OPERATIONAL RESEARCH

COURSES OFFERED BY DEPARTMENT OF OPERATIONAL RESEARCH

Category I

Operational Research Courses for Undergraduate Programme of study with Operational Research as a Single Core Discipline

(B.Sc. Honours in Operational Research Course in four years)

STRUCTURE OF EIGHTH SEMESTER

DISCIPLINE SPECIFIC CORE COURSE – 20: Logistics and Supply Chain Management

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Logistics and Supply Chain Management (DSC-20)	4	3	1	0	-	Nil

Learning Objectives:

- To impart the knowledge of concepts and approaches for supply chain management.
- To tackle the issues and problems related to the management of demand and supply of goods and services.
- To develop skills which helps in understanding how the theories relate to practice.

Learning Outcomes:

Students completing this course will be able to:

- Explain the theoretical terminologies related to supply chain management.

- Differentiate between inbound and outbound logistics and explain concepts of MRP and MRP II, JIT, ERP, DRP, DRP II.
- Describe in detail the role of customer relationship management, the role of IT in supply chain, supply chain IT framework and coordination in supply chain.
- Describe and demonstrate the supplier selection process and sourcing decisions in a supply chain.
- Describe in detail the decisions related to in-house logistics management or outsourcing the logistics to third party or fourth party logistics provider.
- Describe in detail the aspects related to green supply chain management and sustainability in supply chain along with the concepts of lean manufacturing and agile supply chain.
- Demonstrate the application of supply chain analytics.

Syllabus of DSC-20:

Unit I: Introduction to Supply Chain and Supply Chain Networks (15 Hours)
Basics concepts of supply chain and value chain, Evolution of supply chain, Supply chain integration, Important elements of supply chain, Inbound and outbound logistics, Supply chain processes, Introduction to supply chain network, Factors influencing supply chain network, Designing the supply chain network, Framework for structuring a supply chain, Transportation network design.

Unit II: Planning and Control in Supply Chain Operations (15 Hours)
Planning and inventory management, MRP, MRP-II, JIT, ERP, DRP, DRP-II, Facility location, Customer relationship management, Role of IT in supply chain, Supply chain IT framework, Supply chain coordination, Bullwhip effect.

Unit III: Procurement and Strategic Sourcing in Supply Chain Management (15 Hours)
Procurement management, Selection and management of suppliers, Supplier relationship management, Sourcing decisions in a supply chain, Role of sourcing in SC, Third- and Fourth-Party Logistics.

Unit IV: Sustainable, Lean, Agile, and Data-Driven Supply Chain Management (15 Hours)
Global supply chain, Reverse supply chain, Closed loop supply chain, Green supply chain, Sustainability in supply chain, Lean Manufacturing and Agile supply chain, Supply chain analytics: descriptive, predictive and prescriptive analytics.

Practical component (if any) - Nil

Essential Readings:

1. Chopra S., & Meindl, P. (2014). Supply chain management: strategy, planning, and operation (6th ed.). Pearson Education India: India.
2. Gupta, S. M. (2013). Reverse supply chains: issues and analysis. USA: CRC Press.
3. Mentzer, J. T. (2004). Fundamentals of supply chain management: twelve drivers of competitive advantage. USA: Sage publications.
4. Ravindran, A. R., & Warsing Jr., D. P. (2012). Supply chain engineering: models and applications. USA: CRC Press.
5. Rushton, P., Croucher, P., & Baker P. (2014). The handbook of logistics and distribution management: understanding the supply chain. UK: Kogan Page Publishers.
6. Simchi-Levi, D. (2005). Designing and managing the supply chain. USA: McGraw-Hill.

7. Sople, V. V. (2011). Supply chain management: text and cases. India: Pearson Education India.
8. Wang, H. F., & Gupta, S. M. (2011). Green supply chain management: product life cycle approach. USA: McGraw Hill Professional.

Suggested Readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category II

Operational Research Courses for Undergraduate Programme of study with Operational Research as one of the Core Disciplines

(B.A. Programme with Operational Research as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – 14: Logistics and Supply Chain Management

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Logistics and Supply Chain Management (DSC-14)	**4**	**3**	**1**	**0**	**-**	**Nil**

Learning Objectives:

- To impart the knowledge of concepts and approaches for supply chain management.
- To tackle the issues and problems related to the management of demand and supply of goods and services.
- To develop skills which helps in understanding how the theories relate to practice.

