A Dynamical Systems Theory of Thermodynamics



Wassim M. Haddad

Andreas Greven, Gerald Warnecke, Gerhard Keller

Thermodynamics, 2005 This book places thermodynamics on a system theoretic foundation so as to harmonize it with classical mechanics Using the highest standards of exposition and rigor the authors develop a novel formulation of thermodynamics that can be viewed as a moderate sized system theory as compared to statistical thermodynamics This middle ground theory involves deterministic large scale dynamical system models that bridge the gap between classical and statistical thermodynamics The authors theory is motivated by the fact that a discipline as cardinal as thermodynamics A Dynamical Systems Theory of Thermodynamics Wassim M. Haddad, 2019-06-04 A entrusted with some of the most brand new conceptual look at dynamical thermodynamics This book merges the two universalisms of thermodynamics and dynamical systems theory in a single compendium with the latter providing an ideal language for the former to develop a new and unique framework for dynamical thermodynamics In particular the book uses system theoretic ideas to bring coherence clarity and precision to an important and poorly understood classical area of science The dynamical systems formalism captures all of the key aspects of thermodynamics including its fundamental laws while providing a mathematically rigorous formulation for thermodynamical systems out of equilibrium by unifying the theory of mechanics with that of classical thermodynamics This book includes topics on nonequilibrium irreversible thermodynamics Boltzmann thermodynamics mass action kinetics and chemical reactions finite time thermodynamics thermodynamic critical phenomena with continuous and discontinuous phase transitions information theory continuum and stochastic thermodynamics and relativistic thermodynamics A Dynamical Systems Theory of Thermodynamics develops a postmodern theory of thermodynamics as part of mathematical dynamical systems theory The book establishes a clear nexus between thermodynamic irreversibility the second law of thermodynamics and the arrow of time to further unify discreteness and continuity indeterminism and determinism and quantum mechanics and general relativity in the pursuit of understanding the most fundamental property of the universe the entropic arrow of time Physical Chemistry in Depth Johannes Karl Fink, 2009-09-16 Physical Chemistry in Depth is not a stand alone text but complements the text of any standard textbook on Physical Chemistry into depth having in mind to provide profound understanding of some of the topics presented in these textbooks Standard textbooks in Physical Chemistry start with thermodynamics deal with kinetics structure of matter etc The Physical Chemistry in Depth follows this adjustment but adds chapters that are treated traditionally in ordinary textbooks inadequately e.g. general scaling laws the graphlike structure of matter and cross connections between the individual disciplines of Physical Chemistry Admittedly the text is loaded with some mathematics which is a prerequisite to thoroughly understand the topics presented here However the mathematics needed is explained at a really low level so that no additional mathematical textbook is needed Control Theoretic Splines Magnus Egerstedt, Clyde Martin, 2009-12-07 Splines both interpolatory and smoothing have a long and rich history that has largely been application driven This book unifies these constructions in a comprehensive and accessible

way drawing from the latest methods and applications to show how they arise naturally in the theory of linear control systems Magnus Egerstedt and Clyde Martin are leading innovators in the use of control theoretic splines to bring together many diverse applications within a common framework In this book they begin with a series of problems ranging from path planning to statistics to approximation Using the tools of optimization over vector spaces Egerstedt and Martin demonstrate how all of these problems are part of the same general mathematical framework and how they are all to a certain degree a consequence of the optimization problem of finding the shortest distance from a point to an affine subspace in a Hilbert space They cover periodic splines monotone splines and splines with inequality constraints and explain how any finite number of linear constraints can be added This book reveals how the many natural connections between control theory numerical analysis and statistics can be used to generate powerful mathematical and analytical tools This book is an excellent resource for students and professionals in control theory robotics engineering computer graphics econometrics and any area that requires the construction of curves based on sets of raw data Matrix Completions, Moments, and Sums of Hermitian Squares Mihály Bakonyi, Hugo J. Woerdeman, 2011-07-18 Intensive research in matrix completions moments and sums of Hermitian squares has yielded a multitude of results in recent decades This book provides a comprehensive account of this quickly developing area of mathematics and applications and gives complete proofs of many recently solved problems With MATLAB codes and more than 200 exercises the book is ideal for a special topics course for graduate or advanced undergraduate students in mathematics or engineering and will also be a valuable resource for researchers Often driven by questions from signal processing control theory and quantum information the subject of this book has inspired mathematicians from many subdisciplines including linear algebra operator theory measure theory and complex function theory In turn the applications are being pursued by researchers in areas such as electrical engineering computer science and physics The book is self contained has many examples and for the most part requires only a basic background in undergraduate mathematics primarily linear algebra and some complex analysis The book also includes an extensive discussion of the literature with close to 600 references from books and journals from a wide variety of disciplines

