

Principles of **Engineering Economics with Applications**

Engineering economics is an essential subject for engineers. A sound understanding of this subject is required for analyzing complex economic decision-making problems in several core engineering disciplines. Adapted to meet the syllabi requirements of most universities, the text introduces the fundamental concepts of engineering economics. It shows ways to calculate time value of money using cash-flow diagrams and it explains the procedure for making economy studies to select the best alternative. It also elaborates various methods to make replacement and retention decisions, calculate depreciation costs, evaluate public sector projects, perform economy studies considering inflation, arrive at make or buy decisions etc. It further explains project planning and scheduling through CPM and PERT. The concepts and applications of value engineering are also introduced. Various methods for making forecasts, cost estimation and analysis, and decision making under different environments are also discussed. The book is strong in its ability to relate abstract engineering and managerial concepts to real life situations.

Zahid A. Khan is a professor at the Department of Mechanical Engineering, Jamia Millia Islamia, New Delhi. He has published more than 100 articles in national and international journals. His research interests include optimization of design and manufacturing processes parameters, artificial neural network (ANN), fuzzy modelling, and environmental ergonomics.

Arshad N. Siddiquee is a professor at the Department of Mechanical Engineering, Jamia Millia Islamia, New Delhi. He served as Assistant Director at the All India Council of Technical Education (AICTE) from 2005 to 2007. He has published more than 100 articles in national and international journals. His research interests include materials structure property correlation, welding engineering, machining, optimization of design and process parameters using fuzzy modelling.

Brajesh Kumar is an associate professor at the National Institute of Financial Management (NIFM), Faridabad. His areas of interest include mathematical economics, business economics, managerial economics, computer applications in economics, research methodology, and econometrics.

Mustafa H. Abidi is a researcher at the Raytheon Chair for Systems Engineering (RCSE), Advanced Manufacturing Institute, King Saud University, Riyadh. His areas of interest include application of virtual reality techniques for sustainable product development, flexible manufacturing systems, micro-manufacturing, human-computer interaction, additive manufacturing, and reverse engineering.

Principles of
Engineering Economics
with Applications
2nd edition

Zahid A. Khan
Arshad N. Siddiquee
Brajesh Kumar
Mustafa H. Abidi



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press
978-1-108-45885-6 — Principles of Engineering Economics with Applications
Zahid A. Khan , Arshad N. Siddiquee , Brajesh Kumar , Mustafa H. Abidi
Frontmatter
[More Information](#)

CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, vic 3207, Australia
314 to 321, 3rd Floor, Plot No.3, Splendor Forum, Jasola District Centre, New Delhi 110025, India
79 Anson Road, #06–04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781108458856

© Cambridge University Press 2018

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First edition 2012

Second edition 2018

Printed in India

A catalogue record for this publication is available from the British Library

ISBN 978-1-108-45885-6 Paperback

Additional resources for this publication at www.cambridge.org/9781108458856

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Cambridge University Press
978-1-108-45885-6 — Principles of Engineering Economics with Applications
Zahid A. Khan , Arshad N. Siddiquee , Brajesh Kumar , Mustafa H. Abidi
Frontmatter
[More Information](#)

To Our Families

Contents

<i>Foreword</i>	<i>xv</i>
<i>Preface</i>	<i>xix</i>
<i>Acknowledgments</i>	<i>xxi</i>
1 Engineering Economics: A Prologue	1
1.1 Introduction	1
1.2 Introduction to Economics	1
1.3 Need to Study Economics	1
1.4 Circular Flow of Economic Activities	2
1.5 Circular Flow of Income in Different Sectors	6
1.6 Demand Theory	7
1.6.1 Law of Demand	8
1.6.2 Assumptions Used in Defining Demand	8
1.6.3 Demand Schedule	8
1.6.4 Demand Curve	9
1.6.5 Determinants of Demand	9
1.7 Elasticity of Demand	10
1.7.1 Price Elasticity of Demand	10
1.7.2 Income Elasticity of Demand	15
1.7.3 Cross Elasticity	17
1.8 Supply	20
1.8.1 Factors Affecting Supply: The Determinants of Supply	20
1.8.2 Law of Supply	21
1.8.3 Supply Schedule	21
1.8.4 Supply Curve	22
1.9 Definition and Scope of Engineering Economics	22
1.9.1 Meaning of Engineering Economics	22
1.9.2 Definition of Engineering Economics	22
1.9.3 Concepts of Engineering Economics	23
1.9.4 The Scope of Engineering Economics	23
1.9.5 Engineering Economics Environment	23
1.9.6 Types of Efficiency	24
1.10 Consumer and Producer Goods and Services	25
1.11 Necessities, Luxuries and Relation between Price and Demand	25