Learning Outcomes:

Students completing this course will be able to:

- Explain the theoretical terminologies related to supply chain management.
- Differentiate between inbound and outbound logistics and explain concepts of MRP and MRP II, JIT, ERP, DRP, DRP II.
- Describe in detail the role of customer relationship management, the role of IT in supply chain, supply chain IT framework and coordination in supply chain.

- Describe and demonstrate the supplier selection process and sourcing decisions in a supply chain.
- Describe in detail the decisions related to in-house logistics management or outsourcing the logistics to third party or fourth party logistics provider.
- Describe in detail the aspects related to green supply chain management and sustainability in supply chain along with the concepts of lean manufacturing and agile supply chain.
- Demonstrate the application of supply chain analytics.

Syllabus of DSC-14:

Unit I: Introduction to Supply Chain and Supply Chain Networks (15 Hours)
Basics concepts of supply chain and value chain, Evolution of supply chain, Supply chain integration, Important elements of supply chain, Inbound and outbound logistics, Supply chain processes, Introduction to supply chain network, Factors influencing supply chain network, Designing the supply chain network, Framework for structuring a supply chain, Transportation network design.

Unit II: Planning and Control in Supply Chain Operations (15 Hours)
Planning and inventory management, MRP, MRP-II, JIT, ERP, DRP, DRP-II, Facility location, Customer relationship management, Role of IT in supply chain, Supply chain IT framework, Supply chain coordination, Bullwhip effect.

Unit III: Procurement and Strategic Sourcing in Supply Chain Management (15 Hours)
Procurement management, Selection and management of suppliers, Supplier relationship management, Sourcing decisions in a supply chain, Role of sourcing in SC, Third- and Fourth-Party Logistics.

Unit IV: Sustainable, Lean, Agile, and Data-Driven Supply Chain Management (15 Hours)
Global supply chain, Reverse supply chain, Closed loop supply chain, Green supply chain, Sustainability in supply chain, Lean Manufacturing and Agile supply chain, Supply chain analytics: descriptive, predictive and prescriptive analytics.

Practical component (if any) - Nil

Essential Readings:

1. Chopra S., & Meindl, P. (2014). Supply chain management: strategy, planning, and operation (6th ed.). Pearson Education India: India.
2. Gupta, S. M. (2013). Reverse supply chains: issues and analysis. USA: CRC Press.
3. Mentzer, J. T. (2004). Fundamentals of supply chain management: twelve drivers of competitive advantage. USA: Sage publications.
4. Ravindran, A. R., & Warsing Jr., D. P. (2012). Supply chain engineering: models and applications. USA: CRC Press.
5. Rushton, P., Croucher, P., & Baker P. (2014). The handbook of logistics and distribution management: understanding the supply chain. UK: Kogan Page Publishers.
6. Simchi-Levi, D. (2005). Designing and managing the supply chain. USA: McGraw-Hill.
7. Sople, V. V. (2011). Supply chain management: text and cases. India: Pearson Education India.
8. Wang, H. F., & Gupta, S. M. (2011). Green supply chain management: product life cycle approach. USA: McGraw Hill Professional.

Suggested Readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category III

Operational Research Courses for Undergraduate Programme of study with Operational Research as one of the Core Disciplines

(B.A Programme with Operational Research as non-Major or Minor discipline)

DISCIPLINE SPECIFIC CORE COURSE – 8: Logistics and Supply Chain Management

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Logistics and Supply Chain Management (DSC-8)	**4**	**3**	**1**	**0**	**-**	**Nil**

Learning Objectives:

- To impart the knowledge of concepts and approaches for supply chain management.
- To tackle the issues and problems related to the management of demand and supply of goods and services.
- To develop skills which helps in understanding how the theories relate to practice.

Learning Outcomes:

Students completing this course will be able to:

- Explain the theoretical terminologies related to supply chain management.
- Differentiate between inbound and outbound logistics and explain concepts of MRP and MRP II, JIT, ERP, DRP, DRP II.
- Describe in detail the role of customer relationship management, the role of IT in supply chain, supply chain IT framework and coordination in supply chain.
- Describe and demonstrate the supplier selection process and sourcing decisions in a supply chain.
- Describe in detail the decisions related to in-house logistics management or outsourcing the logistics to third party or fourth party logistics provider.

