Optimal Control Systems Solution Manual

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Introduction to Applied Optimization - Urmila Diwekar 2013-03-09
This text presents a multi-disciplined view of optimization, providing students and researchers with a thorough examination of algorithms, methods, and tools from diverse areas of optimization without introducing excessive theoretical detail. This second edition includes additional topics, including global optimization and a real-world case study using important concepts from each chapter. Introduction to Applied Optimization is intended for advanced undergraduate and graduate students and will benefit scientists from diverse areas, including engineers.
Optimal Control - Brian D. O.

Anderson 2007-02-27
Numerous examples highlight this treatment of the use of linear quadratic Gaussian methods for control system design. It explores linear optimal control theory from an engineering viewpoint, with illustrations of practical applications. Key topics include loop-recovery techniques, frequency shaping, and controller reduction. Numerous examples and complete solutions. 1990 edition.

The Theory and Application of Linear Optimal Control - Edmund G. Rynaski 1965
Linear optimal control theory has produced an important synthesis technique for the design of linear multivariable systems. In the present study, efficient design procedures, based on the general optimal theory, have been developed. These procedures make use of design techniques which are similar to the conventional methods of control system analysis. Specifically, a scalar expression is developed which relates the closed-loop poles of the multi- controller, multi-output optimal system to the weighting parameters of a quadratic performance index. Methods analogous to the root locus and Bode plot techniques are then developed for the systematic analysis of this expression. Examples using the aircraft longitudinal equations of motion to represent the object to be controlled are presented to illustrate design procedures which can be carried out in either the time or frequency domains. Both the model-in -the- performance-index and model-following concepts are employed in several of the examples to illustrate the model approach to optimal design.

Automatic Control - Benjamin C. Kuo 1995-01-15
This best-selling introduction to automatic control systems has been updated to reflect the increasing use of computer-aided learning and design, and revised to feature a more accessible approach — without sacrificing depth.

Control Theory for Physicists - John Bechhoefer 2021-04

Bridging the basics to recent research advances, this is the ideal learning and reference work for physicists studying control theory.

Optimal Control - Brian D. O. Anderson 1990

Proceedings - NASA-University Conference on Manual Control 1966

On the Inverse Optimal Control Problem in Manual Control Systems - R. W. Obermayer 1965

Optimal Control Systems - D. Subbaram Naidu 2018-10-03

The theory of optimal control systems has grown and flourished since the 1960's. Many texts, written on varying levels of sophistication, have been published on the subject. Yet even those purportedly designed for beginners in the field are often riddled with complex theorems, and many treatments fail to include topics that are essential to a thorough grounding in the various aspects of and approaches to optimal control. Optimal Control Systems provides a comprehensive but accessible treatment of the subject with just the right degree of mathematical rigor to be complete but practical. It provides a solid bridge between "traditional" optimization using the calculus of variations and what is called "modern" optimal control. It also treats both continuous-time and discrete-time optimal control systems, giving students a firm grasp on both methods. Among this book's most outstanding features is a summary table that accompanies each topic or problem and includes a statement of the problem with a step-by-step solution. Students will also gain valuable experience in using industry-standard MATLAB and SIMULINK software, including the Control System and Symbolic Math Toolboxes. Diverse applications across fields from power engineering to medicine make a foundation in optimal control systems an essential part of an engineer's background. This clear, streamlined presentation is ideal for a graduate level

course on control systems and as a quick reference for working engineers.

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 and Estimation - Robert F. Stengel 2012-10-16

Graduate-level text provides introduction to optimal control theory for stochastic systems, emphasizing application of basic concepts to real problems.

Optimal Control Engineering with MATLAB - Rami A. Maher 2018

For control engineers, optimal control is a tool to design a primal controller which secures system stability and fulfils a certain set of specifications via the optimisation of a specific performance index. In this way, troublesome trial-and-error controller tuning procedures are avoided. The next step is to assess the possibility of practical implementation, and this usually leads to a need to implement some controller trade-offs. To this end, this book aims to construct bridges between conventional parameter optimisation and the methods of optimal control theory.

