

Luenberger Chapter 3 exercise 7 (p 68) asks for an algebraic proof:

Let  $A$  be an  $m \times n$  matrix and  $\mathbf{c}$  be an  $n$ -vector. Prove that  $A\mathbf{x} \leq \mathbf{0}$  implies  $\mathbf{c}'\mathbf{x} \leq 0$  if and only if  $\mathbf{c}' = \mathbf{y}'A$  for some  $\mathbf{y} \geq \mathbf{0}$ .

Consider this example.

(a) Show that

$$\begin{bmatrix} 1 & 1 & 0 \\ 2 & 0 & -1 \end{bmatrix} \mathbf{x} \leq \mathbf{0} \Rightarrow \begin{bmatrix} 3 & 1 & -1 \end{bmatrix} \mathbf{x} \leq 0$$

$$\text{because } \begin{bmatrix} 3 & 1 & -1 \end{bmatrix} = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 0 \\ 2 & 0 & -1 \end{bmatrix}.$$

(b) On the other hand,

$$\begin{bmatrix} 1 & 1 & 0 \\ 2 & 0 & -1 \end{bmatrix} \mathbf{x} \leq \mathbf{0} \not\Rightarrow \begin{bmatrix} 2 & 1 & -1 \end{bmatrix} \mathbf{x} \leq 0$$

$$\text{because } \begin{bmatrix} 2 & 1 & -1 \end{bmatrix} \neq \begin{bmatrix} y_1 & y_2 \end{bmatrix} \begin{bmatrix} 1 & 1 & 0 \\ 2 & 0 & -1 \end{bmatrix}.$$

For example,

$$\begin{bmatrix} 1 & 1 & 0 \\ 2 & 0 & -1 \end{bmatrix} \begin{bmatrix} -1 \\ 1 \\ -2 \end{bmatrix} \leq \mathbf{0} \text{ but } \begin{bmatrix} 2 & 1 & -1 \end{bmatrix} \begin{bmatrix} -1 \\ 1 \\ -2 \end{bmatrix} = 1.$$

Find another vector  $\mathbf{c}' \neq \mathbf{y}'A$  for any  $\mathbf{y} \geq \mathbf{0}$  and show a vector  $\mathbf{x}$  such that  $A\mathbf{x} \leq \mathbf{0}$  and  $\mathbf{c}'\mathbf{x} \not\leq 0$ .

(c) Now prove the **general** result as requested by Luenberger. You may find linear programming duality useful.

# Luenberger Chapter Exercise Answer

**SA Dillow**



## **Luenberger Chapter Exercise Answer:**

Introduction to Modern Economic Growth Daron Acemoglu, 2008-12-15 From Nobel Prize winning economist Daron Acemoglu an incisive introduction to economic growth Introduction to Modern Economic Growth is a groundbreaking text from one of today's leading economists Daron Acemoglu gives graduate students not only the tools to analyze growth and related macroeconomic problems but also the broad perspective needed to apply those tools to the big picture questions of growth and divergence And he introduces the economic and mathematical foundations of modern growth theory and macroeconomics in a rigorous but easy to follow manner After covering the necessary background on dynamic general equilibrium and dynamic optimization the book presents the basic workhorse models of growth and takes students to the frontier areas of growth theory including models of human capital endogenous technological change technology transfer international trade economic development and political economy The book integrates these theories with data and shows how theoretical approaches can lead to better perspectives on the fundamental causes of economic growth and the wealth of nations Innovative and authoritative this book is likely to shape how economic growth is taught and learned for years to come Introduces all the foundations for understanding economic growth and dynamic macroeconomic analysis Focuses on the big picture questions of economic growth Provides mathematical foundations Presents dynamic general equilibrium Covers models such as basic Solow neoclassical growth and overlapping generations as well as models of endogenous technology and international linkages Addresses frontier research areas such as international linkages international trade political economy and economic development and structural change An accompanying Student Solutions Manual containing the answers to selected exercises is available 978 0 691 14163 3 24 95 See <https://press.princeton.edu/titles/8970.html> For Professors only To access a complete solutions manual online email us at [acemoglusolutions@press.princeton.edu](mailto:acemoglusolutions@press.princeton.edu) Linear Systems and Optimal Control Charles K. Chui, Guanrong Chen, 2012-12-06 A knowledge of linear systems provides a firm foundation for the study of optimal control theory and many areas of system theory and signal processing State space techniques developed since the early sixties have been proved to be very effective The main objective of this book is to present a brief and somewhat complete investigation on the theory of linear systems with emphasis on these techniques in both continuous time and discrete time settings and to demonstrate an application to the study of elementary linear and nonlinear optimal control theory An essential feature of the state space approach is that both time varying and time invariant systems are treated systematically When time varying systems are considered another important subject that depends very much on the state space formulation is perhaps real time filtering prediction and smoothing via the Kalman filter This subject is treated in our monograph entitled Kalman Filtering with Real Time Applications published in this Springer Series in Information Sciences Volume 17 For time invariant systems the recent frequency domain approaches using the techniques of Adamjan Arov and Krein also known as AAK balanced realization and  $H^\infty$  theory via Nevanlinna Pick interpolation seem