- Describe in detail the aspects related to green supply chain management and sustainability in supply chain along with the concepts of lean manufacturing and agile supply chain.
- Demonstrate the application of supply chain analytics.

Syllabus of DSC-8:

Unit I: Introduction to Supply Chain and Supply Chain Networks (15 Hours)
Basics concepts of supply chain and value chain, Evolution of supply chain, Supply chain integration, Important elements of supply chain, Inbound and outbound logistics, Supply chain processes, Introduction to supply chain network, Factors influencing supply chain network, Designing the supply chain network, Framework for structuring a supply chain, Transportation network design.

Unit II: Planning and Control in Supply Chain Operations (15 Hours)
Planning and inventory management, MRP, MRP-II, JIT, ERP, DRP, DRP-II, Facility location, Customer relationship management, Role of IT in supply chain, Supply chain IT framework, Supply chain coordination, Bullwhip effect.

Unit III: Procurement and Strategic Sourcing in Supply Chain Management (15 Hours)
Procurement management, Selection and management of suppliers, Supplier relationship management, Sourcing decisions in a supply chain, Role of sourcing in SC, Third- and Fourth-Party Logistics.

Unit IV: Sustainable, Lean, Agile, and Data-Driven Supply Chain Management (15 Hours)
Global supply chain, Reverse supply chain, Closed loop supply chain, Green supply chain, Sustainability in supply chain, Lean Manufacturing and Agile supply chain, Supply chain analytics: descriptive, predictive and prescriptive analytics.

Practical component (if any) - Nil

Essential Readings:

1. Chopra S., & Meindl, P. (2014). Supply chain management: strategy, planning, and operation (6th ed.). Pearson Education India: India.
2. Gupta, S. M. (2013). Reverse supply chains: issues and analysis. USA: CRC Press.
3. Mentzer, J. T. (2004). Fundamentals of supply chain management: twelve drivers of competitive advantage. USA: Sage publications.
4. Ravindran, A. R., & Warsing Jr., D. P. (2012). Supply chain engineering: models and applications. USA: CRC Press.
5. Rushton, P., Croucher, P., & Baker P. (2014). The handbook of logistics and distribution management: understanding the supply chain. UK: Kogan Page Publishers.
6. Simchi-Levi, D. (2005). Designing and managing the supply chain. USA: McGraw-Hill.
7. Sople, V. V. (2011). Supply chain management: text and cases. India: Pearson Education India.
8. Wang, H. F., & Gupta, S. M. (2011). Green supply chain management: product life cycle approach. USA: McGraw Hill Professional.

Suggested Readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category IV

BSc. Physical Sciences/ Mathematical Sciences with Operational Research as one of the three Core Disciplines
CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC CORE COURSE – 8: Logistics and Supply Chain Management

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Logistics and Supply Chain Management (DSC-8)	**4**	**3**	**1**	**0**	**-**	**Nil**

Learning Objectives:

- To impart the knowledge of concepts and approaches for supply chain management.
- To tackle the issues and problems related to the management of demand and supply of goods and services.
- To develop skills which helps in understanding how the theories relate to practice.

Learning Outcomes:

Students completing this course will be able to:

- Explain the theoretical terminologies related to supply chain management.
- Differentiate between inbound and outbound logistics and explain concepts of MRP and MRP II, JIT, ERP, DRP, DRP II.
- Describe in detail the role of customer relationship management, the role of IT in supply chain, supply chain IT framework and coordination in supply chain.
- Describe and demonstrate the supplier selection process and sourcing decisions in a supply chain.
- Describe in detail the decisions related to in-house logistics management or outsourcing the logistics to third party or fourth party logistics provider.
- Describe in detail the aspects related to green supply chain management and sustainability in supply chain along with the concepts of lean manufacturing and agile supply chain.

- Demonstrate the application of supply chain analytics.

Syllabus of DSC-8

Unit I: Introduction to Supply Chain and Supply Chain Networks (15 Hours)
Basics concepts of supply chain and value chain, Evolution of supply chain, Supply chain integration, Important elements of supply chain, Inbound and outbound logistics, Supply chain processes, Introduction to supply chain network, Factors influencing supply chain network, Designing the supply chain network, Framework for structuring a supply chain, Transportation network design.