1.12	Relation between Total Revenue and Demand	27
1.13	Cost Concepts	28
1.14	Relation between Cost and Volume	29
1.15	The Law of Supply and Demand	33
1.16	The Law of Diminishing Marginal Returns	34
1.17	Break-Even Analysis	34
1.18	Profit-Volume (P/V) Chart and P/V Ratio	38
1.19	Competition or Market Structure	41
2.	Fundamentals of Mathematics and Engineering Economics	45
2.1	Introduction	45
2.2	Theory of Consumer Behavior	46
2.3	Meaning of Utility	47
2.3.1	Nature of the Utility Function	47
2.3.2	Existence of Utility Function	48
2.3.3	The Cardinal Marginal Utility Theory	49
2.3.4	Equilibrium of the Consumer	50
2.4	Meaning of Demand	51
2.4.1	Demand Function	51
2.4.2	Quantity Demanded	51
2.4.3	Change in Demand	52
2.4.4	Law of Demand	52
2.4.5	Ordinary Demand Function	54
2.4.6	Compensated Demand Function	55
2.4.7	Reasons for Downward Slope of Demand Curve	55
2.5	Concept of Elasticity	56
2.5.1	Own Price Elasticity	56
2.5.2	Determinants of Price Elasticity	58
2.5.3	Income Elasticity of Demand	59
2.5.4	Cross-Price Elasticity of Demand	60
2.5.5	Engel Curve and Income Elasticity	61
2.5.6	Relationship between Price Elasticity and Marginal Revenue	63
2.6	Law of Diminishing Marginal Utility	63
2.7	Principle of Equi-marginal Utility	65
2.8	Indifference Curves Theory and Ordinal Utility Theory	67
2.8.1	Indifference Curves	67
2.8.2	Nature of Consumer Preferences	68
2.8.3	Indifference Map	69
2.8.4	Rate of Commodity Substitution	69
2.8.5	Properties of ICs	70
2.8.6	Budget Line	72
2.8.7	Consumer's Equilibrium or Maximization of Utility	72
2.8.8	Alternative Method of Utility Maximization	74

Contents

ix

2.9	Application and Uses of Indifference Curves	76
2.9.1	Income and Leisure Choice	76
2.9.2	Revealed Preference Hypothesis	77
2.9.3	Consumer's Surplus	80
3.	Elementary Economic Analysis	83
3.1	Introduction: Theory of the Firm	83
3.2	Law of Supply	83
3.3	Concept of Elasticity of Supply	86
3.4	Meaning of Production	88
3.5	Production Function and its Types	90
3.5.1	General Production Function	90
3.5.2	Cobb-Douglas Production Function	91
3.5.3	Properties of Cobb-Douglas Production Function	93
3.5.4	CES Production Function	94
3.6	Producer's Equilibrium	94
3.7	Concept of Isoquants	96
3.8	Marginal Rate of Technical Substitution	99
3.9	The Elasticity of Substitution	100
3.10	Iso-cost Line	101
3.11	Producer's Surplus	102
3.12	Cost Minimization	102
3.13	Returns to Scale and Returns to Factor	107
3.14	Cost Theory and Estimation	108
3.15	Concept of Costs and their Types	108
3.16	Profits	110
3.16.1	Normal Profits	111
3.16.2	Economic Profits	111
3.17	Profit maximization	112
3.18	Market Structure and Degree of Competition	112
3.18.1	Perfect Competition	113
3.18.2	Monopoly	115
3.18.3	Monopolistic Competition	117
3.18.4	Oligopoly Models	118
3.18.5	Monopsony	120
4.	Interest Formulae and their Applications	123
4.1	Introduction	123
4.2	Why Return to Capital is Considered?	123
4.3	Interest, Interest Rate and Rate of Return	123
4.4	Simple Interest	125
4.5	Compound Interest	126
4.6	The Concept of Equivalence	126