very promising and this will be studied in our forthcoming monograph entitled Mathematical Approach to Signal Processing and System Theory The present elementary treatise on linear system theory should provide enough engineering and mathematics of these two subjects      **An Elementary Introduction to Mathematical Finance** Sheldon M. Ross, 2003 Table of contents

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**and Business Modeling** Wayne Winston, 2014-01-15 Master business modeling and analysis techniques with Microsoft Excel 2013 and transform data into bottom line results Written by award winning educator Wayne Winston this hands on scenario focused guide shows you how to use the latest Excel tools to integrate data from multiple tables and how to effectively build a relational data source inside an Excel workbook Solve real business problems with Excel and sharpen your edge Summarize data with PivotTables and Descriptive Statistics Explore new trends in predictive and prescriptive analytics Use Excel Trend Curves multiple regression and exponential smoothing Master advanced Excel functions such as OFFSET and INDIRECT Delve into key financial statistical and time functions Make your charts more effective with the Power View tool Tame complex optimization problems with Excel Solver Run Monte Carlo simulations on stock prices and bidding models Apply important modeling tools such as the Inquire add in      **A Concrete Approach to Mathematical Modelling** Mike Mesterton-Gibbons, 2011-02-14 WILEY INTERSCIENCE PAPERBACK SERIES The Wiley Interscience Paperback Series consists of selected books that have been made more accessible to consumers in an effort to increase global appeal and general circulation With these new unabridged softcover volumes Wiley hopes to extend the lives of these works by making

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Microsoft Excel Data Analysis and Business Modeling Wayne Winston, 2016-11-29. This is the eBook of the printed book and may not include any media, website access codes or print supplements that may come packaged with the bound book. Master business modeling and analysis techniques with Microsoft Excel 2016 and transform data into bottom line results. Written by award winning educator Wayne Winston, this hands-on scenario focused guide helps you use Excel's newest tools to ask the right questions and get accurate, actionable answers. This edition adds 150 new problems with solutions plus a chapter of basic spreadsheet models to make sure you're fully up to speed. Solve real business problems with Excel and build your competitive advantage. Quickly transition from Excel basics to sophisticated analytics. Summarize data by using PivotTables and Descriptive Statistics. Use Excel trend curves, multiple regression and exponential smoothing. Master advanced functions such as OFFSET and INDIRECT. Delve into key financial, statistical and time functions. Leverage the new charts in Excel 2016 including box and whisker and waterfall charts. Make charts more effective by using Power View. Tame complex optimizations by using Excel Solver. Run Monte Carlo simulations on stock prices and bidding models. Work with the AGGREGATE function and table slicers. Create PivotTables from data in different worksheets or workbooks. Learn about basic probability and Bayes Theorem. Automate repetitive tasks by using macros.

Mathematical Methods for Neural Network Analysis and Design Richard M. Golden, 1996. For convenience many of the proofs of the key theorems have been rewritten so that the entire book uses a relatively uniform notation. *Modern Control Systems Analysis and Design* Walter J. Grantham, Thomas L. Vincent, 1993-01-26. An introduction to analysis techniques used in the design of linear feedback control systems with emphasis on both classical and matrix methods. This text presents all design methods in a building block sequence including a thorough analysis of first and second order systems as well as

general state space systems      *Deterministic Observation Theory and Applications* Jean-Paul Gauthier, Ivan Kupka, 2001-10-08 This 2001 book presents a general theory as well as a constructive methodology to solve observation problems that is reconstructing the full information about a dynamical process on the basis of partial observed data A general methodology to control processes on the basis of the observations is also developed Illustrative but also practical applications in the chemical and petroleum industries are shown This book is intended for use by scientists in the areas of automatic control mathematics chemical engineering and physics

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