Applications of Human Performance Models to System Design - Grant R. McMillan 2013-06-29

The human factors profession is currently attempting to take a more proactive role in the design of man-machine systems than has been character istic of its past. Realizing that human engineering contributions are needed well before the experimental evaluation of prototypes or operational systems, there is a concerted effort to develop tools that predict how humans will interact with proposed designs. This volume provides an over view of one category of such tools: mathematical models of

human performance. It represents a collection of invited papers from a 1988 NATO Workshop. The Workshop was conceived and organized by NATO Research Study Group 9 (RSG.9) on "Modelling of Human Operator Behaviour in Weapon Systems". It represented the culmination of over five years of effort, and was attended by 139 persons from Europe, Canada, and the United States. RSG.9 was established in 1982 by Panel 8 of the Defence Research Group to accomplish the following objectives: * Determine the utility and state of the art of human performance modelling. * Encourage international research and the exchange of ideas. * Foster the practical application of modelling research. * Provide a bridge between the models and approaches adopted by engineers and behavioral scientists. * Present the findings in an international symposium.

Advanced Modern Control System Theory and Design - Stanley M. Shinners 1998-09-30

The definitive guide toadvanced control system design Advanced Modern Control System Theory and Design offers the most comprehensive treatment of advanced control systems available today. Superbly organized and easy to use, this book is designed for an advanced course and is a companion volume to the introductory text, Modern Control System Theory and Design, Second Edition (or any other introductory book on control systems). In addition, it can serve as an excellent text for practicing control system engineers who need to learn more advanced control systems techniques in order to perform their tasks. Advanced Modern Control Systems Theory and Design briefly reviews introductory control system analysis concepts and then presents the methods for designing linear control systems using single-degree and two-degrees-of-freedom compensation techniques. The very important subjects of modern control system design using state-space, pole

placement, Ackermann's formula, estimation, robust control, and H8 techniques are then presented. The following crucial subjects are then covered in the presentation: * Digital Control System Analysis and Design-extends the continuous concepts presented to discrete systems * Nonlinear Control System Design-extends the linear concepts presented tononlinear systems * Introduction to Optimal Control Theory and Its Applications-presents such key topics as dynamic programming and the maximum principle, as well as applications to the space attitude control problem and the lunar soft-landing problem * Control System Design Examples: Complete Case Studies-presents the complete case studies of five control system design examples that illustrate practical design projects Other notable features of this volume are: * Free MATLAB software containing problem solutions which can be retrieved from the Mathworks, Inc. anonymous FTP server at ftp://ftp.mathworks.com/pub/books/advshinners * MATLAB programs and a tutorial on the use of MATLAB incorporated directly into the text * An extensive set of worked-out, illustrative solutions added in dedicated sections at the end of chapters * End-of-chapter problems-one-third with answers to facilitate self-study * A solutions manual containing solutions to the remaining two-thirds of the problems available from the Wiley editorial department.

Data Mining: Concepts and Techniques - Jiawei Han 2011-06-09

Data Mining: Concepts and Techniques provides the concepts and techniques in processing gathered data or information, which will be used in various applications. Specifically, it explains data mining and the tools used in discovering knowledge from the collected data. This book is referred as the knowledge discovery from data (KDD). It focuses on the feasibility, usefulness, effectiveness, and scalability of techniques of large data sets. After describing

data mining, this edition explains the methods of knowing, preprocessing, processing, and warehousing data. It then presents information about data warehouses, online analytical processing (OLAP), and data cube technology. Then, the methods involved in mining frequent patterns, associations, and correlations for large data sets are described. The book details the methods for data classification and introduces the concepts and methods for data clustering. The remaining chapters discuss the outlier detection and the trends, applications, and research frontiers in data mining. This book is intended for Computer Science students, application developers, business professionals, and researchers who seek information on data mining. Presents dozens of algorithms and implementation examples, all in pseudo-code and suitable for use in real-world, large-scale data mining projects Addresses advanced topics such as mining object-relational databases, spatial databases, multimedia databases, time-series databases, text databases, the World Wide Web, and applications in several fields Provides a comprehensive, practical look at the concepts and techniques you need to get the most out of your data

Modern Control System Theory and Design, Solutions Manual - Stanley M. Shinners 1992-09-16

Offers unified treatment of conventional and modern continuous and discrete control theory and demonstrates how to apply the theory to realistic control system design problems. Along with linear and nonlinear, digital and optimal control systems, it presents four case studies of actual designs. The majority of solutions contained in the book and the problems at the ends of the chapters were generated using the commercial software package, MATLAB, and is available free to the users of the book by returning a postcard contained with the book to the MathWorks, Inc. This software also contains the following features/utilities

created to enhance MATLAB and several of the MathWorks' toolboxes: Tutorial File which contains the essentials necessary to understand the MATLAB interface (other books require additional books for full comprehension), Demonstration m-file which gives the users a feel for the various utilities included, OnLine HELP, Synopsis File which reviews and highlights the features of each chapter.

