In recent years, enhanced oil recovery techniques have received much attention in the oil industry. Enhanced oil recovery methods can be divided into three major categories: thermal processes which include steam flooding, steam stimulation, and in-situ combustion; chemical processes which include surfactant-polymer injection, polymer flooding, and caustic flooding; and miscible displacement processes which include miscible hydrocarbon displacement, carbon dioxide injection of large amounts of rather expensive fluids into oil bearing reservoir formations. Commercial application of any enhanced oil recovery process relies upon economic projections that show a decent return on the investment. Because of high chemical costs, it is important to optimize enhanced oil recovery processes to provide the greatest recovery at the lowest chemical injection cost. The aim of this book is to develop an optimal control theory for the determination of operating strategies that maximize the economic attractiveness of enhanced oil recovery processes. The determination of optimal control histories or operating strategies is one of the key elements in the successful usage of new enhanced oil recovery techniques. The information contained in the book will therefore be both interesting and useful to all those working in petroleum engineering, petroleum management and chemical engineering. This sound introduction to classical and modern control theory concentrates on fundamental concepts. Employing the minimum of mathematical elaboration, it investigates the many
applications of control theory to varied and important present-day problems, e.g. economic growth, resource depletion, disease epidemics, exploited population, and rocket trajectories. An original feature is the amount of space devoted to the important and fascinating subject of optimal control. The work is divided into two parts. Part one deals with the control of linear time-continuous systems, using both transfer function and state-space methods. The ideas of controllability, observability and minimality are discussed in comprehensible fashion. Part two introduces the calculus of variations, followed by analysis of continuous optimal control problems. Each topic is individually introduced and carefully explained with illustrative examples and exercises at the end of each chapter to help and test the reader’s understanding. Solutions are provided at the end of the book. Investigates the many applications of control theory to varied and important present-day problems Deals with the control of linear time-continuous systems, using both transfer function and state-space methods Introduces the calculus of variations, followed by analysis of continuous optimal control problems

The published material represents the outgrowth of teaching analytical optimization to aerospace engineering graduate students. To make the material available to the widest audience, the prerequisites are limited to calculus and differential equations. It is also a book about the mathematical aspects of optimal control theory. It was developed in an engineering environment from material learned by the author while applying it to the solution of engineering problems. One goal of the book is to help engineering graduate students learn the fundamentals which are needed to apply the methods to engineering problems. The examples are from geometry and elementary dynamical systems so that they can be understood by all
engineering students. Another goal of this text is to unify optimization by using the differential of calculus to create the Taylor series expansions needed to derive the optimality conditions of optimal control theory.

Covering some of the key areas of optimal control theory (OCT), a rapidly expanding field, the authors use new methods to set out a version of OCT’s more refined ‘maximum principle.’ The results obtained have applications in production planning, reinsurance-dividend management, multi-model sliding mode control, and multi-model differential games. This book explores material that will be of great interest to post-graduate students, researchers, and practitioners in applied mathematics and engineering, particularly in the area of systems and control.

This book introduces a variety of problem statements in classical optimal control, in optimal estimation and filtering, and in optimal control problems with non-scalar-valued performance criteria. Many example problems are solved completely in the body of the text. All chapter-end exercises are sketched in the appendix. The theoretical part of the book is based on the calculus of variations, so the exposition is very transparent and requires little mathematical rigor.

