PAYOFFS. Our overall task will be to determine what is the "best" control for our system. For this we need to specify a specific payoff (or reward) criterion. Let us define the *payoff functional*

$$(P) \qquad\qquad P[\alpha(\cdot)] := \int_0^T r(\mathbf{x}(t), \alpha(t))\, dt + g(\mathbf{x}(T)),$$

where $\mathbf{x}(\cdot)$ solves (ODE) for the control $\alpha(\cdot)$. Here $r : \mathbb{R}^n \times A \to \mathbb{R}$ and $g : \mathbb{R}^n \to \mathbb{R}$ are given, and we call r the *running payoff* and g the *terminal payoff*. The terminal time $T > 0$ is given as well.

THE BASIC PROBLEM. Our aim is to find a control $\alpha^*(\cdot)$, which *maximizes* the payoff. In other words, we want

$$P[\alpha^*(\cdot)] \geq P[\alpha(\cdot)]$$

for all controls $\alpha(\cdot) \in \mathcal{A}$. Such a control $\alpha^*(\cdot)$ is called *optimal.*

Theory Of Optimal Control Mathematical

L.D. Berkovitz

Theory Of Optimal Control Mathematical:

   Introduction to Optimal Control Theory Jack Macki,Aaron Strauss,2012-12-06 This monograph is an introduction to optimal control theory for systems governed by vector ordinary differential equations It is not intended as a state of the art handbook for researchers We have tried to keep two types of reader in mind 1 mathematicians graduate students and advanced undergraduates in mathematics who want a concise introduction to a field which contains nontrivial interesting applications of mathematics for example weak convergence convexity and the theory of ordinary differential equations 2 economists applied scientists and engineers who want to understand some of the mathematical foundations of optimal control theory In general we have emphasized motivation and explanation avoiding the definition axiom theorem proof approach We make use of a large number of examples especially one simple canonical example which we carry through the entire book In proving theorems we often just prove the simplest case then state the more general results which can be proved Many of the more difficult topics are discussed in the Notes sections at the end of chapters and several major proofs are in the Appendices We feel that a solid understanding of basic facts is best attained by at first avoiding excessive generality We have not tried to give an exhaustive list of references preferring to refer the reader to existing books or papers with extensive bibliographies References are given by author s name and the year of publication e g Waltman 1974

   Optimal Control Theory Donald E. Kirk,2012-04-26 Upper level undergraduate text introduces aspects of optimal control theory dynamic programming Pontryagin s minimum principle and numerical techniques for trajectory optimization Numerous figures tables Solution guide available upon request 1970 edition   *Optimal Control Theory* L.D. Berkovitz,2013-03-14 This book is an introduction to the mathematical theory of optimal control of processes governed by ordinary differential eq tions 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 relati ship with applications In order to accommodate a range of mathema cal interests and backgrounds among readers the material is arranged so that the more advanced mathematical sections can be omitted wi out loss of continuity For readers primarily interested in appli tions a recommended minimum course consists of Chapter I the sections of Chapters II III and IV so recommended in the introductory sec tions of those chapters and all of Chapter V The introductory sec tion 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 defini tions 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   *An Introduction to Optimal Control Theory* Aaron Strauss,2012-12-06 This paper is intended for the beginner It is not a state of the art paper for research workers in the field

of control theory Its purpose is to introduce the reader to some of the problems and results in control theory to illustrate the application of these re sults and to provide a guide for his further reading on this subject I have tried to motivate the results with examples especial ly with one canonical simple example described in 3 Many results such as the maximum principle have long and difficult proofs I have omitted these proofs In general I have included only the proofs which are either 1 not too difficult or 2 fairly enlightening as to the nature of the result I have however usually attempted to draw the strongest conclusion from a given proof For example many existing proofs in control theory for compact targets and uniqueness of solutions also hold for closed targets and non uniqueness Finally at the end of each section I have given references to generalizations and origins of the results discussed in that section I make no claim of completeness in the references however as I have often been content merely to refer the reader either to an exposition or to a paper which has an extensive bibliography IV These 1ecture notes are revisions of notes I used for aseries of nine 1ectures on contro1 theory at the International Summer Schoo1 on Mathematica1 Systems and Economics held in Varenna Ita1y June 1967 **Optimal Control** Michael Athans,Peter L. Falb,2013-04-26 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 **Optimal Control** Leslie M. Hocking,1991 Systems that evolve with time occur frequently in nature and modelling the behaviour of such systems provides an important application of mathematics These systems can be completely deterministic but it may be possible too to control their behaviour by intervention through controls The theory of optimal control is concerned with determining such controls which at minimum cost either direct the system along a given trajectory or enable it to reach a given point in its state space This textbook is a straightforward introduction to the theory of optimal control with an emphasis on presenting many different applications Professor Hocking has taken pains to ensure that the theory is developed to display the main themes of the arguments but without using sophisticated mathematical tools Problems in this setting can arise across a wide range of subjects and there are illustrative examples of systems from as diverse fields as dynamics economics population control and medicine Throughout there are