4.7	Cash Flow Diagrams	127
4.8	Terminology and Notations/Symbols	129
4.9	Interest Formula for Discrete Cash Flow and Discrete Compounding	132
4.9.1	Interest Formulae Relating Present and Future Equivalent Values of Single Cash Flows	132
4.9.2	Interest Formulae Relating a Uniform Series (Annuity) to its Present and Future Worth	135
4.10	Interest Formulae Relating an Arithmetic Gradient Series to its Present and Annual Worth	142
4.10.1	Finding P when given G	143
4.10.2	Finding A when given G	144
4.11	Interest Formulae Relating a Geometric Gradient Series to its Present and Annual Worth	148
4.12	Uniform Series with Beginning-of-Period Cash Flows	154
4.13	Deferred Annuities or Shifted Uniform Series	156
4.14	Calculations Involving Uniform Series and Randomly Placed Single Amounts	159
4.15	Calculations of Equivalent Present Worth and Equivalent Annual Worth for Shifted Gradients	161
4.16	Calculations of Equivalent Present Worth and Equivalent Annual Worth for Shifted Decreasing Arithmetic Gradients	165
4.17	Nominal and Effective Interest Rates	168
4.18	Interest Problems with Compounding More-Often-Than-Once Per Year	173
4.18.1	Single Amounts	173
4.18.2	Uniform Series and Gradient Series	175
4.18.3	Interest Problems with Uniform Cash Flows Less-Often-Than Compounding Periods	176
4.18.4	Interest Problems with Uniform Cash Flows More-Often-Than Compounding Periods	178
5.	Methods for Making Economy Studies	185
5.1	Introduction	185
5.2	Basic Methods	185
5.3	Present Worth (P.W.) Method	186
5.4	Future Worth (F.W.) Method	188
5.5	Annual Worth (A.W.) Method	190
5.6	Internal Rate of Return (I.R.R.) Method	196
5.7	External Rate of Return (E.R.R.) Method	199
5.8	Explicit Reinvestment Rate of Return (E.R.R.R.) Method	203
5.9	Capitalized Cost Calculation and Analysis	204
5.10	Payback (Payout) Method	207
6.	Selection among Alternatives	212
6.1	Introduction	212
6.2	Alternatives having Identical Disbursements and Lives	212

Contents

xi

6.3	Alternatives having Identical Revenues and Different Lives	221
6.3.1	Comparisons using the Repeatability Assumption	221
6.3.2	Comparisons using the Coterminated Assumption	225
6.4	Alternatives Having Different Revenues and Identical Lives	228
6.5	Alternatives Having Different Revenues and Different Lives	231
6.6	Comparison of Alternatives by the Capitalized Worth Method	234
6.7	Selection among Independent Alternatives	235
7.	Replacement and Retention Decisions	241
7.1	Introduction	241
7.2	Reasons for Replacement	241
7.3	Terminologies used in Replacement Study	242
7.4	Economic Service Life	242
7.5	Procedure for Performing Replacement Study	245
7.6	Replacement Study over a Specified Study Period	247
8.	Depreciation	254
8.1	Introduction	254
8.2	Depreciation Terminology	254
8.3	Methods of Depreciation	255
8.3.1	Straight Line (SL) Method	255
8.3.2	The Declining Balance (DB) Method	257
8.3.3	Sum-of-the-Years'-Digits (SYD) Method	260
8.3.4	The Sinking Fund Method	262
8.3.5	The Service Output Method	264
9.	Economic Evaluation of Public Sector Projects	266
9.1	Introduction	266
9.2	Benefit/Cost Analysis of a Single Project	267
9.3	Selection between Two Mutually Exclusive Alternatives using Incremental B/C Analysis	269
9.4	Selection Among Multiple Mutually Exclusive Alternatives using Incremental B/C Analysis	271
10.	Economics Study Considering Inflation	276
10.1	Introduction	276
10.2	Effects of Inflation	276
10.3	Present Worth Calculations Adjusted for Inflation	278
10.4	Future Worth Calculations Adjusted for Inflation	281
10.5	Capital Recovery Calculations Adjusted for Inflation	284
11.	Make or Buy Decision	286
11.1	Introduction	286
11.2	Feasible Alternatives for Launching New Products	286
11.3	Decisive Factors for Make or Buy Decision	287