Unit II: Planning and Control in Supply Chain Operations (15 Hours)
Planning and inventory management, MRP, MRP-II, JIT, ERP, DRP, DRP-II, Facility location, Customer relationship management, Role of IT in supply chain, Supply chain IT framework, Supply chain coordination, Bullwhip effect.

Unit III: Procurement and Strategic Sourcing in Supply Chain Management (15 Hours)
Procurement management, Selection and management of suppliers, Supplier relationship management, Sourcing decisions in a supply chain, Role of sourcing in SC, Third- and Fourth-Party Logistics.

Unit IV: Sustainable, Lean, Agile, and Data-Driven Supply Chain Management (15 Hours)
Global supply chain, Reverse supply chain, Closed loop supply chain, Green supply chain, Sustainability in supply chain, Lean Manufacturing and Agile supply chain, Supply chain analytics: descriptive, predictive and prescriptive analytics.

Practical component (if any) - Nil

Essential Readings:

1. Chopra S., & Meindl, P. (2014). Supply chain management: strategy, planning, and operation (6th ed.). Pearson Education India: India.
2. Gupta, S. M. (2013). Reverse supply chains: issues and analysis. USA: CRC Press.
3. Mentzer, J. T. (2004). Fundamentals of supply chain management: twelve drivers of competitive advantage. USA: Sage publications.
4. Ravindran, A. R., & Warsing Jr., D. P. (2012). Supply chain engineering: models and applications. USA: CRC Press.
5. Rushton, P., Croucher, P., & Baker P. (2014). The handbook of logistics and distribution management: understanding the supply chain. UK: Kogan Page Publishers.
6. Simchi-Levi, D. (2005). Designing and managing the supply chain. USA: McGraw-Hill.
7. Sople, V. V. (2011). Supply chain management: text and cases. India: Pearson Education India.
8. Wang, H. F., & Gupta, S. M. (2011). Green supply chain management: product life cycle approach. USA: McGraw Hill Professional.

Suggested Readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CATEGORY-V

B.Sc. (H) Operational Research / B.A. Programme with Operational Research as Major discipline/ B.A Programme with Operational Research as non-Major or Minor discipline Minor/B.Sc. (Physical Sciences/Mathematical Sciences) with OR as one of the three core Disciplines
COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSE) offered by the parent Department, i.e., Department of Operational Research

DISCIPLINE SPECIFIC ELECTIVE (DSE-6(a): APPLIED MATHEMATICAL MODELLING)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Applied Mathematical Modelling (DSE-6(a))	**4**	**3**	**0**	**1**	**-**	**Nil**

Learning Objectives:

The Learning Objectives of this course are as follows:

- To introduce the students to the exciting world of Differential Equations, Mathematical Modelling, and their applications.
- To develop a broad understanding of mathematical theory, concepts and applications.
- To explain the utility of differential equations for understanding real-life scenarios.
- To explain the purpose, concept, and methodology behind the mathematical modelling framework.

Learning Outcomes:

Students completing this course will be able to:

- Understand concepts, issues, and applications of mathematical modelling.
- Formulate Differential Equations for various real-life scenarios via mathematical models.
- Solve first-order non-linear differential equations and linear differential equations of higher order using various techniques.
- Apply these techniques to solve and analyze various mathematical models.

- understand the nature of deterministic mathematical modelling, including model formulation, selection of appropriate mathematical formalism, solution strategies and interpretation of results.

Syllabus of DSE-6(a):

Unit I: An Introduction to Mathematical Modeling (5 hours)
Definition and Importance of Mathematical Modeling, Types of Models: Physical, Mathematical, Statistical, and Simulation Models, Steps in Mathematical Modeling Process, Limitations and Validation of Models

Unit II: Differential Equations based Mathematical Modelling (15 hours)
Overview of mathematical modelling, Types of mathematical models and methods to solve the same; Differential equations and mathematical models, Order and degree of a differential equation, Exact differential equations and integrating factors of first-order differential equations, Reducible second-order differential equations, Application of first-order differential equations to equations to acceleration-velocity model, Growth and decay model.