This work (in two parts), Lecture Notes in Economics and Mathematical Systems, Volume 105 and 106, constitutes the Proceedings of the Fourteenth Biennial Seminar of the Canadian Mathematical Congress, which was held from August 12 to August 25, 1973 at the University of Western Ontario, London, Ontario. The Canadian Mathematical Congress has held Biennial Seminars
since 1977, and these have covered a wide range of topics. The Seminar reported in this publication was concerned with "Optimal Control Theory and its Applications", a subject chosen for its active growth and its wide implications for other fields. Both these aspects are exemplified in these Proceedings. Some lectures provided excellent surveys of particular fields whereas others concentrated on the presentation of new results. There were six distinguished Principal Lecturers: H.T. Banks, A.R. Dobell, H. Halkin, J.L. Lions, R.M. Thrall and W.M. Wonham, all of whom gave five to ten lectures during the two weeks of the Seminar. Except for Dr. Dobell's, these will all be found in Volume 105. Besides the Principal Lecturers there were three Guest Lecturers: M.C. Delfour, V. Jurdjevic and S.P. Sethi, who presented substantial bodies of material in two or three lectures and which are included in Volume 106. Many of the participants also spoke and reports of most of these have also been included (Volume 106). A rigorous introduction to optimal control theory, with an emphasis on applications in economics. This book bridges optimal control theory and economics, discussing ordinary differential equations, optimal control, game theory, and mechanism design in one volume. Technically rigorous and largely self-contained, it provides an introduction to the use of optimal control theory for deterministic continuous-time systems in economics. The theory of ordinary
differential equations (ODEs) is the backbone of the theory developed in the book, and chapter 2 offers a detailed review of basic concepts in the theory of ODEs, including the solution of systems of linear ODEs, state-space analysis, potential functions, and stability analysis. Following this, the book covers the main results of optimal control theory, in particular necessary and sufficient optimality conditions; game theory, with an emphasis on differential games; and the application of control-theoretic concepts to the design of economic mechanisms. Appendixes provide a mathematical review and full solutions to all end-of-chapter problems. The material is presented at three levels: single-person decision making; games, in which a group of decision makers interact strategically; and mechanism design, which is concerned with a designer's creation of an environment in which players interact to maximize the designer's objective. The book focuses on applications; the problems are an integral part of the text. It is intended for use as a textbook or reference for graduate students, teachers, and researchers interested in applications of control theory beyond its classical use in economic growth. The book will also appeal to readers interested in a modeling approach to certain practical problems involving dynamic continuous-time models. The book focuses on symplectic pseudospectral methods for nonlinear optimal
control problems and their applications. Both the fundamental principles and engineering practice are addressed. Symplectic pseudospectral methods for nonlinear optimal control problems with complicated factors (i.e., inequality constraints, state-delay, unspecific terminal time, etc.) are solved under the framework of indirect methods. The methods developed here offer a high degree of computational efficiency and accuracy when compared with popular direct pseudospectral methods. The methods are applied to solve optimal control problems arising in various engineering fields, particularly in path planning problems for autonomous vehicles. Given its scope, the book will benefit researchers, engineers and graduate students in the fields of automatic control, path planning, ordinary differential equations, etc.

This book is devoted to the development of optimal control theory for finite dimensional systems governed by deterministic and stochastic differential equations driven by vector measures. The book deals with a broad class of controls, including regular controls (vector-valued measurable functions), relaxed controls (measure-valued functions) and controls determined by vector measures, where both fully and partially observed control problems are considered. In the past few decades, there have been remarkable advances in the field of systems and control theory thanks to the unprecedented interaction
between mathematics and the physical and engineering sciences. Recently, optimal control theory for dynamic systems driven by vector measures has attracted increasing interest. This book presents this theory for dynamic systems governed by both ordinary and stochastic differential equations, including extensive results on the existence of optimal controls and necessary conditions for optimality. Computational algorithms are developed based on the optimality conditions, with numerical results presented to demonstrate the applicability of the theoretical results developed in the book. This book will be of interest to researchers in optimal control or applied functional analysis interested in applications of vector measures to control theory, stochastic systems driven by vector measures, and related topics. In particular, this self-contained account can be a starting point for further advances in the theory and applications of dynamic systems driven and controlled by vector measures.

This book merges two major areas of control: the design of control systems and adaptive control. Original contributions are made in the polynomial approach to stochastic optimal control and the resulting control laws are then manipulated into a form suitable for application in the self-tuning control framework. A major contribution is the derivation of both scalar and multivariable optimal controllers for the rejection of measurable disturbances using feedforward. A powerful
feature of the book is the presentation of a case-study in which the LQG self-tuner was tested on the pressure control loop of a power station. The broad coverage of the book should appeal not only to research workers, teachers and students of control engineering, but also to practicing industrial control engineers. Combining control theory and modeling, this textbook introduces and builds on methods for simulating and tackling concrete problems in a variety of applied sciences. Emphasizing "learning by doing," the authors focus on examples and applications to real-world problems. An elementary presentation of advanced concepts, proofs to introduce new ideas, and carefully presented MATLAB® programs help foster an understanding of the basics, but also lead the way to new, independent research. With minimal prerequisites and exercises in each chapter, this work serves as an excellent textbook and reference for graduate and advanced undergraduate students, researchers, and practitioners in mathematics, physics, engineering, computer science, as well as biology, biotechnology, economics, and finance.