11.3.1	Criteria for Make Decision	287
11.3.2	Criteria for Buy Decision	288
11.4	Techniques used to Arrive at Make or Buy Decision	288
11.4.1	Simple Cost Analysis	288
11.4.2	Economic Analysis	290
11.4.3	Break-Even Analysis	292
12.	Project Management	297
12.1	Introduction	297
12.2	Phases of Project Management	297
12.2.1	Planning	297
12.2.2	Scheduling	298
12.2.3	Monitoring and Control	298
12.3	Bar or Gantt Charts	298
12.4	Network Analysis Technique	300
12.5	Critical Path Method (CPM)	301
12.5.1	Arrow Diagrams	301
12.5.2	Activity Description	304
12.5.3	Understanding Logic of Arrow Diagrams	305
12.5.4	Dummy Activities	307
12.6	Guidelines for Drawing Network Diagrams or Arrow Diagrams	308
12.7	CPM Calculations	311
12.7.1	Critical Path	312
12.7.2	Critical Activities	312
12.7.3	Non-critical Activities	312
12.7.4	Earliest Event Time	313
12.7.5	Latest Event Time	313
12.8	Calculation of the Earliest Occurrence Time of Events	313
12.9	Calculation of the Latest Occurrence Time of Events	318
12.10	Activity Times	324
12.10.1	Earliest Start Time	325
12.10.2	Earliest Finish Time	325
12.10.3	Latest Finish Time	325
12.10.4	Latest Start Time	326
12.11	Float	330
12.11.1	Types of Float	331
12.11.2	Negative Float	340
12.12	Identification of Critical Path	341
12.13	Program Evaluation and Review Technique (PERT)	343
12.13.1	PERT Activity Time Estimates	343
12.13.2	PERT Computations	344
12.13.3	Computation of Probabilities of Completion by a Specified Date	352
12.14	Project Crashing	358

Contents

xiii

12.14.1	Cost Slope	359
12.14.2	Cost of Crashing	359
13.	Value Engineering	375
13.1	Introduction	375
13.2	Concept of Value Engineering	375
13.3	Nature and Measurement of Value	378
13.3.1	The VE process	378
13.4	Origination Phase	379
13.4.1	Organization	379
13.4.2	Project Selection	379
13.4.3	The VE Team	380
13.5	Project or Study Mission	380
13.5.1	Product Definition and Documentation	380
13.6	Information Phase	380
13.6.1	Qualitative Analysis of Value: Function Analysis	380
13.6.2	Function Analysis Systems Technique (FAST)	381
13.6.3	Constraints Analysis	384
13.7	Quantitative Analysis of Value – State 1 Value Measurement	384
13.7.1	Cost Derivation	384
13.7.2	Worth or Importance Derivation	384
13.7.3	The Value Index	385
13.7.4	Value Measurement Techniques	385
13.8	Innovation Phase	386
13.8.1	Improvement of Value	386
13.9	Evaluation Phase	386
13.9.1	Pre-screening: Qualitative Analysis of Value	386
13.9.2	Quantitative Analysis of Value	386
13.10	Implementation Phase	387
14.	Forecasting	388
14.1	Introduction	388
14.2	Basic Categories of Forecasting Methods	388
14.3	Extrapolative Methods	389
14.3.1	Components of Demand	389
14.3.2	Moving Average Method	390
14.3.3	Weighted Moving Average Method	391
14.3.4	Exponential Smoothing Methods	392
14.3.5	Adaptive Methods	403
14.4	Causal or Explanatory Methods	403
14.4.1	Regression Analysis	403
14.4.2	Simple Regression Analysis	404
14.4.3	Multiple Regression Analysis	413