Unit III: Understanding Compartmental Modeling (15 hours)
Introduction to compartmental models, General solution of the homogeneous equation of second order, Principle of superposition for a homogeneous equation; Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, introduction to epidemic modelling framework

Unit IV: An Operational Research Perspective of Differential Equations (10 hours)
Application of first-order and second-order differential equations in marketing management, decision science, reliability theory, and other OR domains

Practical component (if any) – (30 Hours)

Practical/Lab to be performed on a computer using OR/Statistical packages.
1. Plotting of the second and third order respective solution families of the differential equation.
2. Growth and decay model (exponential case only).
3. Lake pollution model (with constant/seasonal flow and pollution concentration).
4. Predatory-prey model (basic Volterra model, with density dependence, effect of DDT, two prey, one predator).
5. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).

Essential Readings:

1. Barnes, Belinda & Fulford, Glenn R. (2015). Mathematical Modelling with Case Studies, Using Maple and MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.
2. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equation and Boundary Value Problems: Computing and Modelling (5th ed.). Pearson Education.
3. Ross, Shepley L. (2004). Differential Equations (3rd ed.). John Wiley & Sons. India

Suggested Readings:

1. Giordano, F. R., Fox W. P., and Horton S. B. (2014), A first course in mathematical modeling, Brooks/Cole.

2. Mesterton-Gibbons, M. (2007). A concrete approach to mathematical modeling. Addison-Wesley.
3. Strogatz, S. (1994). Nonlinear dynamics and chaos. Westview Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-6(b): BUSINESS ANALYTICS FOR MANAGEMENT DECISIONS)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Business Analytics for Management Decisions DSE-6(b)	**4**	**3**	**0**	**1**	**-**	**Nil**

Learning Objectives:

The Learning Objectives of this course are as follows:

- To raise awareness of Business Analytics among students and make them understand the application of business analytics in an organization.
- To acquaint them with necessary technical skills to support business decision-making and relevance and usefulness of business analytics solutions.

Learning Outcomes:

Students completing this course will be able to:

- Gain an understanding of basic concepts of Business Analytics and differentiate between them.
- Apply various techniques of business analytics in real-life scenarios.
- Interpret the effectiveness of business analytics solutions.
- Support business decision-making using relevant business analytics methods.

Syllabus of DSE-6(b):

Unit I: Introduction to Business Analytics: (7 Hours)

Concept and application areas, roles and responsibilities of business analysts, an overview of techniques of business analytics, usefulness of data for business analytics, understanding data, data collection, data cleaning and preparation, data visualization, data-driven decision making.

Unit II: Database and Data-warehouse (10 Hours)

Introduction to Database Management System, Advantages of DBMS over file-based system, 3-level architecture, Relational databases and SQL, Database vs. Data Warehouse, Overview of Data Mining.

Unit III: Predictive Analytics and Time Series Analysis (18 Hours)

An introduction to regression analysis, Simple Linear Regression model: meaning, hypothesis testing, confidence interval, coefficient of determination, Decision Tree: meaning, examples and application. Introduction to time series, Components of time series: Trend, Seasonal, Cyclical and Irregular. Measure of Trend, seasonality and cyclic component. Exponential Smoothing: Single Exponential Smoothing.

Unit IV: Mathematical Optimization for Business 10 Hours)

An Introduction to Linear Programming, Graphical Solution, Simplex method, Sensitivity Analysis, Introduction to Simulation, Monte Carlo Simulation technique.

Practical component (if any) - (30 Hours)

Practical/Lab to be performed on a computer using OR/Statistical/Database packages:

1. Using DDL commands of create table, alter table, drop table.
2. Utilization of DML commands of select, insert, update, delete.
3. Understanding of condition specification using Boolean and comparison operators (AND, OR =, >, < etc.).
4. Utility of arithmetic operators and aggregate functions (COUNT, SUM, AVG etc.).
5. Fitting a simple linear regression model.
6. Construction and visualization of Decision Tree.
7. Plot and visualize time series data.
8. Measurement of components of time series.
9. Solution of a Linear Programming Problem.
10. Application of Monte Carlo Simulation.