Algebraic Curves over a Finite Field J. W. P. Hirschfeld, Gabor Korchmaros, Fernando Torres, 2013-03-25 This book provides an accessible and self contained introduction to the theory of algebraic curves over a finite field a subject that has been of fundamental importance to mathematics for many years and that has essential applications in areas such as finite geometry number theory error correcting codes and cryptology Unlike other books this one emphasizes the algebraic geometry rather than the function field approach to algebraic curves The authors begin by developing the general theory of curves over any field highlighting peculiarities occurring for positive characteristic and requiring of the reader only basic knowledge of algebra and geometry The special properties that a curve over a finite field can have are then discussed The geometrical theory of linear series is used to find estimates for the number of rational points on a curve following the theory

of St hr and Voloch The approach of Hasse and Weil via zeta functions is explained and then attention turns to more advanced results a state of the art introduction to maximal curves over finite fields is provided a comprehensive account is given of the automorphism group of a curve and some applications to coding theory and finite geometry are described The book includes many examples and exercises It is an indispensable resource for researchers and the ideal textbook for Robust Optimization Aharon Ben-Tal, Laurent El Ghaoui, Arkadi Nemirovski, 2009-08-10 Robust optimization is still a relatively new approach to optimization problems affected by uncertainty but it has already proved so useful in real applications that it is difficult to tackle such problems today without considering this powerful methodology Written by the principal developers of robust optimization and describing the main achievements of a decade of research this is the first book to provide a comprehensive and up to date account of the subject Robust optimization is designed to meet some major challenges associated with uncertainty affected optimization problems to operate under lack of full information on the nature of uncertainty to model the problem in a form that can be solved efficiently and to provide guarantees about the performance of the solution The book starts with a relatively simple treatment of uncertain linear programming proceeding with a deep analysis of the interconnections between the construction of appropriate uncertainty sets and the classical chance constraints probabilistic approach It then develops the robust optimization theory for uncertain conic quadratic and semidefinite optimization problems and dynamic multistage problems. The theory is supported by numerous examples and computational illustrations An essential book for anyone working on optimization and decision making under uncertainty Robust Optimization also makes an ideal graduate textbook on the subject Modern Anti-windup Synthesis Luca Zaccarian, Andrew R. Teel, 2011-07-11 This book provides a wide variety of state space based numerical algorithms for the synthesis of feedback algorithms for linear systems with input saturation Specifically it addresses and solves the anti windup problem presenting the objectives and terminology of the problem the mathematical tools behind anti windup algorithms and more than twenty algorithms for anti-windup synthesis illustrated with examples Luca Zaccarian and Andrew Teel s modern method combining a state space approach with algorithms generated by solving linear matrix inequalities treats MIMO and SISO systems with equal ease The book aimed at control engineers as well as graduate students ranges from very simple anti windup construction to sophisticated anti windup algorithms for nonlinear systems Describes the fundamental objectives and principles behind anti windup synthesis for control systems with actuator saturation Takes a modern state space approach to synthesis that applies to both SISO and MIMO systems Presents algorithms as linear matrix inequalities that can be readily solved with widely available software Explains mathematical concepts that motivate synthesis algorithms Uses nonlinear performance curves to quantify performance relative to disturbances of varying magnitudes Includes anti windup algorithms for a class of Euler Lagrange nonlinear systems Traces the history of anti windup research through an extensive annotated bibliography Distributed Control of Robotic Networks Francesco Bullo, Jorge