14.5	Qualitative or Judgmental Methods	413
14.5.1	Build-up Method	414
14.5.2	Survey Method	414
14.5.3	Test Markets	414
14.5.4	Panel of Experts	414
14.6	Forecast Errors	415
15.	Cost Estimation	422
15.1	Introduction	422
15.2	How Does an Organization Estimate Cost?	422
15.2.1	Cost Estimates	423
15.2.2	Cost Estimation Approach	423
15.2.3	Accuracy of Estimates	424
15.2.4	Cost Estimation Methods	424
15.3	Unit Method	424
15.4	Cost Indexes	426
15.5	Cost Estimation Relationships	427
15.5.1	Cost-Capacity Equation	427
15.5.2	Factor Method	428
15.5.3	Learning Curve	429
15.6	Estimation and Allocation of Indirect Cost	432
16.	Decision Making	439
16.1	Introduction	439
16.2	Terminologies used in Decision Making	439
16.3	Steps in Decision Making	439
16.4	Decision Making Environment	442
16.5	Decision Making under Uncertainty	442
16.5.1	The Maximax Criterion	442
16.5.2	The Maximin Criterion	443
16.5.3	The Minimax Regret Criterion	443
16.5.4	The Realism Criterion (Hurwicz's Rule)	444
16.5.5	Criterion of Insufficient Reason (Laplace's Rule)	444
16.6	Decision Making under Risk	445
16.6.1	Expected Monetary Value (EMV)	445
16.6.2	Expected Opportunity Loss (EOL)	447
16.6.3	Expected Value of Perfect Information (EVPI)	449
16.7	Marginal Analysis	449
16.8	Decision Trees	451
	Appendix A	457
	Appendix B	505
	Appendix C	508
	Bibliography	511
	Index	514

Foreword

In the face of cut-throat competition of the present day, businesses the world over have become more and more technical. Alongside other professionals, engineers play a key role in running businesses successfully across the globe. They play an important role in decision-making, both in the manufacturing and service industries. Most of these decisions are made primarily on the basis of economic factors and their assessment. It is often seen that decision-makers do not possess the required knowledge and skills related to engineering, and thus, they frequently call upon engineers to make technical-economic analyses and suggest recommendations. Engineering Economy is an important subject for aspiring as well as practicing engineers today, as the techniques and models thus adopted assist engineers and managers in making well-thought-out decisions. They can use the knowledge of this subject to analyse and draw conclusions as they work on projects of all kinds of complexities.

The success of engineering and business projects is usually measured in terms of financial efficiency. A project would be able to achieve maximum financial efficiency if it is properly planned and operated with respect to its technical, social and financial requirements. Since it is the engineers who understand the technical requirements of a project, they are best placed to assimilate the technical details with their knowledge of engineering economy to do an effective economic analysis and arrive at a sound managerial decision.

The present volume, comprising 16 chapters, covers many such issues pertaining to economic analysis of projects. Chapter 1 summarizes the basic principles of engineering economy and its applications. Chapter 2 describes the fundamental concepts of mathematics and engineering economics, which will help readers learn the basic mathematical concepts required for economic analysis. The roles of factors involved in economic analysis have been discussed at length in Chapter 3. Chapter 4 describes the key concept of value of money, on which economic analyses are based. Topics such as simple and compound interests, cash flow diagrams, determination of equivalent cash flow at different points in time, nominal and effective interest rates have also been explained here. Chapter 5 describes the basic methods that can be used by engineers to perform economy-studies. The methods that can be used for selecting the best alternative out of many, have been presented in Chapter 6. Chapter 7 describes the procedure to be followed to decide whether an organization should continue to use existing physical assets (such as a machine) or whether the asset should be replaced. The value of a physical asset depreciates, that is diminishes, with time; this concept of depreciation as well

as the procedure for calculating depreciation costs have been described in Chapter 8. Chapter 9 describes different methods such as benefit-cost ratio for the economic evaluation of large public-sector projects. The concept of inflation and how it affects the worth of capital have been discussed in Chapter 10. Often organizations have to make decisions as to whether they should manufacture a component in-house or buy it from outside. The procedure of arriving at a make-or-buy-decision has been explained in Chapter 11. In Chapter 12, the focus is project management. Concepts such as CPM, PERT and project crashing have been described here to enable readers understand and apply these techniques for timely and economic completion of their projects. Chapter 13 presents a well-established technique, value engineering, adopted to reduce the cost of a product and increase its value. The success of an organization depends on how efficiently and effectively it can forecast the demand for its products.

Chapter 14, describes the underlying concepts, methods and models of forecasting. Chapter 15, explains the various types of costs and describes the different methods for cost estimation. The last chapter of the book, Chapter 16 discusses the various methods used for taking decisions under different decision-making environments. This book, highlights the principles and applications of economic analysis in a lucid manner, supported by a large number and wide range of engineering-oriented examples and end-of-chapter exercises. It covers the syllabi of undergraduate and postgraduate courses of major Indian and overseas universities. Special chapters such as Fundamentals of Mathematics and Engineering Economics, Elementary Economic Analysis, Project Management, Value Engineering, and Forecasting, covered in this book are rare in books of this kind, which makes it distinct from existing books.