many worked examples and numerous exercises with solutions are provided   *Principles of Optimal Control Theory* R. Gamkrelidze,2013-03-09 In the late 1950 s the group of Soviet mathematicians consisting of L S Pontryagin V G Boltyanskii R V Gamkrelidze and E F Mishchenko made fundamental contributions to optimal control theory Much of their work was collected in their monograph The Mathematical Theory of Optimal Processes Subsequently Professor Gamkrelidze made further important contributions to the theory of necessary conditions for problems of optimal control and general optimization problems In the present monograph Professor Gamkrelidze presents his current view of the fundamentals of optimal control theory It is intended for use in a one semester graduate course or advanced undergraduate course We are now making these ideas available in English to all those interested in optimal control theory West Lafayette Indiana USA Leonard D Berkovitz Translation Editor Vll Preface This book is based on lectures I gave at the Tbilisi State University during the fall of 1974 It contains in essence the principles of general control theory and proofs of the maximum principle and basic existence theorems of optimal control theory Although the proofs of the basic theorems presented here are far from being the shortest I think they are fully justified from the conceptual view point In any case the notions we introduce and the methods developed have one unquestionable advantage they are constantly used throughout control theory and not only for the proofs of the theorems presented in this book   *Optimal Control Theory* Suresh P. Sethi,2022-01-03 This new 4th edition offers an introduction to optimal control theory and its diverse applications in management science and economics It introduces students to the concept of the maximum principle in continuous as well as discrete time by combining 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 encountered in business and economics It applies optimal control theory to the functional areas of management including finance production and marketing as well as the economics of growth and of natural resources In addition it features material on stochastic Nash and Stackelberg differential games and an adverse selection model in the principal agent framework Exercises are included in each chapter while the answers to selected exercises help deepen readers understanding of the material covered Also included are appendices of supplementary material on the solution of differential equations the calculus of variations and its ties 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 the foundation for the book in which the author applies it to business management problems developed from his own research and classroom instruction The new edition has been refined and updated making it a valuable resource for graduate courses on applied optimal control theory but also for financial and industrial engineers economists and operational researchers interested in applying dynamic optimization in their fields   **An Introduction to Optimal Control Problems in Life Sciences and Economics** Sebastian Aniţa,Viorel Arnăutu,Vincenzo

Capasso,2011-05-05 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 *Nonlinear Optimal Control Theory* Leonard David Berkovitz,Negash G. Medhin,2012-08-25 Nonlinear Optimal Control Theory presents a deep wide ranging introduction to the mathematical theory of the optimal control of processes governed by ordinary differential equations and certain types of differential equations with memory Many examples illustrate the mathematical issues that need to be addressed when using optimal control techniques in diverse areas Drawing on classroom tested material from Purdue University and North Carolina State University the book gives a unified account of bounded state problems governed by ordinary integrodifferential and delay systems It also discusses Hamilton Jacobi theory By providing a sufficient and rigorous treatment of finite dimensional control problems the book equips readers with the foundation to deal with other types of control problems such as those governed by stochastic differential equations partial differential equations and differential games Optimal Control Theory Robert Pallu de La Barrière,1980 **Optimal Control Theory** Suresh P. Sethi,Gerald L. Thompson,2000-07-31 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 authors have applied to business management problems developed from their research and classroom instruction Sethi and Thompson have provided management science and economics communities with a thoroughly revised edition of their classic text on Optimal Control Theory The new edition has been completely refined with careful attention to the text and graphic material presentation Chapters cover a range of topics including finance production and inventory problems marketing problems machine maintenance and replacement problems of optimal consumption of natural resources and applications of control theory to economics The book contains new results that were not available when the first edition was published as well as an expansion of the material on stochastic optimal control theory Mathematical Theory of Optimal Processes L.S. Pontryagin,1987-03-06 The fourth and final volume in this comprehensive set presents the maximum principle as a wide ranging solution to nonclassical variational problems This one mathematical method can be applied in a variety of situations including linear equations with variable coefficients optimal processes with delay and the jump condition As with the three preceding volumes all the material contained with the 42 sections of this volume is made easily accessible by way of numerous examples both concrete and abstract in nature **Primer on Optimal Control Theory** Jason L. Speyer,David H. Jacobson,2010-05-13 A rigorous

