessions covering the topics of advances in HPC applications, parallel algorithms, performance analyses and optimization, application of parallel computing in industry and engineering, and HPC interval methods. In addition, three of the topical minisymposia are described by a corresponding overview article on the minisymposia topic. In order to cover the state-of-the-art of the field, at the end of the book a set of abstracts describe some of the conference talks not elaborated into full articles.

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This volume consists of a collection of chapters by recognized experts to provide a comprehensive fundamental theoretical continuum treatment of constitutive laws used for modelling the mechanical and coupled-field properties of various types of solid materials. It covers the main types of solid material behaviour, including isotropic and anisotropic nonlinear elasticity, implicit theories, viscoelasticity, plasticity, electro- and magneto-mechanical interactions, growth, damage, thermomechanics, poroelasticity, composites and homogenization. The volume provides a general framework for research in a wide range of applications involving the deformation of solid materials. It will be of considerable benefit to both established and early career researchers concerned with fundamental theory in solid mechanics and its applications by collecting diverse material in a single volume. The readership ranges from beginning graduate students to senior researchers in academia and industry.

This book explores mathematics in a wide variety of applications, ranging from problems in electronics, energy and the environment, to mechanics and mechatronics. The book gathers 81 contributions submitted to the 20th European Conference on Mathematics for Industry, ECMI 2018, which was held in Budapest, Hungary in June 2018. The application areas include: Applied Physics, Biology and Medicine, Cybersecurity, Data Science, Economics, Finance and Insurance, Energy, Production Systems, Social Challenges, and Vehicles and Transportation. In turn, the mathematical technologies discussed include: Combinatorial Optimization, Cooperative Games, Delay Differential Equations, Finite Elements, Hamilton-Jacobi Equations, Impulsive Control, Information Theory and Statistics, Inverse Problems, Machine Learning, Point Processes, Reaction-Diffusion Equations, Risk Processes, Scheduling Theory, Semidefinite Programming, Stochastic Approximation, Spatial Processes, System Identification, and Wavelets. The goal of the European Consortium for Mathematics in Industry (ECMI) conference series is to promote interaction between academia and industry, leading to innovations in both fields. These events have attracted leading experts from business, science and academia, and have promoted the application of novel mathematical technologies to industry. They have also encouraged industrial sectors to share challenging problems where mathematicians can provide fresh insights and perspectives. Lastly, the ECMI conferences are one of the main forums in which significant advances in industrial mathematics are presented, bringing together prominent figures from business, science and academia to promote the use of innovative mathematics in industry.

During the last decades, continuum mechanics of porous materials has achieved great attention, since it allows for the consideration of the volumetrically coupled behaviour of the solid matrix deformation and the pore-fluid flow. Naturally, applications of porous media models range from civil and environmental engineering, where, e. g. , geote- nical problems like the consolidation problem are of great interest, via mechanical engineering, where, e. g. , the description of sinter materials or polymeric and metallic foams is a typical problem, to chemical and biomechanical engineering, where, e. g. , the complex structure of l- ing tissues is studied. Although these applications are principally very different, they basically fall into the category of multiphase materials, which can be described, on the macroscale, within the framework of the well-founded Theory of Porous Media (TPM). With the increasing power of computer hardware together with the rapidly decreasing computational costs, numerical solutions of complex coupled problems became possible and have been seriously investigated. However, since the quality of the numerical solutions strongly depends on the quality of the underlying physical model together with the experimental and mathematical possibilities to successfully determine realistic material parameters, a successful treatment of porous materials requires a joint consideration of continuum mechanics, experimental mechanics and numerical methods. In addition, micromechanical - vestigations and homogenization techniques are very helpful to increase the phenomenological understanding of such media.

These papers address state-of-the-art knowledge of thermo-hydro-mechanical behaviours of deep argillaceous rocks. They introduce achievements in laboratory test methods for determining the coupling parameters of deep argillaceous rocks, amongst other things.

