Fundamentals of Engineering Economics

Edited by Kal Renganathan Sharma

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- Copyright Page
- Table of Contents
- Excerpt of Chapter 1

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Fundamentals of Engineering Economics

By Kal Renganathan Sharma

Prairie View A&M University
Contents

Dedication ix
About the Author xi
Preface xiii

CHAPTER 1.0 1
Overview of Engineering Economy

1.1 What is Engineering, What is Economy and What is Engineering Economy? 1
Example 1.0 Start of Technocrats of Texas 4
1.2 Seven Principles of Engineering Economy 4
1.3 Summary 5
1.4 References 6
1.5 Exercises 6

CHAPTER 2.0 9
Fixed and Variable Costs

2.1 One Time and Recurring Costs 9
2.2 Life Cycle of an Enterprise 10
2.3 Total Revenue, Total Cost and Profitable Region 11
Example 2.1 Garlic Nibbler Snack Factory 12
2.4 Giffen and Veblen Goods 15
Example 2.2 Japanese Robots 15
Example 2.3 Lawnmowers from China 17
2.5 Dualistic Relations 19
2.6 Summary 23
2.7 References 24
2.8 Exercises 28
CHAPTER 3.0
Time Worth of Money

3.1 Simple and Compound Interest
   Example 3.1 Compound Interest Calculated on an Every Day Basis
   29
   3.1.2 Effective Interest Rate
   29
   3.2 Uniform Series of Payments
   32
   3.2.1 Given A, i and N Find F
   33
   Example 3.2 Doubling Time of Investment
   34
   3.2.2 Given A, i and N, Find P
   36
   Example 3.3 Perpetual Payment and Father’s Day Prize
   37
   Example 3.4 0% Interest Rate
   38
   Example 3.5 Nest Egg of Alice Smith
   38
   Example 3.6 Diversified Portfolio
   39
   Example 3.7 George Titan’s Royalty Payments and Investment
   39
   3.2.3 Given F, i and A, Find N
   39
   3.2.4 Given P, i and A, Find N
   40
   3.2.5 Given F, A and N, Find i
   41
   3.2.6 Given P, A and N, Find i
   42
   Example 3.8 U-Pay now & I-Pay Later
   42
   Example 3.9 When does a Micro-Power plant become a more attractive investment?
   43
   3.3 Uniform Gradient Series of Payments
   44
   3.4 Continuous Compounding
   45
   3.4.1 F/P, F/A, P/A, A/F, A/P for Continuous Compounding
   46
   Example 3.10 Continuous Compounding
   47
   3.4.2 Given A, i, N Find i During Continuous Compounding
   47
   Example 3.11 Time Taken to Achieve Investment Goal
   48
   Example 3.12 Biodiesel Production from Waste Cooking Oil
   49
   Example 3.13 Credit Card Debt of all US Households
   50
   Example 3.14 Time Taken to Pay off Credit Card Debt
   50
   Example 3.15 Deferred Annuity
   50
   3.5 Summary
   51
   3.6 References
   52
   3.7 Exercises
   52

CHAPTER 4.0
Five Methods for Evaluation of Capital Project

4.1 Overview
   57
4.2 Present Worth Analysis, PW
   58
   Example 4.1 Hydrogen from Fast Pyrolysis and Steam Reforming
   58
   Example 4.2 Replacement for WTC, World Trade Center
   59
   Example 4.3 Capitalized Worth of Stone’s Replacement for WTC
   60
4.3 Future Worth Analysis, FW
   60
   Example 4.4 University Apartments
   60

Example 4.5 Present Worth of a Sugar Mill
   61
Example 4.6 Invest in Gold or Stock Market
   62
Example 4.7 Electric/Gas Hybrid Vehicle
   63
Example 4.8 Effect of Inflation on PW
   64
Example 4.9 Life-Cycle Cost Analysis of HVAC Systems
   65
Example 4.10 Municipal Garbage Collection Truck
   66
Example 4.11 Hexane Extraction of Rice-Bran Oil
   66
4.4 Annual Worth Analysis, AW
   67
Example 4.12 Annual Worth, AW of a Bio-Diesel Plant in Taiwan
   68
Example 4.13 Debt Consolidation
   68
Example 4.14 Solar Panel
   70
4.5 IRR, Internal Rate of Return
   70
Example 4.15 Profitability of Liquefaction Plants
   71
Example 4.16 Ethanol Production by Fermentation
   73
4.6 ERR, External Rate of Return
   73
4.7 Payback Period
   74
Example 4.17 Copper-Chlorine Thermochemical Cycles for Hydrogen Production
   75
4.8 Summary
   75
4.9 References
   76
4.10 Exercises
   77

CHAPTER 5.0
Comparison of Alternates and Decision Analysis

5.1 Overview Example
   91
5.2 Best Process to Manufacture CNTs, Carbon Nanotubes Example
   93
5.3 Cost Savings by using Microfiltration Pre-Treatment during SWRO, Seawater Reverse Osmosis
   95
Example 5.3 Bioethanol from Sugarcane Bagasse
   96
Example 5.4 Sequestration by Dimethyl Carbonate Formation
   98
5.4 Study Period – Don’t Compare an Apple and an Orange
   99
Example 5.5 Life Cycle Cost of Photocopier
   99
Example 5.6 LED Lighting
   101
5.5 Household Finances
   107
Example 5.8 Refinancing of Steve Gandhi
   109
Example 5.9 Toyota National Clearance
   109
5.6 Summary
   112
5.7 References
   113
5.8 Exercises
   114
CHAPTER 3.0