introduction to optimal control theory which will enable engineers and scientists to put the theory into practice   *The Mathematical Theory of Optimal Processes* Lev Semenovich Pontri␣a␣gin,1964   **Geometric Optimal Control** Heinz Schättler,Urszula Ledzewicz,2012-06-26 This book gives a comprehensive treatment of the fundamental necessary and sufficient conditions for optimality for finite dimensional deterministic optimal control problems The emphasis is on the geometric aspects of the theory and on illustrating how these methods can be used to solve optimal control problems It provides tools and techniques that go well beyond standard procedures and can be used to obtain a full understanding of the global structure of solutions for the underlying problem The text includes a large number and variety of fully worked out examples that range from the classical problem of minimum surfaces of revolution to cancer treatment for novel therapy approaches All these examples in one way or the other illustrate the power of geometric techniques and methods The versatile text contains material on different levels ranging from the introductory and elementary to the advanced Parts of the text can be viewed as a comprehensive textbook for both advanced undergraduate and all level graduate courses on optimal control in both mathematics and engineering departments The text moves smoothly from the more introductory topics to those parts that are in a monograph style were advanced topics are presented While the presentation is mathematically rigorous it is carried out in a tutorial style that makes the text accessible to a wide audience of researchers and students from various fields including the mathematical sciences and engineering Heinz Sch ttler is an Associate Professor at Washington University in St Louis in the Department of Electrical and Systems Engineering Urszula Ledzewicz is a Distinguished Research Professor at Southern Illinois University Edwardsville in the Department of Mathematics and Statistics   **The Calculus of Variations and Optimal Control** George Leitmann,1981-05-31 This book is intended to present an introductory treatment of the calculus of variations in Part I and of optimal control theory in Part II The discussion in Part I is restricted to the simplest problem of the calculus of variations The topic is entirely classical all of the basic theory had been developed before the turn of the century Consequently the material comes from many sources   *Theory of Optimal Control and Mathematical Programming* Michael D. Canon,Clifton D. Cullum,Elijah Polak,1969 This book has three basic aims to present a unified theory of optimization to introduce nonlinear programming algorithms to the control engineer and to introduce the nonlinear programming expert to optimal control This volume can be used either as a graduate text or as a reference text Preface   **Calculus of Variations and Optimal Control Theory** Daniel Liberzon,2012-01-08 This textbook offers a concise yet rigorous introduction to calculus of variations and optimal control theory and is a self contained resource for graduate students in engineering applied mathematics and related subjects Designed specifically for a one semester course the book begins with calculus of variations preparing the ground for optimal control It then gives a complete proof of the maximum principle and covers key topics such as the Hamilton Jacobi Bellman theory of dynamic programming and linear quadratic optimal control Calculus of Variations and Optimal Control Theory also traces the historical development

of the subject and features numerous exercises notes and references at the end of each chapter and suggestions for further study Offers a concise yet rigorous introduction Requires limited background in control theory or advanced mathematics Provides a complete proof of the maximum principle Uses consistent notation in the exposition of classical and modern topics Traces the historical development of the subject Solutions manual available only to teachers Leading universities that have adopted this book include University of Illinois at Urbana Champaign ECE 553 Optimum Control Systems Georgia Institute of Technology ECE 6553 Optimal Control and Optimization University of Pennsylvania ESE 680 Optimal Control Theory University of Notre Dame EE 60565 Optimal Control   *Optimal Control Theory with Applications in Economics* Thomas A. Weber,2011-09-30 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

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