This book is a unique presentation of thermodynamic methods of construction of continuous models. It is based on a uniform approach following from the entropy inequality and using Lagrange multipliers as auxiliary quantities in its evaluation. It covers a wide range of models OCo ideal gases, thermoviscoelastic fluids, thermoelastic and thermoviscoelastic solids, plastic polycrystals, miscible and immiscible mixtures, and many others. The structure of phenomenological thermodynamics is justified by a systematic derivation from the Liouville equation, through the BBGKY-hierarchy-derived Boltzmann equation, to an extended thermodynamics. In order to simplify the reading, an extensive introduction to classical continuum mechanics and thermostatics is included. As a complementary volume to Part II, which will contain applications and examples, and to Part III, which will cover numerical methods, only a few simple examples are presented in this first Part. One exception is an extensive example of a linear poroelastic material because it will not appear in future Parts. The book is the first presentation of continuum thermodynamics in which foundations of continuum mechanics, microscopic foundations and transition to extended thermodynamics, applications of extended thermodynamics beyond ideal gases, and thermodynamic foundations of various material theories are exposed in a uniform and rational way. The book may serve both as a support for advanced courses as well as a desk reference.

This book contains 12 chapters dealing with the studies on volcanoes, their geological and geophysical setting, the theoretical aspects and the numerical modeling on volcanoes, the applications of volcanoes to the industry, and the impact of volcanoes on the human health, in different geological settings and using several techniques and methods, including the volcanology, the seismology, the statistical methods to assess the correlation between seismic and volcanic activity (modified Ripley's K-function to regional seismicity), the field geological survey of volcanic successions, the analytical methods of petrologic analysis, the petrography of the volcanic rocks with the individuation of the modal compositions of volcanic rocks and their comparison with major elements and trace elements in variation diagrams, and the argon isotopic measurements performed through the peak height comparison (unspiked) method. The oceanographic methods have also been applied to case studies of submarine volcanic edifices located in the Canary Islands (Atlantic Ocean), including the sampling of the water column with a conductivity-temperature-depth (CTD) sensor rosette with 24 Niskin bottles, in order to determinate key physical and chemical parameters, such as the total-scale pH, the total dissolved inorganic carbon (C), the total alkalinity (A), the temperature, the salinity, and the dissolved oxygen. Problems of volcanic risk mitigation have also been treated, regarding the eruption disasters in Indonesia, a country where a high number of people live next to the volcanoes, and characterized by the lack of public awareness of the eruption disasters. Petrographic methods have been successfully applied to the study of the Cretaceous magmatism of the layered gabbroids of the Chukotka region (Pekulney Ridge, Russia), and geodynamic implications have been successfully established through geological and petrographic studies. The relationships among the mantle wedge, the convective heat and mass transfer, the infiltration metasomatism, the zoning, and the mathematical models have been applied to the comprehension of complex volcanic areas through the theoretical aspects of volcanic studies on magmatic chambers coupled with numerical modeling, including finite element models (FEMs) in the individuation of volcanic deformations.

The book provides the reader with the knowledge, tools, and methods to understand the phenomenon of hysteresis in porous materials. As many challenges have been met only recently, the book summarizes the research results usually found only scattered in the literature, connecting knowledge from traditionally separated research fields to provide a better understanding of the physical phenomena of coupled elastic-fluid systems. The result is an invaluable self-contained reference book for materials scientists, civil, mechanical and construction engineers concerned with development and maintenance of structures made of porous materials.

A multidisciplinary field, encompassing both geophysics and civil engineering, geomechanics deals with the deformation and failure process in geomaterials such as soil and rock. Although powerful numerical tools have been developed, analytical solutions still play an important role in solving practical problems in this area. Analytic Methods in Geomechanics provides a much-needed text on mathematical theory in geomechanics, beneficial for readers of varied backgrounds entering this field. Written for scientists and engineers who have had some exposure to engineering mathematics and strength of materials, the text covers major topics in tensor analysis, 2-D elasticity, and 3-D elasticity, plasticity, fracture mechanics, and viscoelasticity. It also discusses the use of displacement functions in poroelasticity, the basics of wave propagations, and dynamics that are relevant to the modeling of geomaterials. The book presents both the fundamentals and more advanced content for understanding the latest research results and applying them to practical problems in geomechanics. The author gives concise explanations of each subject area, using a step-by-step process with many worked examples. He strikes a balance between breadth of material and depth of details, and includes recommended reading in each chapter for readers who would like additional technical information. This text is suitable for students at both undergraduate and graduate levels, as well as for professionals and researchers.