This book is an introduction to the mathematical theory of optimal control of processes governed by ordinary differential equations. It is intended for students and professionals in mathematics and in areas of application who want a broad, yet relatively deep, concise and coherent introduction to the subject and to its relationship with applications. In order to accommodate a range of mathematical interests and backgrounds among readers, the material is arranged so that the more advanced mathematical sections can
be omitted without loss of continuity. For readers primarily interested in applications a recommended minimum course consists of Chapter I, the sections of Chapters II, III, and IV so recommended in the introductory sections of those chapters, and all of Chapter V. The introductory section of each chapter should further guide the individual reader toward material that is of interest to him. A reader who has had a good course in advanced calculus should be able to understand the definitions and statements of the theorems and should be able to follow a substantial portion of the mathematical development. The entire book can be read by someone familiar with the basic aspects of Lebesque integration and functional analysis. For the reader who wishes to find out more about applications we recommend references [2], [13], [33], [35], and [50], of the Bibliography at the end of the book.

This work (in two parts), Lecture Notes in Economics and Mathematical Systems, Volume 105 and 106, constitutes the Proceedings of the Fourteenth Biennial Seminar of the Canadian Mathematical Congress, which was held from August 12 to August 25, 1973 at the University of Western Ontario, London, Ontario. The Canadian Mathematical Congress has held Biennial Seminars since 1947, and these have covered a wide range of topics. The Seminar reported in this publication was concerned with "Optimal Control Theory and its Applications", a subject chosen for its active growth and its wide implications for other fields. Both these aspects are exemplified in these Proceedings. Some lectures provided excellent surveys of particular fields.
whereas others concentrated on the presentation of new results. There were six distinguished Principal Lecturers: H.T. Banks, A.R. Dobell, H. Halkin, J.L. Lions, R.M. Thrall and W.M. Wonham, all of whom gave five to ten lectures during the two weeks of the Seminar. Except for Dr. Dobell's, these will all be found in Volume 105. Besides the Principal Lecturers there were three Guest Lecturers: M.C. Delfour, V. Jurdjevic and S.P. Sethi, who presented substantial bodies of material in two or three lectures and which are included in Volume 106. Many of the participants also spoke and reports of most of these have also been included (Volume 106).

A rigorous introduction to optimal control theory, which will enable engineers and scientists to put the theory into practice.

Optimization and optimal control are the main tools in decision making. Because of their numerous applications in various disciplines, research in these areas is accelerating at a rapid pace. “Optimization and Optimal Control: Theory and Applications” brings together the latest developments in these areas of research as well as presents applications of these results to a wide range of real-world problems. This volume can serve as a useful resource for researchers, practitioners, and advanced graduate students of mathematics and engineering working in research areas where results in optimization and optimal control can be applied.

Geared toward advanced undergraduate and graduate engineering students, this text introduces the theory and applications of optimal control. It serves as a bridge to the
technical literature, enabling students to evaluate the implications of theoretical control work, and to judge the merits of papers on the subject. Rather than presenting an exhaustive treatise, Optimal Control offers a detailed introduction that fosters careful thinking and disciplined intuition. It develops the basic mathematical background, with a coherent formulation of the control problem and discussions of the necessary conditions for optimality based on the maximum principle of Pontryagin. In-depth examinations cover applications of the theory to minimum time, minimum fuel, and to quadratic criteria problems. The structure, properties, and engineering realizations of several optimal feedback control systems also receive attention. Special features include numerous specific problems, carried through to engineering realization in block diagram form. The text treats almost all current examples of control problems that permit analytic solutions, and its unified approach makes frequent use of geometric ideas to encourage students' intuition.