Optimal Control and Viscosity Solutions of Hamilton-Jacobi-Bellman Equations - Martino Bardi 2009-05-21

This softcover book is a self-contained account of the theory of viscosity solutions for first-order partial differential equations of Hamilton–Jacobi type and its interplay with Bellman’s dynamic programming approach to optimal control and differential games. It will be of interest to scientists involved in the theory of optimal control of deterministic linear and nonlinear systems. The work may be used by graduate students and researchers in control theory both as an introductory textbook and as an up-to-date reference book.

Modern Control Engineering - P.N. Paraskevopoulos 2017-12-19

"Illustrates the analysis, behavior, and design of linear control systems using classical, modern, and advanced control techniques. Covers recent methods in system identification and optimal, digital, adaptive, robust, and fuzzy control, as well as stability, controllability, observability, pole placement, state observers, input-output decoupling, and model matching."

Linear State-Space Control Systems - Robert L. Williams, II 2007-02-09

The book blends readability and accessibility common to undergraduate control systems texts with the mathematical rigor necessary to form a solid theoretical foundation. Appendices cover linear algebra and provide a Matlab overivew and files. The reviewers pointed out that this is an ambitious project but one that will pay off

because of the lack of good up-to-date textbooks in the area.

Digital Control Systems - Benjamin C. Kuo 1980

Calculus of Variations and Optimal Control Theory - Daniel Liberzon 2012

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

Convex Optimization - Stephen Boyd 2004-03-08

Convex optimization problems arise frequently in many different fields. This book provides a comprehensive introduction to the subject, and shows in detail how such problems can be solved

numerically with great efficiency. The book begins with the basic elements of convex sets and functions, and then describes various classes of convex optimization problems. Duality and approximation techniques are then covered, as are statistical estimation techniques. Various geometrical problems are then presented, and there is detailed discussion of unconstrained and constrained minimization problems, and interior-point methods. The focus of the book is on recognizing convex optimization problems and then finding the most appropriate technique for solving them. It contains many worked examples and homework exercises and will appeal to students, researchers and practitioners in fields such as engineering, computer science, mathematics, statistics, finance and economics.

Applied Optimal Control - A. E. Bryson 1975-01-01

This best-selling text focuses on the analysis and design of complicated dynamics systems. CHOICE called it “a high-level, concise book that could well be used as a reference by engineers, applied mathematicians, and undergraduates. The format is good, the presentation clear, the diagrams instructive, the examples and problems helpful...References and a multiple-choice examination are included.”

Vibration Control of Active Structures - A. Preumont 2012-12-06

I was introduced to structural control by Raphael Haftka and Bill Hallauer during a one year stay at the Aerospace and Ocean Engineering department of Virginia Tech., during the academic year 1985-1986. At that time, there was a tremendous interest in large space structures in the USA, mainly because of the Strategic Defense Initiative and the space station program. Most of the work was theoretical or numerical, but Bill Hallauer was one of the few experimen talists trying to implement control systems which worked on actual structures. When I returned to Belgium, I was

appointed at the chair of Mechanical Engi neering and Robotics at ULB, and I decided to start some basic vibration control experiments on my own. A little later, smart materials became widely available and offered completely new possibilities, particularly for precision structures, but also brought new difficulties due to the strong coupling in their constitutive equations, which requires a complete reformulation of the classical modelling techniques such as finite elements. We started in this new field with the sup port of the national and regional governments, the European Space Agency, and some bilateral collaborations with European aerospace companies. Our Active Structures Laboratory was inaugurated in October 1995.

Engineering Vibration Analysis with Application to Control Systems - C. Beards 1995-06-17

Most machines and structures are required to operate with low levels of vibration as smooth running leads to reduced stresses and fatigue and little noise. This book provides a thorough explanation of the principles and methods used to analyse the vibrations of engineering systems, combined with a description of how these techniques and results can be applied to the study of control system dynamics. Numerous worked examples are included, as well as problems with worked solutions, and particular attention is paid to the mathematical modelling of dynamic systems and the derivation of the equations of motion. All engineers, practising and student, should have a good understanding of the methods of analysis available for predicting the vibration response of a system and how it can be modified to produce acceptable results. This text provides an invaluable insight into both.

Modelling Control Systems Using IEC 61499 - Robert Lewis 2001-04-23

The IEC 61499 standard was developed to model distributed

control systems. This book introduces the main concepts and models defined in the IEC 61499 standard, particularly the use of function blocks, covering service interface function blocks, event function blocks, industrial application examples, and future development. The book is written as a user guide for the application of the standard for modeling distributed systems, and will useful for those working in industrial control, software engineering, and manufacturing systems. Lewis is the UK expert on two IEC working groups. Annotation copyrighted by Book News Inc., Portland, OR.