Time Worth of Money

3.1 Simple and Compound Interest
   Example 3.1 Compound Interest Calculated on an Every Day Basis 29
   Example 3.2 Effective Interest Rate 32
   Example 3.3 Perpetual Payment and Father’s Day Prize 37
   Example 3.4 0% Interest Rate 38
   Example 3.5 Nest Egg of Alice Smith 38
   Example 3.6 Dividends Portfolio 38
   Example 3.7 George Titan’s Royalty Payments and Investment 39
   Example 3.8 U-Pay now & I-Pay Later 42
   Example 3.9 When does a Micro-Power plant become a more attractive investment? 43
3.2 Uniform Series of Payments
   Example 3.10 Continuous Compounding 46
   Example 3.11 Time Taken to Achieve Investment Goal 48
   Example 3.12 Biodiesel Production from Waste Cooking Oil 49
   Example 3.13 Credit Card Debt of all US Households 50
   Example 3.14 Time Taken to Pay off Credit Card Debt 50
   Example 3.15 Deferred Annuity 50
   Example 3.16 Retirement Savings 50
   Example 3.17 Biodiesel Production from Waste Cooking Oil 49
   Example 3.18 Credit Card Debt of all US Households 50
   Example 3.19 Time Taken to Pay off Credit Card Debt 50
   Example 3.20 Deferred Annuity 50
   Example 3.21 Retirement Savings 50
   Example 3.22 Continuous Compounding 46
   Example 3.23 Time Taken to Achieve Investment Goal 48
   Example 3.24 Biodiesel Production from Waste Cooking Oil 49
   Example 3.25 Credit Card Debt of all US Households 50
   Example 3.26 Time Taken to Pay off Credit Card Debt 50
   Example 3.27 Deferred Annuity 50
   Example 3.28 Retirement Savings 50

3.3 Uniform Gradient Series of Payments
   Example 3.13 Biodiesel Production from Waste Cooking Oil 49
   Example 3.14 Credit Card Debt of all US Households 50
   Example 3.15 Deferred Annuity 50

3.4 Continuous Compounding
   Example 3.10 Continuous Compounding 47
   Example 3.11 Time Taken to Achieve Investment Goal 48
   Example 3.12 Biodiesel Production from Waste Cooking Oil 49
   Example 3.13 Credit Card Debt of all US Households 50
   Example 3.14 Time Taken to Pay off Credit Card Debt 50
   Example 3.15 Deferred Annuity 50

3.5 Summary
   Example 3.10 Continuous Compounding 47
   Example 3.11 Time Taken to Achieve Investment Goal 48
   Example 3.12 Biodiesel Production from Waste Cooking Oil 49
   Example 3.13 Credit Card Debt of all US Households 50
   Example 3.14 Time Taken to Pay off Credit Card Debt 50
   Example 3.15 Deferred Annuity 50

3.6 References

3.7 Exercises

CHAPTER 4.0

Five Methods for Evaluation of Capital Project

4.1 Overview
   Example 4.1 Hydrogen from Fast Pyrolysis and Steam Reforming 58
   Example 4.2 Replacement for WTC, World Trade Center 59
   Example 4.3 Capitalized Worth of Stone’s Replacement for WTC 60
   Example 4.4 University Apartments 60

4.2 Present Worth Analysis, PW
   Example 4.1 Hydrogen from Fast Pyrolysis and Steam Reforming 58

4.3 Future Worth Analysis, FW
   Example 4.4 University Apartments 60

4.4 Annual Worth Analysis, AW
   Example 4.12 Annual Worth, AW of a Bio-Diesel Plant in Taiwan 68

4.5 IRR, Internal Rate of Return
   Example 4.15 Profitability of Liquefaction Plants 71
   Example 4.16 Ethanol Production by Fermentation 73

4.6 ERR, External Rate of Return
   Example 4.17 Copper-Chlorine Thermochemical Cycles for Hydrogen Production 75

4.7 Summary

4.8 Exercises

CHAPTER 5.0

Comparison of Alternates and Decision Analysis

5.1 Overview Example

5.2 Cost Savings by using Microfiltration Pre-Treatment during SWRO, Sea Water Reverse Osmosis

5.3 Study Period – Don’t Compare an Apple and an Orange

5.4 Optimization

5.5 Household Finances

5.6 Summary

5.7 References

5.8 Exercises
CHAPTER 6.0  Depreciation and Replacement Analysis

6.1  Overview
6.2  MACRS, Modified Accelerated Cost Recovery System
Example 6.1 Depreciation Charge of Off shore drilling Asset
6.3  Methods of Depreciation
6.3.1  Method of Straight Line
Example 6.2 Method of Straight Line for Depreciation of HRA, Helical Ribbon Agitator
6.3.2  Method of Declining Balance
Example 6.3 Method of Declining Balance Line for Depreciation of HRA, Helical Ribbon Agitator
6.3.3  Method of Units of Production Example
6.4  Hexane Extraction of Rice-Bean Oil (Kindly see Example 4.11)
6.4.1  Replacement Analysis
Example 6.5 Photocopier Before-Tax
Example 6.6 Best Year for Abandonment
6.5  Summary
6.6  References
6.7  Exercises

CHAPTER 7.0  Taxes, Tariffs and Duties

7.1  Overview
7.2  Tax Reform
7.3  Types of Taxes
7.4  Tax Consequences of Evaluation of a Single Project
Example 7.1 Present Worth of a Sugar Mill after Tax Consequences
Example 7.2 PW of ABS Plant Taking into Account Inflation and Tax Consequences
Example 7.3 Profitability of Liquefaction Plants
7.5  Summary
7.6  References
7.7  Exercises