Cortés, Sonia Martínez, 2009-07-06 This self contained introduction to the distributed control of robotic networks offers a distinctive blend of computer science and control theory The book presents a broad set of tools for understanding coordination algorithms determining their correctness and assessing their complexity and it analyzes various cooperative strategies for tasks such as consensus rendezvous connectivity maintenance deployment and boundary estimation The unifying theme is a formal model for robotic networks that explicitly incorporates their communication sensing control and processing capabilities a model that in turn leads to a common formal language to describe and analyze coordination algorithms Written for first and second year graduate students in control and robotics the book will also be useful to researchers in control theory robotics distributed algorithms and automata theory. The book provides explanations of the basic concepts and main results as well as numerous examples and exercises Self contained exposition of graph theoretic concepts distributed algorithms and complexity measures for processor networks with fixed interconnection topology and for robotic networks with position dependent interconnection topology Detailed treatment of averaging and consensus algorithms interpreted as linear iterations on synchronous networks Introduction of geometric notions such as partitions proximity graphs and multicenter functions Detailed treatment of motion coordination algorithms for deployment rendezvous connectivity maintenance and boundary estimation PDE Control of String-Actuated Motion Ji Wang, Miroslav Krstic, 2022-10-25 New adaptive and event triggered control designs with concrete applications in undersea construction offshore drilling and cable elevators Control applications in undersea construction cable elevators and offshore drilling present major methodological challenges because they involve PDE systems cables and drillstrings of time varying length coupled with ODE systems the attached loads or tools that usually have unknown parameters and unmeasured states In PDE Control of String Actuated Motion Ji Wang and Miroslav Krstic develop control algorithms for these complex PDE ODE systems evolving on time varying domains Motivated by physical systems the book s algorithms are designed to operate with rigorous mathematical guarantees in the presence of real world challenges such as unknown parameters unmeasured distributed states environmental disturbances delays and event triggered implementations. The book leverages the power of the PDE backstepping approach and expands its scope in many directions Filled with theoretical innovations and comprehensive in its coverage PDE Control of String Actuated Motion provides new design tools and mathematical techniques with far reaching potential in adaptive control delay systems and event triggered control **Optimization and** Learning Via Stochastic Gradient Search Felisa Vázguez-Abad, Bernd Heidergott, 2025-10-28 An introduction to gradient based stochastic optimization that integrates theory and implementation This book explains gradient based stochastic optimization exploiting the methodologies of stochastic approximation and gradient estimation Although the approach is theoretical the book emphasizes developing algorithms that implement the methods The underlying philosophy of this book is that when solving real problems mathematical theory the art of modeling and numerical algorithms complement each other