Writing a book requires in-depth subject knowledge, dedication, sincere effort, sacrifices, and teaching and research experience. As head of the institution, I am aware that the first author of this volume, Dr Zahid Akhtar Khan, Professor in Mechanical Engineering, Jamia Millia Islamia, New Delhi, has more than 20 years of teaching and research experience. He has taught in overseas universities such as the University Sains Malaysia, Malaysia, and the King Abdulaziz University, Jeddah, Kingdom of Saudi Arabia. Apart from teaching, he is actively involved in research and development activities. He has published more than 45 research papers in reputed national and international journals and over 20 papers in the proceedings of conferences held in India and abroad. In addition, he has also contributed chapters in three books related to Mechanical Engineering. VDM Verlag, a German publishing company, has published one of his monographs. Dr Khan has supervised several MTech dissertations and BTech projects. Presently he is supervising five PhD and three MTech. students. He and his colleague Mr Arshad Noor Siddiquee have been instrumental in developing quite a few laboratories, including the Metrology Lab, in the department and in preparing proposals for financial grants. This year they have submitted a proposal for SAP (worth ~75 lakh) to the University Grants Commission. They, along with their team of students, have filed a patent with the Controller General of Patents, Design and Trademarks, Government of India, for the designing and development of a convertible wheel chair.

Dr Khan has been discharging additional duties as coordinator for the training and placement of postgraduate students; as member, sports committee of the faculty; in-charge of the faculty magazine 'Tech-Times'; in-charge of the Engineering workshop; member of the result analysis committee; member of the sub-purchase committee of the department; advisor of the students of Mechanical Engineering; and tabulator of the MTech and BTech results.

He has received international recognition: his biography has been published in 'Marqui's Who's Who in Science and Engineering, Tenth edition, 2008-09'. He has received the International Scientist of the Year 2008 award given by the International Biographical Centre, Cambridge, UK. He is a member of the Emerald Literati Network, UK, and is also on the panel of reviewers of international journals.

Arshad Noor Siddiquee, the second author of this book, has graduated from Government Engineering College, Jabalpur. He completed his MTech from the Indian Institute of Technology, Delhi, where he is currently pursuing his doctoral studies. He is presently working as an associate professor in the Department of Mechanical Engineering, Jamia Millia Islamia. He played a key role in the developmental phase of Glasgow University College in Oman during 1998-2001. He has had hands-on experience in the establishment and accreditation of technical institutions during his tenure at the All India Council for Technical Education (AICTE), New Delhi, in the capacity of an assistant director. Siddiquee has dexterously used his skills in making the Faculty of Engineering and Technology profile for ranking evaluation of institutions and also in making proposals for Petroleum Engineering and Aeronautical Engineering programmes. He has contributed chapters on engineering subjects to three books of reputed publishers and over 15 research papers to international journals. He is on the panel of reviewers for Elsevier and Springer journals.

Dr Brajesh Kumar, the third author, has worked in the Department of Expenditure, Ministry of Finance, Government of India, and is currently serving as an associate professor at the National Institute of Financial Management (NIFM), Faridabad. His areas of interest are managerial economics, financial econometrics and computer applications in economics. He has published several research works on managerial economics, and macro- and micro-economics. Dr Kumar is associated with various national and international organizations in different capacities; for instance, agro-expert, Federation of Indian Chambers of Commerce and Industry (FICCI); read group member, Centre for Trade and Development (CENTAD); and programme coordinator, civil servants from North-East Cadre.

I am extremely pleased to find that despite their most sincere involvement, commitment and dedication to teaching and research, the authors have put in so much effort in writing this extremely useful and timely book. This must have demanded of them time away from family, great sacrifices, pains and compromises. I have learnt that the range and content of the book has received excellent appreciation from its reviewers. It is an interesting fact that the market review of the publisher revealed that no single title in India is, so far, available to fulfill students' requirements in engineering economy. I have no doubt that this is a definitive text on the subject; that it would meet the genuine needs of students, teachers, and practising

engineers and managers alike. I congratulate the authors for accomplishing this challenging task and wish them every success.