CHAPTER 8.0  Public Sector Initiatives and Benefit-to-Cost Ratio

8.1  Introduction
8.1.1  Marshall Plan
8.1.2  Taj Mahal
8.1.3  Great Wall of China
8.1.4  Pyramid of Giza
8.1.5  Eiffel Tower
8.1.6  Suez Canal
8.1.7  Hoover Dam
8.1.8  Apollo Program
8.1.9  NASA Mars Science Laboratory Mission
8.1.10  Interstate Highways
8.2  B-C-D Method
Example 8.1 Firefighting in Yellowstone National Park in 1988
Example 8.2 Replacement for WTC, World Trade Center
8.3  Summary
8.4  References
8.5  Exercises

CHAPTER 9.0  Break-Even Analysis and Spider Plots

9.1  Overview
Example 9.1 Break-Even Analysis for PEV, Chevy Volt
Example 9.2 Spider Plot for Life-Cycle Cost of Chevy Volt
9.2  Exercises

APPENDICES

A. Discrete Compounding – Interest and Annuity Tables, Table A-1 to Table A-23
B. Continuous Compounding – Interest and Annuity Tables Table B-1 to B-25
CHAPTER 6.0 Depreciation and Replacement Analysis
6.1 Overview 131
6.2 MACRS, Modified Accelerated Cost Recovery System 132
Example 6.1 Depreciation Charge of Off shore drilling Asset 134
6.3 Method of Depreciation 134
6.3.1 Method of Straight Line 134
Example 6.2 Method of Straight Line for Depreciation of HRA, Helical Ribbon Agitator 136
6.3.2 Method of Declining Balance 136
Example 6.3 Method of Declining Balance Line for Depreciation of HRA, Helical Ribbon Agitator 138
6.3.3 Method of Units of Production Example 139
6.4 Hexane Extraction of Rice-Bean Oil (Kindly see Example 4.11) 141
6.4 Replacement Analysis 141
Example 6.5 Photocopier Before-Tax 142
Example 6.6 Best Year for Abandonment 144
6.5 Summary 145
6.6 References 146
6.7 Exercises 146

CHAPTER 7.0 Taxes, Tariffs and Duties
7.1 Overview 153
7.2 Tax Reform 154
7.3 Types of Taxes 155
7.4 Tax Consequences of Evaluation of a Single Project 155
Example 7.7 Present Worth of a Sugar Mill after Tax Consequences 157
Example 7.8 PW of ABS Plant Taking into Account Inflation and Tax Consequences 158
Example 7.9 Profitability of Liquefaction Plants 161
7.5 Summary 162
7.6 References 163
7.7 Exercises 163

CHAPTER 8.0 Public Sector Initiatives and Benefit-to-Cost Ratio
8.1 Introduction 167
8.1.1 Marshall Plan 168
8.1.2 Taj Mahal 168
8.1.3 Great Wall of China 168
8.1.4 Pyramid of Giza 168
8.1.5 Eiffel Tower 168
8.1.6 Suez Canal 168
8.1.7 Hoover Dam 168
8.1.8 Apollo Program 169
8.1.9 NASA Mars Science Laboratory Mission 169
8.1.10 Interstate Highways 169
8.2 B-C-D Method 170
Example 8.1 Firefighting in Yellowstone National Park in 1988 172
Example 8.2 Replacement for WTC, World Trade Center 172
8.3 Summary 173
8.4 References 173
8.5 Exercises 173

CHAPTER 9.0 Break-Even Analysis and Spider Plots
9.1 Overview 179
Example 9.1 Break-Even Analysis for PEV, Chevy Volt 180
Example 9.2 Spider Plot for Life-Cycle Cost of Chevy Volt 180
9.2 Exercises 182

APPENDICES
A. Discrete Compounding – Interest and Annuity Tables, Table A-1 to Table A-23 191
B. Continuous Compounding – Interest and Annuity Tables Table B-1 to B-25 215
This book is dedicated to my eldest son R. Hari Subrahmanyan Sharma (alias Ramkishan) who turned nine on Aug-13-2010.
Kal Renganathan Sharma serves as Adjunct Professor of Chemical Engineering at the Roy G. Perry College of Engineering at Prairie View A & M University, Prairie View, TX. He instructs CHEG 2003 Economic Analysis and Technical Applications. He received his B.Tech. from Indian Institute of Technology, Chennai, India, in 1985, MS and Ph.D degrees in 1987 and 1990 from West Virginia University, Morgantown, WV, all three degrees in chemical engineering. He received the once in a school time prize from nursery to higher secondary school for the Best All Round Student of the Penultimate year from the Rev. Brothers of St. Gabriel at RSK Higher Secondary School, Trichy, India. He has held a number of high level academic positions in India and USA.

Dr. Sharma, KR, is the author of 10 books, 4 Book-Chapters, 19 journal articles, 503 conference papers and 108 other presentations. He has instructed over 2500 students in 83 semesterwise courses in India and USA over the past 15 years.

The economy has changed rapidly. Both the nation’s economy and the world economy has undergone changes since the World War II. The end of cold war has given impetus to rise of globalization. China and India are now invited to attend G20 meetings. Engineering education imparts a variety of skills to the student. Skills from economics can be synergistically applied. The engineering economy is a field of endeavor that explains different methods to evaluate alternates available to the business owner. Engineering Economy is the study of the feasibility and evaluation of the cost of possible solutions to engineering problems. When benefits outweigh costs the alternate becomes a acceptable one. The lowest cost among alternates can be selected by using different methods discussed in detail in the textbook. This is calculated at a certain interest rate over a certain prescribed period of time.

The inverse problem of determining the interest rate, i, given the F, A and N is explained in detail in this work. The binomial series expansion of \((1+i)^N\) is used to obtain mathematical expressions. N can be estimated given the future amount, F, uniform series of payments, A and interest rate i by obtaining the logarithms where necessary.