Modern Control Systems - Richard C. Dorf 2011

Modern Control Systems, 12e, is ideal for an introductory undergraduate course in control systems for engineering students. Written to be equally useful for all engineering disciplines, this text is organized around the concept of control systems theory as it has been developed in the frequency and time domains. It provides coverage of classical control, employing root locus design, frequency and response design using Bode and Nyquist plots. It also covers modern control methods based on state variable models including pole placement design techniques with full-state feedback controllers and full-state observers. Many examples throughout give students ample opportunity to apply the theory to the design and analysis of control systems. Incorporates computer-aided design and analysis using MATLAB and LabVIEW MathScript.

Control System Design - Bernard Friedland 2012-03-08

Introduction to state-space methods covers feedback control; state-space representation of dynamic systems and dynamics of linear systems; frequency-domain analysis; controllability and observability; shaping the dynamic response; more. 1986 edition.

Modern Digital Control Sys 2e - Raymond G. Jacquot 1995

This work presents traditional methods and current

techniques of incorporating the computer into closed-loop dynamic systems control, combining conventional transfer function design and state variable concepts. Digital Control Designer - an award-winning software program which permits the solution of highly complex problems - is included (3.5 IBM-compatible disk). This edition: supplies new coverage of the Ragazzini technique; describes digital filtering, including Butterworth prototype filters; and more. A solutions manual is included for instructors.

Feedback Systems - Karl Johan Åström 2021-02-02

The essential introduction to the principles and applications of feedback systems—now fully revised and expanded This textbook covers the mathematics needed to model, analyze, and design feedback systems. Now more user-friendly than ever, this revised and expanded edition of Feedback Systems is a one-volume resource for students and researchers in mathematics and engineering. It has applications across a range of disciplines that utilize feedback in physical, biological, information, and economic systems. Karl Åström and Richard Murray use techniques from physics, computer science, and operations research to introduce control-oriented modeling. They begin with state space tools for analysis and design, including stability of solutions, Lyapunov functions, reachability, state feedback observability, and estimators. The matrix exponential plays a central role in the analysis of linear control systems, allowing a concise development of many of the key concepts for this class of models. Åström and Murray then develop and explain tools in the frequency domain, including transfer functions, Nyquist analysis, PID control, frequency domain design, and robustness. Features a new chapter on design principles and tools, illustrating the types of problems that can be solved using feedback Includes a new chapter on fundamental limits and new material on the Routh-

Hurwitz criterion and root locus plots Provides exercises at the end of every chapter Comes with an electronic solutions manual An ideal textbook for undergraduate and graduate students Indispensable for researchers seeking a self-contained resource on control theory

Solutions Manual for Optimal Control Systems - Laurie Kelly 2004-02

Optimal Control with Aerospace Applications - James M Longuski 2013-11-04

Want to know not just what makes rockets go up but how to do it optimally? Optimal control theory has become such an important field in aerospace engineering that no graduate student or practicing engineer can afford to be without a working knowledge of it. This is the first book that begins from scratch to teach the reader the basic principles of the calculus of variations, develop the necessary conditions step-by-step, and introduce the elementary computational techniques of optimal control. This book, with problems and an online solution manual, provides the graduate-level reader with enough introductory knowledge so that he or she can not only read the literature and study the next level textbook but can also apply the theory to find optimal solutions in practice. No more is needed than the usual background of an undergraduate engineering, science, or mathematics program: namely calculus, differential equations, and numerical integration. Although finding optimal solutions for these problems is a complex process involving the calculus of variations, the authors carefully lay out step-by-step the most important theorems and concepts. Numerous examples are worked to demonstrate how to apply the theories to everything from classical problems (e.g., crossing a river in minimum time) to engineering problems (e.g., minimum-fuel launch of a satellite). Throughout the book use is made of the time-optimal launch of a satellite into orbit

as an important case study with detailed analysis of two examples: launch from the Moon and launch from Earth. For launching into the field of optimal solutions, look no further!