Najeeb Jung, IAS
Vice-Chancellor, Jamia Millia Islamia

Preface

ABOUT ENGINEERING ECONOMICS WITH APPLICATIONS

Engineers are required to provide economically feasible solutions to existing problems. To achieve this, engineers must possess knowledge of economy to evaluate the monetary consequences of the products, projects and processes that they design. Engineering design solutions do not exist in a vacuum but within the context of a business opportunity. Since almost every problem has multiple solutions, so the issue is: how does one rationally select a design with the most favorable economic result? The answer to this question is provided by engineering economy. Engineering economy, the analysis of the economic consequences of engineering decisions, is said to have originated in A. M. Wellington's *The Economic Theory of Railway Location*, published in 1887. Engineering economy is now considered a part of the education of every engineer, as it provides a systematic framework for evaluating the economic aspects of competing design solutions. Just as engineers model the effect of temperature on cutting tools or the thermodynamic response of an air compressor, they must also model the economic impact of their recommendations. What is 'engineering economy' and why is it so important? The initial reaction of many engineering students to this question is, 'money matters will be handled by someone else and I need not worry about these matters'. In reality, any engineering project must be, not only physically realizable but also economically affordable. Understanding and applying economic principles to engineering have never been more important. Engineering is more than a problem-solving activity focusing on the development of products, systems, and processes to satisfy a need or demand. Beyond function and performance, solutions must also be economically viable. Design decisions affect limited resources such as time, material, labor, capital and natural resources, not only initially i.e. during conceptual design but also through the remaining phases of the life cycle i.e. during detailed design, manufacture and distribution, service, retirement and disposal. Engineers should realize that the solution provided by them does not make sense and will not be acceptable, if it is not profitable.

EDUCATION LEVEL AND USE OF TEXT

The contents of this book have been designed in such a way that it serves two primary purposes: (i) to provide students with a sound understanding of the principles, basic concepts, and methodology of engineering economy; and (ii) to help students develop proficiency with these methods and with the processes for facilitating rational decisions they are likely to encounter in professional practice. Interestingly, an, engineering economics with applications, course may be a student's only college exposure to the systematic evaluation of alternative investment opportunities. In this respect, *Engineering Economics with Applications* is intended to serve as a basic text for classroom instruction and as well as a reference for use by practicing engineers in all areas (chemical, civil, computer, electrical, industrial, and mechanical engineering). The book is also useful for people engaged in the management of technical activities.

It is well suited for undergraduate as well as postgraduate courses in engineering economic analysis, project analysis, or engineering cost analysis. Additionally, because of its simple and easy to understand language, it is perfect for those who are studying the subject for the first time and on their own, and for those who simply want to review. The systematic approach used in the text design allows a practitioner unacquainted with economics and engineering principles to use the text to learn, understand, and correctly apply the principles and techniques for effective decision making.

SALIENT FEATURES OF THE BOOK

- Simple and easy to understand language.
- The concepts have been explained in a lucid manner.
- Numerous comprehensive real life examples appear throughout the book.
- Extended learning exercises, in the end-of-chapter problem sets.
- A large number of figures and diagrams enrich the text.
- Some special chapters such as 'Chapter 2: Fundamental Concepts of Mathematics and Engineering Economics', 'Chapter 3: Basic Mathematical Concepts for Economic Analysis', 'Chapter 12: Project Management', 'Chapter 14: Forecasting', 'Chapter 15: Cost Estimation' and 'Chapter 16: Decision Making', that generally do not appear in engineering economy texts are included in this book.

Acknowledgments

We are extremely grateful to the Almighty for thy blessings, which of course have been with us always, and for giving us the strength and dedication to complete this book to the best of our ability.

We are thankful to all people, including our colleagues and students, for extending their help and support in completing this book.

We are grateful to Raytheon Chair for Systems Engineering (RCSE), Advanced Manufacturing Institute for the funding. We would also like to thank our parent institutions for allowing us to complete this book.

We are extremely thankful to the Cambridge University Press, particularly Gauravjeet Singh Reen for his untiring efforts and continuous support, for timely publication of the book.

Last but not the least, we thank our beloved family members, who suffered a lot during completion of this book as we could not spend as much time with them we should have. We thank them for bearing with us.