The fundamental principles, concepts and methods of engineering economy are provided. Current trends and issues are reflected in the worked examples and end of chapter exercises. Alternates are drawn from case studies. These include the Keystone pipeline project, CW of World Trade Center, six different methods to prepare bioethanol, biodiesel plant in Taiwan, micro power plant, combined cycle power plant, meglumine antimonoxate drug from supercritical extraction, on-shore oil well, solar hats, stirling dish solar power plant, photovoltaic panel solar power plant, liquefaction plants, copper chlorine thermochemical cycle for hydrogen, energy efficient windows, continuous mass polymerization process to manufacture ABS, renovation of Macy’s department store, heap leaching and agitation leaching of gold, rechargeable batteries for electric car, PEVs and HEV, hybrid electric vehicles, four different cooling tower designs, oil refinery, economics of life insurance, social security, printing press vs. e-book, anti-allergic cream, sequestration by dimethyl carbonate formation, microfiltration, SWRO, sea water reverse osmosis plant, catalytic process to manufacture CNTs, carbon nanotubes, hexane extraction of rice bran oil, municipal garbage collection truck, activated carbon from bamboo, polypropylene gas manufacture, custom foam fabricator, car rental, coffee house, frozen yoghurt parlor, short path distillation, olive oil business, bonds from private sector, Chevy volt, public internet, gas sales and convenience store, condominiums at Galveston beach, outpatient drug treatment center, overseas travel ticket, snack factory, break-even points in flower shop, soda beverage, cars, quadratic price-demand relations for tomatoes, peaches, inelastic supply of common salt, dualistic relations of price and demand, Le-Chatellier-Samuelson principle are discussed in detail. G20 nations and GDP estimates by PPP, purchasing power parity and the changing world
order in economies is touched upon. Life-cycle costs of aviation lighting, LED, photocopier, HVAC systems are discussed. Depreciation, taxes, replacement analysis are discussed.

Unique Features

Optimization concepts are discussed in detail. Brainstorming can be used to develop alternates for a given problem.

- The five methods of analysis, PW, FW, AW, IRR and ERR can be used to evaluate the alternates. Evaluation of alternates can be used to invest in the more profitable process, selection of the lower cost alternate, quantitate the savings accrued from implementation of a process improvement and assessment of environmental impact of chemical processes. Alternates can be mutually exclusive, independent projects and screening by other criteria.
- When the PWs of both alternates are within 20% of each other the projects can be adjudged as too close to call within the sensitivity of the estimates of the capital and operating expenses and expected revenues.
- Rudiments of household finance are discussed.
- The capitalization worth factors and sinking fund factors are calculated and presented as annuity tables as well as in graphical form.
- In addition to P/A, F/A, A/F, A/P, F/P, P/F closed form analytical expressions to calculate the interest rate, i and pay period, N has been developed.
- Benefit/Cost Ratio of public sector projects are discussed.

Main Topics Discussed in this Chapter

- Definitions of Engineering, Economy
- Alternates and Rules of Brainstorming
- Economic Merits of Alternates
- Deviation Analysis, Decision Analysis
- Action Plan
- Principles of Engineering Economy
- Steps of Problem Solving


Technological advances in machines, materials, computers, structures, and electronics have changed the job description of the engineer rapidly. Economic merits of the different alternatives available to the solution of a given problem can be evaluated in a systematic manner. The dollars-and-cents side of decision making is discussed in detail in this book. According to an estimate in 2005, there are about 240 million vehicles on the road in the United States. The economy fueled by the automotive sector is large.

Engineering is defined by ABET (Accreditation for Engineering and Technology) as the profession in which the knowledge gained in physics, chemistry, life sciences, and mathematics is applied to make products in large scale that increase the prosperity of man. This must be achieved with a judicious choice of materials, at the lowest cost in a manner that is benign to the environment, and that keeps all the stakeholders safe. Examples of engineering achievements can be seen in the top engineering inventions of the 20th century. According to the National Academy of Engineering, the top 20 engineering achievements of the 20th century are listed in Table 1.0 (1).

Economy consists of the sum total of all income from goods produced and services offered in a state or nation. It deals with the interactions between people and wealth. The size of the United States' economy can be measured using parameters such as GDP (Gross Domestic Product) GNP (Gross National Product) is different from GDP with respect to inclusion of income earned abroad. GDP sticks to within the domicile of the nation. The sizes of the economies of 20 nations that meet regularly as G20 are listed in Table 2.0. The 19 nations, other than the European Union, are listed according to the sizes of their economies. The numbers in Table 2.0 were developed by the prices laid down by the IMF, the International Monetary Fund, for the year 2008.
Chapter 1.0
Overview of Engineering Economy

Main Topics Discussed in this Chapter

- Definitions of Engineering, Economy
- Alternates and Rules of Brainstorming
- Economic Merits of Alternates
- Deviation Analysis, Decision Analysis
- Action Plan
- Principles of Engineering Economy
- Steps of Problem Solving


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Table 2.0 GDP of G20 Nations (Purchasing Power Parity or PPP) and India are more than 1 billion each. When the economic activities by the sugarcane industry. The cement and paper industries are large in India. The population of both China is the largest economy. India recently added 100 million cellular phones. It has the second largest sugar production yuan (Chinese). Based on PPP, China is the world’s second largest economy and India is the world’s fourth equivalent to 1.8 yuan (Chinese) using PPP method. The nominal exchange rate is 1 US$ exchanged at 7.6 method provides for cost-of-living differences between different regions in the world. In 2003, 1 US$ was haircuts can be purchased in Thanjavur, India, for 1 US dollar than in San Francisco, California. The PPP two countries based on long-term considerations of relative price levels between the two countries. Identical School of Salamanca in the 16th century. The concept stems from the development of exchange rates between the PPP method used to calculate the size of the G20 portion of the world economy.