This book constitutes the thoroughly refereed post-conference proceedings of the 6th International Conference on Finite Difference Methods, FDM 2014, held in Lozenetz, Bulgaria, in June 2014. The 36 revised full papers were carefully reviewed and selected from 62 submissions. These papers together with 12 invited papers cover topics such as finite difference and combined finite difference methods as well as finite element methods and their various applications in physics, chemistry, biology and finance.

This book is concerned with the study of continuum mechanics applied to biological systems, i.e., continuum biomechanics. This vast and exciting subject allows description of when a bone may fracture due to excessive loading, how blood behaves as both a solid and fluid, down to how cells respond to mechanical forces that lead to changes in their behavior, a process known as mechanotransduction. We have written for senior undergraduate students and first year graduate students in mechanical or biomedical engineering, but individuals working at biotechnology companies that deal in biomaterials or biomechanics should also find the information presented relevant and easily accessible. Table of Contents: Tensor Calculus / Kinematics of a Continuum / Stress / Elasticity / Fluids / Blood and Circulation / Viscoelasticity / Poroelasticity and Thermoelasticity / Biphasic Theory

Engineering geologists face the task of addressing geological factors that can affect planning with little time and with few resources. A solution is using the right tools to save time searching for answers and devote attention to making critical engineering decisions. The Handbook of Research on Trends and Digital Advances in Engineering Geology is an essential reference source for the latest research on new trends, technology, and computational methods that can model engineering phenomena automatically. Featuring exhaustive coverage on a broad range of topics and perspectives such as acoustic energy, landslide mapping, and natural hazards, this publication is ideally designed for academic scientists, industry and applied researchers, and policy and decision makers seeking current research on new tools to aid in timely decision-making of critical engineering situations.

Engineers and geologists in the petroleum industry will find Petroleum Related Rock Mechanics, 2e, a powerful resource in providing a basis of rock mechanical knowledge - a knowledge which can greatly assist in the understanding of field behavior, design of test programs and the design of field operations. Not only does this text give an introduction to applications of rock mechanics within the petroleum industry, it has a strong focus on basics, drilling, production and reservoir engineering. Assessment of rock mechanical parameters is covered in depth, as is acoustic wave propagation in rocks, with possible link to 4D seismics as well as log interpretation. Learn the basic principles behind rock mechanics from leading academic and industry experts Quick reference and guide for engineers and geologists working in the field Keep informed and up to date on all the latest methods and fundamental concepts

This book collects the theoretical derivation of a recently presented general variational macroscopic continuum theory of multiphase poroelasticity (VMTPM), together with its applications to consolidation and stress partitioning problems of interest in several applicative engineering contexts, such as in geomechanics and biomechanics. The theory is derived based on a purely-variational deduction, rooted in the least-Action principle, by considering a minimal set of kinematic descriptors. The treatment herein considered keeps a specific focus on the derivation of most general medium-independent governing equations. It is shown that VMTPM recovers paradigms of consolidated use in multiphase poroelasticity such as Terzaghi's stress partitioning principle and Biot's equations for wave propagation. In particular, the variational treatment permits the derivation of a general medium-independent stress partitioning law, and the proposed variational theory predicts that the external stress, the fluid pressure, and the stress tensor work-associated with the macroscopic strain of the solid phase are partitioned according to a relation which, from a formal point of view, turns out to be strictly compliant with Terzaghi's law, irrespective of the microstructural and constitutive features of a given medium. Moreover, it is shown that some experimental observations on saturated sandstones, generally considered as proof of deviations from Terzaghi's law, are ordinarily predicted by VMTPM. As a peculiar prediction of VMTPM, the book shows that the phenomenon of compression-induced liquefaction experimentally observed in cohesionless mixtures can be obtained as a natural implication of this theory by a purely rational deduction. A characterization of the phenomenon of crack closure in fractured media is also inferred in terms of macroscopic strain and stress paths. Altogether the results reported in this monograph exemplify the capability of VMTPM to describe and predict a large class of linear and nonlinear mechanical behaviors observed in two-phase saturated materials.