Mathematical Control Theory - Jerzy Zabczyk 2009-11-03

Mathematical Control Theory: An Introduction presents, in a mathematically precise manner, a unified introduction to deterministic control theory. In addition to classical concepts and ideas, the author covers the stabilization of nonlinear systems using topological methods, realization theory for nonlinear systems, impulsive control and positive systems, the control of rigid bodies, the stabilization of infinite dimensional systems, and the solution of minimum energy problems. "Covers a remarkable number of topics....The book presents a large amount of material very well, and its use is highly recommended." --Bulletin of the AMS

Resilient Control Architectures and Power Systems - Craig Rieger 2022-01-26

Master the fundamentals of resilient power grid control applications with this up-to-date resource from four industry leaders Resilient Control Architectures and Power Systems delivers a unique perspective on the singular challenges presented by increasing automation in society. In particular, the book focuses on the difficulties presented by the increased automation of the power grid. The authors provide a simulation of this real-life system, offering an accurate and comprehensive picture of a how a power control system works and, even more importantly, how it can fail. The editors invite various experts in the field to describe how and why power systems fail due to cyber security threats, human error, and complex interdependencies. They also discuss promising new concepts researchers are exploring that promise to make these control systems much more resilient to threats of all kinds. Finally,

resilience fundamentals and applications are also investigated to allow the reader to apply measures that ensure adequate operation in complex control systems. Among a variety of other foundational and advanced topics, you'll learn about: The fundamentals of power grid infrastructure, including grid architecture, control system architecture, and communication architecture The disciplinary fundamentals of control theory, human-system interfaces, and cyber security The fundamentals of resilience, including the basis of resilience, its definition, and benchmarks, as well as cross-architecture metrics and considerations The application of resilience concepts, including cyber security challenges, control challenges, and human challenges A discussion of research challenges facing professionals in this field today Perfect for research students and practitioners in fields concerned with increasing power grid automation, Resilient Control Architectures and Power Systems also has a place on the bookshelves of members of the Control Systems Society, the Systems, Man and Cybernetics Society, the Computer Society, the Power and Energy Society, and similar organizations.

Optimal and Robust Control - Luigi Fortuna 2012-02-02

While there are many books on advanced control for specialists, there are few that present these topics for nonspecialists. Assuming only a basic knowledge of automatic control and signals and systems, Optimal and Robust Control: Advanced Topics with MATLAB offers a straightforward, self-contained handbook of advanced topics and tools in automatic

Optimal Control - Leslie M. Hocking 1991

Systems that evolve with time occur frequently in nature and modelling the behavior of such systems provides an important application of mathematics. These systems can be completely deterministic, but it may be possible too to control their behavior 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 fields as diverse as dynamics, economics, population control, and medicine. Throughout there are many worked examples, and numerous exercises (with solutions) are provided.

Optimal Control - Frank L. Lewis 2012-02-01

A NEW EDITION OF THE CLASSIC TEXT ON OPTIMAL CONTROL THEORY As a superb introductory text and an indispensable reference, this new edition of Optimal Control will serve the needs of both the professional engineer and the advanced student in mechanical, electrical, and aerospace engineering. Its coverage encompasses all the fundamental topics as well as the major changes that have occurred in recent years. An abundance of computer simulations using MATLAB and relevant Toolboxes is included to give the reader the actual experience of applying the theory to real-world situations. Major topics covered include: Static Optimization Optimal Control of Discrete-Time Systems Optimal Control of Continuous-Time Systems The Tracking Problem and Other LQR Extensions Final-Time-Free and Constrained Input Control Dynamic Programming Optimal Control for Polynomial Systems Output Feedback and Structured Control Robustness and Multivariable Frequency-Domain Techniques Differential Games Reinforcement Learning and Optimal Adaptive Control

Advanced Control Engineering - Roland Burns 2001-11-07
Advanced Control Engineering provides a complete course in control engineering for undergraduates of all technical disciplines. Included are real-life case studies, numerous problems, and accompanying MatLab programs.
The Calculus of Variations and Optimal Control - George Leitmann 2013-06-29
When the Tyrian princess Dido landed on the North African shore of the Mediterranean sea she was welcomed by a local chieftain. He offered her all the land that she could enclose between the shoreline and a rope of knotted cowhide. While the legend does not tell us, we may assume that Princess Dido arrived at the correct solution by stretching the rope into the shape of a circular arc and thereby maximized the area of the land upon which she was to found Carthage. This story of the founding of Carthage is apocryphal. Nonetheless it is probably the first account of a problem of the kind that inspired an entire mathematical discipline, the calculus of variations and its extensions such as the theory of optimal control. 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; however, those most useful to me have been the books of Oskar Bolza and of George M. Ewing. Part II is devoted to the elementary aspects of the modern extension of the calculus of variations, the theory of optimal control of dynamical systems.
Calculus of Variations and Optimal Control Theory - A Concise Introduction Instructor′s Manual - Daniel Liberzon 2012-01-01
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