The combined GDP of 19 nations listed in Table 2.0 is about 51 trillion US dollars. This is a significant part of the world economy.

Currency exchange rates used to be based upon the wealth of nations as measured by the amount of gold each nation possessed. The wealth of a nation is not the same as the nation’s economy. The calculation of the size of economy varies among one method to another. The PPP method used to calculate the size of the G20 economies listed in Table 2.0 is called the Purchasing Power Parity method. This idea can be traced back to the School of Salamanca in the 16th century. The concept stems from the development of exchange rates between two countries based on long-term considerations of relative price levels between the two countries. Identical goods are expected to have the same price and cannot vary with markets. According to Wikipedia (2), more haircuts can be purchased in Thanjavur, India, for 1 US dollar than in San Francisco, California. The PPP method provides for cost-of-living differences between different regions in the world. In 2003, 1 US$ was equivalent to 1.8 yuan (Chinese) using PPP method. The nominal exchange rate is 1 US$ exchanged at 7.6 yuan (Chinese). Based on PPP, China is the world’s second largest economy and India is the world’s fourth largest economy. India recently added 100 million cellular phones. It has the second largest sugar production by the sugarcane industry. The cement and paper industries are large in India. The population of both China and India is more than 1 billion each. When the economic activities of all people are taken into account, the sizes of their economies go through a sudden jump in value! According to Mahatma Gandhi, India consisted of certain interest rate over a certain prescribed period of time. Here are some alternates that can be resolved into one selected for implementation by using one of the methods explained in later chapters:

(i) The inclusion of ER fluids (electro rheological fluids) as automatic transmission fluids by Chrysler Corp. is going to increase the mpg of the new line called Dodge Cognizance by 15%. It extends the life of the transmission by 20,000 miles. How much can the company afford to spend in order to implement this invention?

(ii) You are hired by a leading credit card company, Ford Chase Bank. One of their directors, Julie Hollas, wants you to perform a small calculation for her. A customer wants to charge a Japanese robot to his credit card. The price of the robot, including sales tax, is $8550.50. How many years will it take to pay off the credit card balance if the monthly payment is $16.70 and the annualized credit card interest rate is 23%?

(iii) Gasoline prices have skyrocketed in the nation. The national average price per gallon of gasoline has risen to $4. The president is considering increasing off-shore drilling to get more oil. Each oil rig would cost $10 million. It would require 70,000 oil rigs to deliver 0.5 billion gallons of gas for automobiles every week. The utility costs run to $120,000 per year. The situation is expected to continue for the next four years. Calculate the IRR for this investment. The MARR can be taken as 8%.

(iv) Calculate the monthly payment on a 2007 Toyota Corolla costing $12,999. Another $1000 was needed to obtain the title, license plate, and taxes. After cash down of $1500, the number of pay periods was 72 months. The interest rate per annum is 7%. A $2500 one-time charge for power train warranty up to 100,000 miles was levied up front.

(v) Alice Jones operates a flower shop in downtown Houston. It costs her $5 per day to pay the rent, $1 per day for the water used to preserve the freshness of the flowers, and $2.5 per day for air conditioning the flowers per day. The cost to pluck and bring the flowers from the garden in rural Texas to Houston city runs her a quarter per flower. The price-demand relation for the flowers takes the form of:

\[ p = 0.65 - 0.0081D \]

Calculate the break-even points. Construct the total revenue and total cost as a function of demand, D, in the attached graph paper. What is the demand at minimum profit to Alice?

(vi) K. R. Sridhar, CEO of Bloom Box, was featured on CBS’s 60 Minutes. Bloom Box makes micro power plants using SOFC, solid oxide fuel cell technology. A bloom box can be purchased for $3000. It consists of miniaturized fuel cells made of silica. The cost of electricity to power up a new home would be $8.0 cents per kWh. Should the existing utility company charge 12.5 cents per kWh, calculate the number of years it would take for a bloom box to be a good investment for new homeowner Jack Tripper. Jack Tripper is the head of a family of 6 members with 4 children. Use the present worth method to evaluate the single project of micro power plants for individual homes. Assume that 600 kWh of electricity is consumed every month at the Tripper residence. (i=10%).

(vii) You are hired by Cowboy Investments upon graduation. They are developing a new investment plan for customers named “U-Pay-Now & I-Pay-Later.” The deal is that the client pays $500 every month to Cowboy Investments. After a said period in a number of years, Cowboy Investments will have the client cease payments and begin to receive $500 every month forever. At 10% annualized interest rate (the historic performance of Dow Jones), how many years would you recommend be the said period?

(viii) Furniture-to-Stay offers you the following deal: A sofa, loveseat, and chair are available for $1250. A mattress is built in with the sofa, which can be pulled out when you have guests over. This is at an additional cost of $200. The delivery charge is $100 and a 3-year warranty for stain resistance is available for $200. For the first 3 years there is no interest rate charged (i.e., “No Interest Til 2012”).
Table 2.0 GDP of G20 Nations (Purchasing Power Parity or PPP)

<table>
<thead>
<tr>
<th>Nation</th>
<th>GDP (in Billions of US$)</th>
<th>GDP (in Billions of US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>14,256</td>
<td>Mexico</td>
</tr>
<tr>
<td>China</td>
<td>7,903</td>
<td>South Korea</td>
</tr>
<tr>
<td>Japan</td>
<td>4,159</td>
<td>Canada</td>
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<td>India</td>
<td>3,920</td>
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<td>United Kingdom</td>
<td>2,139</td>
<td>Australia</td>
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<tr>
<td>Italy</td>
<td>2,118</td>
<td>Argentina</td>
</tr>
<tr>
<td>Russia</td>
<td>2,100</td>
<td>South Africa</td>
</tr>
<tr>
<td>France</td>
<td>2,018</td>
<td>Saudi Arabia</td>
</tr>
<tr>
<td>Brazil</td>
<td>2,013</td>
<td>European Union</td>
</tr>
</tbody>
</table>

The combined GDP of 19 nations listed in Table 2.0 is about 51 trillion US dollars. This is a significant portion of the world economy.