Essential Readings:

1. Camm, J. D., Cochran, J. J., Fry, M. J., Ohlmann, J. W., Anderson, D. R., Sweeney, D. J., & Williams, T. A. (2015). Essentials of business analytics. Stamford, CT, USA: Cengage Learning.
2. Elmasri, R., & Navathe, S. B. (2017). Fundamentals of Database Systems 7th Edition. Pearson Education
3. Gujarati, D. N. (2021). Essentials of econometrics. Sage Publications.
4. Makridakis, S., Wheelwright, S. C., & Hyndman, R. J. (2008). Forecasting methods and applications. John wiley & sons.
5. Hillier, F. S., & Lieberman, G. J. (2015). Introduction to operations research. McGraw-Hill.
6. Taha, H. A., & Taha, H. A. (2003). Operations research: an introduction (Vol. 7). Upper Saddle River, NJ: Prentice hall.

Suggested Readings:

1. Jank, W. (2011). Business analytics for managers. Springer Science & Business Media.
2. Sharda, R., Delen, D., & Turban, E. (2014). Business intelligence and analytics: systems for decision support. Pearson.
3. Date, C. J. (2003). Addison-Wesley, Introduction to Database Systems 8TH

Edition, Pearson Education.
4. Han, J., & Kamber, M. (2001) . Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers.
5. Pindyck, R. S., & Rubinfeld, D. L. (1976). Econometric models and economic forecasts. McGraw-Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-6(c): INTRODUCTION TO PRICING AND REVENUE OPTIMIZATION)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Pricing and Revenue Optimization (DSE-6(c))	**4**	**3**	**1**	**0**	**-**	**Nil**

Learning Objectives:

The Learning Objectives of this course are as follows:
- To make students understand the different pricing principles and the revenue management concept.
- To acquaint them with optimization models of revenue management and their application across different industries.

Learning Outcomes:

Students completing this course will be able to:

- Understand the introductory pricing and revenue optimization problem.
- Gain an understanding of the economics of price differentiation and market segmentation.
- Comprehend the revenue management system and the factors affecting the system.
- Develop and solve mathematical models for revenue optimization.
- Identify the applications of revenue management to different industries.

Syllabus of DSE-6(c):

Unit I: Introduction **(15 hours)**

History of Pricing and Revenue Optimization. Strategies of Price Optimization. Basic Price Optimization: The Price-Response Function, measures of Price sensitivity: slope and

elasticity, Price Response with Competition, The Basic Price Optimization Problem.

Unit II: Price Differentiation & Constrained Supply (15 hours)
Price Differentiation: The Economics of Price Differentiation, Limits to Price Differentiation, Tactics for Price Differentiation, Volume Discounts. Pricing with Constrained Supply: The Nature of Supply Constraints, Optimal Pricing with a Supply Constraint.

Unit III: Revenue Management (15 hours)
Conceptual framework of revenue management: levels of RM, strategy for RM, booking control. Revenue management system. Demand-management decisions. Factors affecting revenue management. Role of revenue management in various industries. Single resource capacity control: types of control, Littlewood's two-class model.

Unit IV: Capacity allocation (15 hours)
Capacity allocation for multiple resources, i.e. network management. Applicability of network RM, types of networks. Network RM via Linear Programming approach. Introduction to Overbooking models: overbooking based on service criteria; overbooking based on economic criteria (simple risk-based booking limit model).

Practical component (if any): Nil

Essential Readings:

1. Phillips, R. L. (2005). Pricing and revenue optimization. Stanford University Press.
2. Talluri, K. T., & Van Ryzin, G. J. (2006). The theory and practice of revenue management (Vol. 68). Springer Science & Business Media.
3. Cross, G. R. (1997). Revenue management: hard-core tactics for market domination. New York: Broadway Books.
4. Lilien, G. L., Kotler, P., & Moorthy, K. S. (1995). Marketing models. Prentice Hall.
5. Yeoman, I., & McMahon-Beattie, U. (Eds.). (2004). Revenue management and pricing: case studies and applications. Cengage Learning EMEA.

Suggested Readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-6(d): MULTIPLE OBJECTIVE OPTIMIZATION)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		

Multiple Objective Optimization (DSE-6(d))	**4**	**3**	**1**	**0**	**--**	**Nil**

Learning Objectives:

The Learning Objectives of this course are as follows:

- To provide a comprehensive understanding of multi-objective optimization problems, focusing on classical methods in Operational Research.
- To equip students with the key concepts, mathematical foundations, and traditional techniques for analysing and solving multi-objective problems, emphasizing their applicability in various applications of Operational Research.