The structures of living tissues are continually changing due to growth and response to the tissue environment, including the mechanical environment. Tissue Mechanics is an in-depth look at the mechanics of tissues. Tissue Mechanics describes the nature of the composite components of a tissue, the cellular processes that produce these constituents, the assembly of the constituents into a hierarchical structure, and the behavior of the tissue’s composite structure in the adaptation to its mechanical environment. Organized as a textbook for the student needing to acquire the core competencies, Tissue Mechanics will meet the demands of advanced undergraduate or graduate coursework in Biomedical Engineering, as well as, Chemical, Civil, and Mechanical Engineering. Key features: Detailed Illustrations Example problems, including problems at the end of sections A separate solutions manual available for course instructors A website (http://tissue-mechanics.com/) that has been established to provide supplemental material for the book, including downloadable additional chapters on specific tissues, downloadable PowerPoint presentations of all the book's chapters, and additional exercises and examples for the existing chapters. About the Authors: Stephen C. Cowin is a City University of New York Distinguished Professor, Departments of Biomedical and Mechanical Engineering, City College of the City University of New York and also an Adjunct Professor of Orthopaedics, at the Mt. Sinai School of Medicine in New York, New York. In 1985 he received the Society of Tulane Engineers and Lee H. Johnson Award for Teaching Excellence and a recipient of the European Society of Biomechanics Research Award in 1994. In 1999 he received the H. R. Lissner medal of the ASME for contributions to biomedical engineering. In 2004 he was elected to the National Academy of Engineering (NAE) and he also received the Maurice A. Biot medal of the American Society of Civil Engineers (ASCE). Stephen B. Doty is a Senior Scientist at Hospital for Special Surgery, New York, New York and Adjunct Professor, School of Dental and Oral Surgery, Columbia University, New York, NY. He has over 100 publications in the field of anatomy, developmental biology, and the physiology of skeletal and connective tissues. His honors include several commendations for participation in the Russian/NASA spaceflights, the Spacelab Life Science NASA spaceflights, and numerous Shuttle missions that studied the influence of spaceflight on skeletal physiology. He presently is on the scientific advisory board of the National Space Biomedical Research Institute, Houston, Texas.

This volume contains seven keynote lectures and over 100 technical contributions by scientists, researchers, engineers and students from more than 25 countries and regions worldwide on the subject of soft soil engineering.

Continuum Mechanics of Solids is an introductory text for graduate students in the many branches of engineering, covering the basics of kinematics, equilibrium, and material response. As an introductory book, most of the emphasis is upon the kinematically linear theories of elasticity, plasticity, and viscoelasticity, with two additional chapters devoted to topics in finite elasticity. Further chapters cover topics in fracture and fatigue and coupled field problems, such as thermoelasticity, chemoelasticity, poroelasticity, and piezoelectricity. There is ample material for a two semester course, or by selecting only topics of interest for a one-semester offering. The text includes numerous examples to aid the student. A companion text with over 180 fully worked problems is also available.

In Mechanics of Poroelastic Media the classical theory of poroelasticity developed by Biot is developed and extended to the study of problems in geomechanics, biomechanics, environmental mechanics and materials science. The contributions are grouped into sections covering constitutive modelling, analytical aspects, numerical modelling, and applications to problems. The applications of the classical theory of poroelasticity to a wider class of problems will be of particular interest. The text is a standard reference for researchers interested in developing mathematical models of poroelasticity in geoenvironmental mechanics, and in the application of advanced theories of poroelastic biomaterials to the mechanics of biomaterials.