Currency exchange rates used to be based upon the wealth of nations as measured by the amount of gold each nation possessed. The wealth of a nation is not the same as the nation’s economy. The calculation of the size of economy varies among one method to another. The PPP method used to calculate the size of the G20 economies listed in Table 2.0 is called the Purchasing Power Parity method. This idea can be traced back to the School of Salamanca in the 16th century. The concept stems from the development of exchange rates between two countries based on long-term considerations of relative price levels between the two countries. Identical goods are expected to have the same price and cannot vary with markets. According to Wikipedia (2), more identical goods are expected to have the same price and cannot vary with markets. According to Wikipedia (2), more identical goods are expected to have the same price and cannot vary with markets.

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Certain interest rate over a certain prescribed period of time. Here are some alternates that can be resolved into one selected for implementation by using one of the methods explained in later chapters:

(i) The inclusion of ER fluids (electro rheological fluids) as automatic transmission fluids by Chrysler Corp. is going to increase the mpg of the new line called Dodge Cognizance by 15%. It extends the life of the transmission by 20,000 miles. How much can the company afford to spend in order to implement this invention?

(ii) You are hired by a leading credit card company, Ford Chase Bank. One of their directors, Julie Hollas, wants you to perform a small calculation for her. A customer wants to charge a Japanese robot to his credit card. The price of the robot, including sales tax, is $8550. How many years will it take to pay off the credit card balance if the monthly payment is $167.60 and the annualized credit card interest rate is 23%?

(iii) Gasoline prices have skyrocketed in the nation. The national average price per gallon of gasoline has risen to $4. The president is considering increasing off-shore drilling to get more oil. Each oil rig would cost $10 billion. It would require 70,000 oil rigs to deliver 0.5 billion gallons of gas for automobiles every week. The utility costs run to $120,000 per year. The situation is expected to continue for the next four years. Calculate the IRR for this investment. The MARR can be taken as 8%.

(iv) Calculate the monthly payment on a 2007 Toyota Corolla costing $12,999. Another $1000 was needed to obtain the title, license plate, and taxes. After cash down of $1500, the number of pay periods was 72 months. The interest rate per annum is 7%. A $2500 one-time charge for power train warranty up to 100,000 miles was levied up front.

(v) Alice Jones operates a flower shop in downtown Houston. It costs her $5 per day to pay the rent, $1 per day for the water used to preserve the freshness of the flowers, and $2.25 per day for air conditioning the flowers per day. The cost to pluck and bring the flowers from the garden in rural Texas to Houston city runs her a quarter per flower. The price-demand relation for the flowers takes the form of:

\[ p = 0.65 - 0.001D \]

Calculate the break-even points. Construct the total revenue and total cost as a function of demand, D, in the attached graph paper. What is the demand at maximum profit to Alice?

(vi) K. R. Sridhar, CEO of Bloom Box, was featured on CBS's 60 Minutes. Bloom Box makes micro power plants using SOFC, solid oxide fuel cell technology. A bloom box can be purchased for $3000. It consists of miniaturized fuel cells made of silica. The cost of electricity to power up a new home would be 8.0 cents per kWh. Should the existing utility company charge 12.5 cents per kWh, calculate the number of years it would take for a bloom box to be a good investment for new homeowner Jack Tripper. Jack Tripper is the head of a family of 6 members with 4 children. Use the present worth method to evaluate the single project of micro power plants for individual homes. Assume that 600 kWh of electricity is consumed every month at the Tripper residence. (i=10%).

(vii) You are hired by Cowboy Investments upon graduation. They are developing a new investment plan for customers named “I-Pay-Now & I-Pay-Later.” The deal is that the client pays $500 every month to Cowboy Investments. After a said period in a number of years, Cowboy Investments will have the client cease payments and begin to receive $500 every month forever. At 10% annualized interest rate (the historic performance of Dow Jones), how many years would you recommend be the said period?

(viii) Furniture-to-Stay offers you the following deal: A sofa, loveseat, and chair are available for $1250. A mattress is built in with the sofa, which can be pulled out when you have guests over. This is at an additional cost of $200. The delivery charge is $100 and a 3-year warranty for stain resistance is available for $200. For the first 3 years there is no interest rate charged (i.e., “No Interest Til 2012”).
For the following three years, an annualized interest rate of 12% is charged. Calculate the monthly payment over 6 years.

(ii) Sam Malone is considering whether to invest in solar panels. This homeowner has gathered the following information for his town:

(a) Average cost of residential energy is 12 cents per kWh
(b) Government subsidy runs to 60% of investment by homeowner
(c) Each square foot of panel produces 18 kWh every year and the cost of installation per square foot of panel is $99.

Sam has 385 sq. ft. of roof space. What is the break-even point in years for the installation of solar panels? Assume an interest rate of 5% per year.

(x) Should overnight delivery courier mail be conducted using airplanes flown by pilots or personal rapid transit systems without onboard operators?

(xi) Should assembly lines for putting together desktop computers be filled with workers or by automated robots?

(xii) Should college computer labs be serviced using a hotline or by a manned computer help desk?

**Example 1.0 Start of Technocrats of Texas**

A team of alumni and faculty from a leading university in Texas conceived a business plan to develop a consulting service enterprise.

