INTRODUCTION TO OPERATIONS RESEARCH

Ninth Edition

FREDERICK S. HILLIER
Stanford University

GERALD J. LIEBERMAN
Late of Stanford University

BODHIBRATA NAG
Indian Institute of Management Calcutta

PREETAM BASU
Indian Institute of Management Calcutta

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Frederick S. Hillier was born and raised in Aberdeen, Washington, where he was an award winner in statewide high school contests in essay writing, mathematics, debate, and music. As an undergraduate at Stanford University he ranked first in his engineering class of over 300 students. He also won the McKinsey Prize for technical writing, won the Outstanding Sophomore Debater award, played in the Stanford Woodwind Quintet, and won the Hamilton Award for combining excellence in engineering with notable achievements in the humanities and social sciences. Upon his graduation with a B.S. degree in Industrial Engineering, he was awarded three national fellowships (National Science Foundation, Tau Beta Pi, and Danforth) for graduate study at Stanford with specialization in operations research. After receiving his PhD degree, he joined the faculty of Stanford University, where he earned tenure at the age of 28 and the rank of full professor at 32. He also received visiting appointments at Cornell University, Carnegie-Mellon University, the Technical University of Denmark, the University of Canterbury (New Zealand), and the University of Cambridge (England). After 35 years on the Stanford faculty, he took early retirement from his faculty responsibilities in 1996 in order to focus full time on textbook writing, and now is Professor Emeritus of Operations Research at Stanford.

Dr. Hillier’s research has extended into a variety of areas, including integer programming, queueing theory and its application, statistical quality control, and the application of operations research to the design of production systems and to capital budgeting. He has published widely, and his seminal papers have been selected for republication in books of selected readings at least 10 times. He was the first-prize winner of a research contest on “Capital Budgeting of Interrelated Projects” sponsored by The Institute of Management Sciences (TIMS) and the U.S. Office of Naval Research. He and Dr. Lieberman also received the honorable mention award for the 1995 Lanchester Prize (best English-language publication of any kind in the field of operations research), which was awarded by the Institute of Operations Research and the Management Sciences (INFORMS) for the 6th edition of this book. In addition, he was the recipient of the prestigious 2004 INFORMS Expository Writing Award for the 8th edition of this book.

Dr. Hillier has held many leadership positions with the professional societies in his field. For example, he has served as Treasurer of the Operations Research Society of America (ORSA), Vice President for Meetings of TIMS, Co-General Chairman of the 1989 TIMS International Meeting in Osaka, Japan, Chair of the TIMS Publications Committee, Chair of the ORSA Search Committee for Editor of Operations Research, Chair of the ORSA Resources Planning Committee, Chair of the ORSA/TIMS Combined Meetings Committee, and Chair of the John von Neumann Theory Prize Selection Committee for INFORMS. He continues to serve as the Series Editor for Springer’s International Series in Operations Research and Management Science, a particularly prominent book series that he founded in 1993.

In addition to Introduction to Operations Research and two companion volumes, Introduction to Mathematical Programming (2nd ed., 1995) and Introduction to Stochastic Models in Operations Research (1990), his books are The Evaluation of Risky Interrelated Investments (North-Holland, 1969), Queueing
About the Authors


The late Gerald J. Lieberman sadly passed away in 1999. He had been Professor Emeritus of Operations Research and Statistics at Stanford University, where he was the founding chair of the Department of Operations Research. He was both an engineer (having received an undergraduate degree in mechanical engineering from Cooper Union) and an operations research statistician (with an AM from Columbia University in mathematical statistics, and a PhD from Stanford University in statistics).

Dr. Lieberman was one of Stanford’s most eminent leaders in recent decades. After chairing the Department of Operations Research, he served as Associate Dean of the School of Humanities and Sciences, Vice Provost and Dean of Research, Vice Provost and Dean of Graduate Studies, Chair of the Faculty Senate, member of the University Advisory Board, and Chair of the Centennial Celebration Committee. He also served as Provost or Acting Provost under three different Stanford presidents.

Throughout these years of university leadership, he also remained active professionally. His research was in the stochastic areas of operations research, often at the interface of applied probability and statistics. He published extensively in the areas of reliability and quality control, and in the modeling of complex systems, including their optimal design, when resources are limited.

Highly respected as a senior statesman of the field of operations research, Dr. Lieberman served in numerous leadership roles, including as the elected president of The Institute of Management Sciences. His professional honors included being elected to the National Academy of Engineering, receiving the Shewhart Medal of the American Society for Quality Control, receiving the Cuthbertson Award for exceptional service to Stanford University, and serving as a fellow at the Center for Advanced Study in the Behavioral Sciences. In addition, the Institute of Operations Research and the Management Sciences (INFORMS) awarded him and Dr. Hillier the honorary mention award for the 1995 Lanchester Prize for the 6th edition of this book. In 1996, INFORMS also awarded him the prestigious Kibble Medal for his exceptional contributions to the field of operations research and management science.


Bodhibrata Nag is an Associate Professor in the Operations Management Group of the Indian Institute of Management (IIM) Calcutta. He received his PhD (Fellow) in Operations Research and System Analysis from IIM Calcutta after having received his Bachelor of Technology degree in Electrical Engineering from the Indian Institute of Technology (IIT) Madras. He has received training in case method of teaching and case development at Harvard Business School and power projects design at various establishments of Electricite de France.

Dr. Nag has more than twenty years of industry experience and more than five years of teaching experience and has served in the Central Electricity Authority’s Central Power Engineering Service and Indian Railway Service for more than two decades in senior management positions of various bodies, including Director of Research Design and Standards Organization of Ministry of Railways. He has been involved in design of power projects, operation and maintenance of electric locomotives, administration of
technology transfer and R&D projects, when he developed pioneering operations research applications for optimal design of power projects and railway operations. He has authored a book titled *Optimal Design of Timetables for Large Railways* and has been a consultant to the Ministry of Railways, Ministry of Urban Development and Ministry of Health and Family Welfare of the Government of India.

Dr. Nag has been elected Fellow of the Institution of Engineers (India) and Senior Member of the Institution of Electrical and Electronics Engineers. He was awarded the Fulbright-Nehru Senior Research Fellowship for research on comparative studies of operating strategies of US and Indian railroads at the University of Michigan and the University of Texas during 2010–11. His research interests are application of analytic techniques for planning, design and operations of energy and logistics systems.

Preetam Basu is an Assistant Professor in the Operations Management Group of the Indian Institute of Management (IIM) Calcutta. He has a doctorate degree in Operations Management from the University of Connecticut, USA. Earlier, he did his M.S. in Applied Mathematics from the University of Minnesota, USA. His doctoral thesis focused on business problems at the interface of operations and finance. His research interests include supply chain management, start-up operations, services outsourcing, supply chain finance, working capital management, modeling of financial services and revenue management. He has presented his work at numerous prestigious international conferences.

Dr. Basu has taught various operations research and quantitative courses at IIM Calcutta, IIM Ranchi and University of Connecticut. Currently, he is engaged in research in the fields of financial supply chains and asset-liability management of pension funds in India. He is a Microsoft Certified Solution Developer (MCSD).