with no one outlook dominating the others. The book first covers the theory of stochastic approximation including advanced models and state of the art analysis methodology treating applications that do not require the use of gradient estimation It then presents gradient estimation developing a modern approach that incorporates cutting edge numerical algorithms Finally the book culminates in a rich set of case studies that integrate the concepts previously discussed into fully worked models The use of stochastic approximation in statistics and machine learning is discussed and in depth theoretical treatments for selected gradient estimation approaches are included Numerous examples show how the methods are applied concretely and end of chapter exercises enable readers to consolidate their knowledge Many chapters end with a section on Practical Considerations that addresses typical tradeoffs encountered in implementation The book provides the first unified treatment of the topic written for a wide audience that includes researchers and graduate students in applied mathematics engineering computer science physics and economics <u>Delay-Adaptive Linear Control</u> Yang Zhu, Miroslav Krstic, 2020-04-28 Actuator and sensor delays are among the most common dynamic phenomena in engineering practice and when disregarded they render controlled systems unstable Over the past sixty years predictor feedback has been a key tool for compensating such delays but conventional predictor feedback algorithms assume that the delays and other parameters of a given system are known When incorrect parameter values are used in the predictor the resulting controller may be as destabilizing as without the delay compensation Delay Adaptive Linear Control develops adaptive predictor feedback algorithms equipped with online estimators of unknown delays and other parameters Such estimators are designed as nonlinear differential equations which dynamically adjust the parameters of the predictor The design and analysis of the adaptive predictors involves a Lyapunov stability study of systems whose dimension is infinite because of the delays and nonlinear because of the parameter estimators This comprehensive book solves adaptive delay compensation problems for systems with single and multiple inputs outputs unknown and distinct delays in different input channels unknown delay kernels unknown plant parameters unmeasurable finite dimensional plant states and unmeasurable infinite dimensional actuator states Presenting breakthroughs in adaptive control and control of delay systems Delay Adaptive Linear Control offers powerful new tools for **Entropy** Gerhard Keller, 2003-10-26 The concept of entropy arose in the the control engineer and the mathematician physical sciences during the nineteenth century particularly in thermodynamics and statistical physics as a measure of the equilibria and evolution of thermodynamic systems Two main views developed the macroscopic view formulated originally by Carnot Clausius Gibbs Planck and Caratheodory and the microscopic approach associated with Boltzmann and Maxwell Since then both approaches have made possible deep insights into the nature and behavior of thermodynamic and other microscopically unpredictable processes However the mathematical tools used have later developed independently of their original physical background and have led to a plethora of methods and differing conventions. The aim of this book is to identify the unifying threads by providing surveys of the uses and concepts of entropy in diverse areas of mathematics and

the physical sciences Two major threads emphasized throughout the book are variational principles and Liapunov functionals The book starts by providing basic concepts and terminology illustrated by examples from both the macroscopic and microscopic lines of thought In depth surveys covering the macroscopic microscopic and probabilistic approaches follow Part I gives a basic introduction from the views of thermodynamics and probability theory Part II collects surveys that look at the macroscopic approach of continuum mechanics and physics Part III deals with the microscopic approach exposing the role of entropy as a concept in probability theory namely in the analysis of the large time behavior of stochastic processes and in the study of qualitative properties of models in statistical physics Finally in Part IV applications in dynamical systems ergodic and information theory are presented The chapters were written to provide as cohesive an account as possible making the book accessible to a wide range of graduate students and researchers Any scientist dealing with systems that exhibit entropy will find the book an invaluable aid to their understanding Stability and Control of Large-Scale Dynamical Systems Wassim M. Haddad, Sergey G. Nersesov, 2011-12-04 Modern complex large scale dynamical systems exist in virtually every aspect of science and engineering and are associated with a wide variety of technological environmental and social phenomena This book develops stability analysis and control design framework for nonlinear large scale interconnected dynamical systems The British National Bibliography Arthur James Wells, 2006 Encyclopedia of Mathematical Physics Jean-Pierre Françoise, Gregory L. Naber, Sheung Tsun Tsou, 2006 The Encyclopedia of Mathematical Physics provides a complete resource for researchers students and lecturers with an interest in mathematical physics It enables readers to access basic information on topics peripheral to their own areas to provide a repository of the core information in the area that can be used to refresh the researcher's own memory banks and aid teachers in directing students to entries relevant to their course work The Encyclopedia does contain information that has been distilled organised and presented as a complete reference tool to the user and a landmark to the body of knowledge that has accumulated in this domain It also is a stimulus for new researchers working in mathematical physics or in areas using the methods originating from work in mathematical physics by providing them with focused high quality background information Editorial Board Jean Pierre Fran oise Universit Pierre et Marie Curie Paris France Gregory L Naber Drexel University Philadelphia PA USA Tsou Sheung Tsun University of Oxford UK Also available online via ScienceDirect 2006 featuring extensive browsing searching and internal cross referencing between articles in the work plus dynamic linking to journal articles and abstract databases making navigation flexible and easy Subject Guide to Books in Print ,1997 The Bulletin of Mathematics Books ,1992

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