Later, she was cleared of any wrongdoing. The Civil Rights Act of 1964, signed into law by President Lyndon B. Johnson, must be followed in all activities of the enterprise.

The decision has to come from the alternates developed. The alternates can be developed using a brainstromming session. The more creative and resourceful the team members are, the better the selection of alternates available for a go/no-go decision would be. The problem can be reformulated and restated to ease the flow of alternates. An open mind is recommended during the development of alternates. The method may not be used to justify a certain course of action. Four rules of brainstorming were dictated by Osborn (4). These are as follows:

(a) Negative feedback can become overly critical and stifle creative juices and alternates from flowing.
(b) Poet-like free flow of ideas is welcome.
(c) Quantity breeds quality.
(d) Improvement can be aimed. Combinations can work out.

The basic steps of brainstorming include:

(a) Preliminary Discussion: Problem is stated and participants get warmed up. This acts as a prelude to the main session.
(b) Brainstorming Main Session: An unrelated problem is first brainstormed. Then the assigned problem is brainstormed. Ideas are allowed to flow and are recorded objectively.
(c) The ideas are evaluated for possible flowering into alternates.

In Principle 2, deviation analysis is used and the focus is on the differences. The future outcomes from the alternates are set as higher priority. Based on differences among alternates, a future course of action is selected.

Goal setting is extremely important as emphasized in Principle 3. A common unit of measure (such as dollars and cents) totals costs or total profits that can be generated from the alternate considered is captured in Principle 4. All relevant criteria as mentioned in Principle 5 are important. For instance, retail giant Wal-Mart posts low prices for its customers. However, the company had to pay several million dollars as compensation for discrimination based on the skin color of an African American woman. She was apprehended for forging her money order.

Alternate A: To sign up with companies such as Reliant Energy under one of their plans.

Alternate B: To install solar panels and generate all the electricity needs of the enterprise.

Alternate C: To buy enough fuel cells and install a micro power plant to meet all the electricity needs of the enterprise.

**1.2 Seven Principles of Engineering Economy**

The foundation of the discipline of Engineering Economy can be seen in terms of seven principles (3). These seven principles are:

1.0 Make a List of Alternates: Plan A, Plan B, etc.
2.0 What Is Different among the Alternates?
3.0 Be Clear on What You Want.
4.0 Develop Common Performance Measures.
5.0 Meet All Relevant Criteria.
6.0 Weigh the Risk Against the Projected Rewards.
7.0 Check the Results of Action Plan and Revise Plan If/When Necessary.

The decision has to come from the alternates developed. The alternates can be developed using a brainstromming session. The more creative and resourceful the team members are, the better the selection of alternates available.
For the following three years, an annualized interest rate of 12% is charged. Calculate the monthly payment over 6 years.

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(a) Average cost of residential energy is 12 cents per kWh
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Sam has 385 sq. ft. of roof space. What is the break-even point in years for the installation of solar panels? Assume an interest rate of 5% per year.

Example 1.0 Start of Technocrats of Texas

A team of alumni and faculty from a leading university in Texas conceived a business plan to develop a consulting service for people in need of help with technical or engineering projects. They decided to focus on the development of low-cost, high-quality service for small businesses. The team identified a need for engineering services in the local community and believed they could fill this gap.

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1.4 References


1.5 Exercises

1.0 What are the differences between GDP and GNP?
2.0 What is the connection between a nation’s GDP and its wealth?
3.0 Based on PPP (Purchasing Power Parity), China and India moved up in the rankings based on the size of a nation’s GDP, while Australia moved down. Why is this?
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10.0 Why should a consistent viewpoint be maintained when comparing alternates?

Problems

11.0 Rahul Gandhi has purchased a new home in Fairfield, Texas. The price of the 1776 sq. ft. home is $131,000. Develop the alternates for Mr. Gandhi to buy homeowner’s insurance for hazards such as floods, fire, hurricane, windstorm, etc. (Hint: consider deductibles).

12.0 After starring in a summer blockbuster film, actress Julia Roberts explores purchasing a mansion near Houston. She is willing to sign a mortgage amount up to $1.5 million. Action Mortgage gives out 15-year loans over $417,000 at 5.625% fixed rate. Develop the alternates for Julia to apply for the mortgage. Consideration may be given to an ARM (adjustable rate mortgage), fixed-rate 30-year mortgage, fixed-rate 15-year mortgage, or FHA (federal housing loan). Some of the lenders and rates offered are shown in Table 3.0 (5).

<table>
<thead>
<tr>
<th>#</th>
<th>Lender</th>
<th>15-yr loans over $417,000</th>
<th>30-yr loans over $417,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Action Mortgage</td>
<td>5.125%</td>
<td>5.625%</td>
</tr>
<tr>
<td>2</td>
<td>Allegiance Financial Services</td>
<td>5.375%</td>
<td>6.125%</td>
</tr>
<tr>
<td>3</td>
<td>Home Loan Specialists</td>
<td>5.0%</td>
<td>5.75%</td>
</tr>
<tr>
<td>4</td>
<td>Mortgage Associates</td>
<td>6.25%</td>
<td>6.75%</td>
</tr>
<tr>
<td>5</td>
<td>Residential Finance</td>
<td>6.75%</td>
<td>7.0%</td>
</tr>
<tr>
<td>6</td>
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<td>7.0%</td>
<td>7.375%</td>
</tr>
</tbody>
</table>

13.0 About five years ago the rides at AstroWorld were dismantled and the 104 acres housing the amusement park were left barren. Fort Worth Investment Partnership has purchased the property recently. The undisclosed purchase price can be estimated at $100 million. The old AstroWorld property sits across Loop 610 from Reliant Park and near a light-rail stop. Develop alternates for use of this land. Choose from real estate development, hotel development, amusement park, horse racing track, etc.