Learning Outcomes:

Students completing this course will be able to:

- Understand the theoretical principles of multi-objective optimization.
- Formulate multi-objective optimization problems using classical techniques.
- Understand Pareto optimality and trade-off analysis.
- Analyse the existence of solutions using fundamental principles.
- Implement classical algorithms for solving multi-objective optimization problems.
- Analyse the trade-off results of multi-objective optimization in real-world scenarios.

Syllabus of DSE-6(d):

Unit I: Introduction (12 hours)

Introduction to Multi-Objective Optimization Problem (MOOP). Definition and significance of MOOP and its comparison with a single-objective optimization problem. Basics of convexity and concavity in MOOP. Dominance relations, Pareto optimality and Weak Pareto Optimality. Multi-objective problem formulations with Applications in Operational Research.

Unit II: Optimality Conditions and Duality (12 hours)

Fritz-John and Karush-Kuhn-Tucker necessary and sufficient optimality conditions for Pareto optimality. Duality concepts in MOOP. Weak and strong duality results using Wolfe's dual.

Unit III: Scalarization Methods (18 hours)

Introduction to scalarization techniques for MOOP. Weighted sum method: theory and applications. ε-constraint method: theory and applications. Lexicographic optimization. Goal programming: setting goals and trade-off analysis. Comparative analysis of scalarization methods based on their benefits and limitations. Constructing the Pareto frontier. Characterization and interpretation of Pareto optimal solutions. Visualizing trade-offs through graphical representation.

Unit IV: Interactive Approaches and Cases (18 hours)

Introduction to interactive methods for decision-making. User preferences in generating solutions. Tchebycheff method. Weighted Tchebycheff method. Formulation of multi-objective linear programming and integer programming problems. Cases in manufacturing, service sector, transportation and logistics optimization, financial and environmental applications.

Practical component (if any) – Nil

Essential Readings:

1. Fran Sérgio Lobato & Valder Steffen Jr (2017). Multi-Objective Optimization Problems: Concepts and Self-Adaptive Parameters with Mathematical and Engineering Applications. Springer.
2. Panos M. Pardalos, Antanas Žilinskas & Julius Žilinskas (2017). Non-Convex Multi-Objective Optimization. Springer Optimization and Its Applications, Volume 123, Springer.
3. Ralph E. Steuer (1986). Multiple Criteria Optimization: Theory, Computation and Application. Wiley Series in Probability and Mathematical Statistics-Applied, Wiley.
4. Matthias Ehrgott (2005). Multicriteria Optis and applications. Cengage Learning EMEA.

Suggested Readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-6(e): RELIABILITY TESTING)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reliability Testing (DSE-6(e))	**4**	**3**	**1**	**0**	**-**	**Nil**

Learning Objectives:

The Learning Objectives of this course are as follows:

- To teach life data and degradation data analyses that can help in Engineering Management during Design and Development Phase, Design Verification Phase and Process Validation Phase of a product (electrical, electronic and mechanical, software) life cycle.
- To teach how to find whether the reliability of a given device (system) at a certain age is sufficiently high. How many test items to be tested for this purpose?
- To teach how to model Accelerated Life Tests
- The students will be familiar with the software development process concepts, various life cycles and reliability assessment.

Learning Outcomes:

Students completing this course will be able to:

- Learn life data and degradation data analytic techniques in industries that manufacture electrical, electronic, mechanical, and software items.
- To find out if a product has met a certain reliability requirement with a specific confidence.
- To model testing and planning of lifetime data sets in accelerated environmental conditions
- Comprehend various software testing approaches.
- Understand about the mathematical models for software reliability assessment and prediction

Syllabus of DSE-6(e):

Unit I: Life data analysis (15 hours)

Product Life Cycle, Integrating reliability into product's life cycle, Reliability tasks for a typical product life cycle, Reliability Metrics, Product's Life distributions, Hard Failure and Soft Failure, Life data analysis with complete, time-censored, and failure censored data sets, Degradation data, Relation of Degradation to Failure, Degradation Modelling: Data-Driven Models; Models based on Stochastic Processes (Wiener and Gamma Processes).

Unit I1: Hardware Reliability Testing (15 hours)

Reliability Verification Testing – Verification Testing, Success Testing, Success- Failure Testing, Testing to Failure, Exponential Test Planning, Weibull Test Planning. Accelerated Tests(ATs)- Need for Accelerated Tests, Types of Accelerated Tests: Accelerated Life Tests (ALTs) and Accelerated Degradation Tests (ADTs), Types of Stress Schemes-Constant-Stress; Step-Stress; Progressive Stress; Cyclic Stress; Random Stress; and their various combinations, Stress- Life Relationships, Acceleration Factor, ALT Test Plans.