This fully revised 3rd edition offers an introduction to optimal control theory and its diverse applications in management science and economics. It brings to students the concept of the maximum principle in continuous, as well as discrete, time by using dynamic programming and Kuhn-Tucker theory. While some mathematical background is needed, the emphasis of the book is not on mathematical rigor, but on modeling realistic situations faced in business and economics. The book exploits optimal control theory to the functional areas of management including finance, production and
marketing and to economics of growth and of natural resources. In addition, this new edition features materials on stochastic Nash and Stackelberg differential games and an adverse selection model in the principal-agent framework. The book provides exercises for each chapter and answers to selected exercises to help deepen the understanding of the material presented. Also included are appendices comprised of supplementary material on the solution of differential equations, the calculus of variations and its relationships to the maximum principle, and special topics including the Kalman filter, certainty equivalence, singular control, a global saddle point theorem, Sethi-Skiba points, and distributed parameter systems. Optimal control methods are used to determine optimal ways to control a dynamic system. The theoretical work in this field serves as a foundation for the book, which the author has applied to business management problems developed from his research and classroom instruction. The new edition has been completely refined and brought up to date. Ultimately this should continue to be a valuable resource for graduate courses on applied optimal control theory, but also for financial and industrial engineers, economists, and operational researchers concerned with the application of dynamic optimization in their fields. This work describes all basic equations and inequalities that form the necessary and sufficient optimality conditions of variational calculus and the theory of optimal control. Subjects addressed include developments in the investigation of optimality conditions, new classes of solutions, analytical and computation methods, and applications.
The calculus of variations is used to find functions that optimize quantities expressed in terms of integrals. Optimal control theory seeks to find functions that minimize cost integrals for systems described by differential equations. This book is an introduction to both the classical theory of the calculus of variations and the more modern developments of optimal control theory from the perspective of an applied mathematician. It focuses on understanding concepts and how to apply them. The range of potential applications is broad: the calculus of variations and optimal control theory have been widely used in numerous ways in biology, criminology, economics, engineering, finance, management science, and physics. Applications described in this book include cancer chemotherapy, navigational control, and renewable resource harvesting. The prerequisites for the book are modest: the standard calculus sequence, a first course on ordinary differential equations, and some facility with the use of mathematical software. It is suitable for an undergraduate or beginning graduate course, or for self study. It provides excellent preparation for more advanced books and courses on the calculus of variations and optimal control theory.

Optimal control theory is a technique being used increasingly by academic economists to study problems involving optimal decisions in a multi-period framework. This textbook is designed to make the difficult subject of optimal control theory easily
accessible to economists while at the same time maintaining rigour. Economic intuitions are emphasized, and examples and problem sets covering a wide range of applications in economics are provided to assist in the learning process. Theorems are clearly stated and their proofs are carefully explained. The development of the text is gradual and fully integrated, beginning with simple formulations and progressing to advanced topics such as control parameters, jumps in state variables, and bounded state space. For greater economy and elegance, optimal control theory is introduced directly, without recourse to the calculus of variations. The connection with the latter and with dynamic programming is explained in a separate chapter. A second purpose of the book is to draw the parallel between optimal control theory and static optimization. Chapter 1 provides an extensive treatment of constrained and unconstrained maximization, with emphasis on economic insight and applications. Starting from basic concepts, it derives and explains important results, including the envelope theorem and the method of comparative statics. This chapter may be used for a course in static optimization. The book is largely self-contained. No previous knowledge of differential equations is required.

Die mathematische Theorie der optimalen Steuerung hat sich im Zusammenhang mit Berechnungen für die Luft- und Raumfahrt schnell zu einem wichtigen und eigenständigen Gebiet der angewandten Mathematik entwickelt. Die optimale Steuerung durch partielle Differentialgleichungen modellierter Prozesse wird eine

This book serves not only as an introduction, but also as an advanced text and reference source in the field of deterministic optimal control systems governed by ordinary differential equations. It also includes an introduction to the classical calculus of variations. An important feature of the book is the inclusion of a large number of examples, in which the theory is applied to a wide variety of economics problems. The presentation of simple models helps illuminate pertinent qualitative and analytic points, useful when confronted with a more complex reality. These models cover: economic growth in both open and closed economies, exploitation of (non-) renewable resources, pollution control, behaviour of firms, and differential games. A great emphasis on precision pervades the book, setting it apart from the bulk of literature in this area. The rigorous techniques presented should help the reader avoid errors which often recur in the application of control theory within economics.
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In the development of optimal control, the complexity of the systems to which it is applied has increased significantly, becoming an issue in scientific computing. In order to carry out model-reduction on these systems, the authors of this work have developed a method based on asymptotic analysis. Moving from abstract explanations to examples and applications with a focus on structural network problems, they aim at combining techniques of homogenization and approximation. Optimal Control Problems for Partial Differential Equations on Reticulated Domains is an excellent reference tool for graduate students, researchers, and practitioners in mathematics and areas of
engineering involving reticulated domains.

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