14.0 Develop alternates for the following scenario: Enterprise Products Partners and Duncan Energy partners have announced that Acadian Gas has entered into an additional long-term contract with a shipper to transport natural gas on Acadian’s Haynesville Extension pipeline, now under construction. It increases total capacity commitments by 200 million cu. ft. per day. Work on the 270-mile Haynesville Extension is expected to be finished in the 3rd quarter of 2011.

15.0 You have been awarded a contract to provide design and early engineering services for development of the Araromi Refinery project in Nigeria. You shall provide services for a 160,000 barrel-per-day Greenfield refinery and marine facility that will produce motor gasoline, automotive gas oil, and kerosene and jet fuel. What are the alternates in order to deliver the same amount of fuel in terms of calorific value?

16.0 Richard Stock arrived in the United States from Great Britain in order to pursue graduate studies in chemical engineering. He wanted to apply for a credit card. Select two or three from the following that would be suitable alternates for Richard. Discuss which of the seven principles of engineering economy can be used in the selection.

(1) A credit card is offered by the local credit union. The interest rate is at the prime lending rate. The credit line is low at $1000.
(2) Chase Bank offers a credit line of $12,000, but the interest rate is 24%.
(3) Macy’s department store offers a credit line of $10,000 at an interest rate of 20%, but you have to shop at Macy’s stores. It is not valid in other locations.
(4) Chevron Oil Co. offers a credit card that offers a credit line of $2800 at an interest rate of 10%.
(5) The local bank offers personal loans up to $5000 with collateral of your automobile.

17.0 Mary Corleone is ready to go to college. The Eduserv provides student loans at low interest rates. Mary’s friend is willing to pay for her tuition and living expenses. Wells Fargo Bank is willing to give papa Michael Corleone a home equity loan at little over the prime rate to pay for his daughter’s
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<td>Texas Mortgage Link</td>
<td>7.0%</td>
<td>7.375%</td>
</tr>
</tbody>
</table>
college education. Develop the alternates available to Mary to obtain the financial resources needed to pay for college tuition.

18.0 Upon graduation you have been hired by Consolidation Coal Co. The coal contains 3% sulfur-containing compounds. When coal-fired steam boilers are used to raise steam, which is then used to turn turbines that are used to raise electricity, the sulfur can cause SO₂ emissions that can pollute the atmosphere. One way to keep the environment clean is to remove the sulfur from the coal fuel before usage. Another method would be to scrub the gases from the boiler plant using calcium oxide lining. CaO would react with SO₂ to form CaSO₄. The exit gases would be devoid of sulfur dioxide. Pyropower has developed a fluidized bed combustor (FBC) that mixes the coal and CaO and then the combustion process takes place. The SO₂ and other SOₓ gases are captured in situ in the FBC. Develop the alternates for clean coal technologies. Which of the seven principles was used in the analysis?

19.0 Anita Murthy wanted to visit with Ann Tataglia in Boston. Anita has to travel from Morgantown, West Virginia. She called up the Hertz car rental company, who would allow her to rent a new car for a week. Anita will pay for the gas, and there are no caps on the driving mileage. A Greyhound bus can take her from Morgantown to Pittsburgh. She can also fly Continental Airlines from Pittsburgh to Boston. From Logan Airport, Anita can hail a taxi cab to Ann’s place. Her friend’s friend can drive her in his car to Boston. Develop the alternates for Anita to travel to Ann Tataglia’s in Boston.

Victor Whiting was planning on having six guests over at his new home in Cypress, Texas.

20.0 He can purchase Pillsbury flour and a recipe book from Wal-Mart and bake his own bread in a bread maker. The Pepperidge Farm truck delivers fresh loaves Mondays and Thursdays. What are the alternates for making bread available for Mr. Whiting’s guests?

11.0 George Tataseo bought a new car that can run on different fuels. He knows a gas pump that supplies fuel at the following prices:

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Price per gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>$2.49</td>
</tr>
<tr>
<td>Diesel</td>
<td>$2.00</td>
</tr>
<tr>
<td>Ethanol-Gasoline Blend</td>
<td>$1.75</td>
</tr>
</tbody>
</table>

If George’s Dodge Colt gave him 30 mpg, how much money can be saved by using E20 instead of gasoline or diesel when driving 28,600 miles?

Chapter 2.0

Fixed and Variable Costs

Learning Objectives

- Delineate Direct and Indirect Costs
- Familiarity with Cash Cost, Book Cost, Sunk Cost, and Opportunity Cost
- Fixed, Variable, and Incremental Costs
- Life Cycle of Enterprise
- Total Cost, Total Revenue, and Profit
- Break-Even Analysis
- Second Break-Even Point—What Does This Mean?

2.1 One-Time and Recurring Costs

An eminent expert in the field of business administration defines the ABCs of the MBA program as: (i) Accounting; (ii) Finance; and (iii) Economics. Executives tending to do well with limited resources usually thank accountants for where they derived their critical information. Sound accounting practices need a good understanding of costing principles. The types of costs can be delineated based on the frequency of their occurrence. For instance, fixed costs are usually one-time occurrences. Variable costs occur more frequently, usually once every billing period. Incremental costs are those that are incurred proportionally to the number of goods produced. Instances of fixed costs, variable costs, and incremental costs can be seen in Example 2.1.

In the Garlic Bread Nibbler snack factory as discussed below in Example 2.1, the following are examples of fixed costs:

- Property Tax
- Equipment Cost of Kneader
- Equipment Cost of Mixer
- Equipment Cost of Chopper
- Equipment Cost of Roaster
- Equipment Cost of Coloring Bowl
- Insurance Fees
- Interest on Borrowed Capital
- General Management & Administration Salaries.