Unit III: Software Testing and its Levels (15 hours)

Software Development Life Cycle (SDLC), Software Testing, Advantages and Challenges in Software Testing. Verification and Validation (V & V), code inspection, Test Cases, Test Plans, and Test Strategies. Software Testing Techniques: Static Testing, Dynamic Testing, Black Box Testing, White Box Testing. Levels of Testing: Unit Testing, Integration, System Testing, and Acceptance Testing. Functional vs. Non-functional Testing. Cost related to testing.

Unit IV: Software Reliability Models (15 Hours)

Introduction to Software Reliability and its usage in the Testing Phase, Difference of Hardware and Software Reliability, Musa's Basic execution time model, Jelinski-Moranda Model a Infinite Failure Category Model: Duane's Model. Non-homogeneous Poisson Process-based modeling (exponential and S-shaped).

Practical component (if any) - Nil

Essential Readings:

1. Hφyland, A. and M. Rausand (2004). System Reliability Theory: Models and Statistical Methods, 2nd edition John Wiley & Sons Inc., Hobokens, New Jersey.
2. Nelson, W.B. (1990). Accelerated Testing: Statistical Models, Test Plans, and Data Analysis, John Wiley & Sons Inc., Hoboken, New Jersey.
3. Wasserman,G.S. (2003). Reliability Verification and Testing in Engineering Designs, Marcel Dekker Inc., New York.

4. Yang, G. (2007). Life Cycle Reliability Engineering, John Wiley & Sons, Inc., Hoboken, New Jersey
5. Kapur, P. K., Pham, H., Gupta, A., & Jha, P. C. (2011). Software reliability assessment with OR applications (Vol. 364). London: Springer.
6. Aggarwal, K. K., & Singh Y. (2005). Software engineering, New Age International.
7. Pressman, R. S. (2005). Software engineering: a practitioner's approach. Palgrave Macmillan.
8. Yamada, S. (2014). Software reliability modeling: fundamentals and applications. Tokyo: Springer.

Suggested Readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE (DSE-6(f): SOFT COMPUTING METHODS)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Soft Computing Methods (DSC-6(f))	4	3	0	1	-	Nil

Learning Objectives:

The Learning Objectives of this course are as follows:
- Familiarize with soft computing concepts.
- Introduce and use the concepts of Neural Networks, Fuzzy Logic and Genetic Algorithm.

Learning Outcomes:

Upon successful completion of this course the student will be able to:
- Identify and describe soft computing techniques and their roles in building intelligent machines.
- Understand and apply artificial Neural Networks in real life applications.
- Apply fuzzy logic and reasoning to handle uncertainty and solve various decision-making problems.
- Apply genetic algorithms to combinatorial optimization problems.

Syllabus of DSC-6(f):

Unit I: Introduction to Soft Computing **(7 hours)**

Soft Computing: Definition, History, Conception and Importance, Soft computing versus Hard computing, Some applications of soft computing techniques. Introduction to Fuzzy Computing, Evolutionary Computing: Genetic Algorithms, Genetic Programming and Neural Computing.

Unit II: Fuzzy Computing (14 hours)

Fuzzy Set theory, Fuzzy versus Crisp set, Fuzzy Relation, Fuzzification, Minmax Composition, Defuzzification Method, Fuzzy Logic, Fuzzy Rule based systems, Predicate logic, Fuzzy Decision Making, Fuzzy Control, Fuzzy Classification.

Unit III: Evolutionary Computing (14 hours)

Genetic Algorithm: Basic GA framework and different GA architectures, Fitness function GA operators: Encoding, Crossover, Selection, Mutation. Solving single-objective optimization problems using GA.

Unit IV: Applications (10 hours)

Application of Fuzzy Computing in stock market prediction, supply chain and Genetic Algorithm in Optimization: Travelling Salesman Problem, Vehicle routing problem.

Practical component (if any) – (30 hours)

Perform the following practical:

1. Write program to perform fuzzy set operations and properties.
2. Write program to define fuzzy sets and membership functions using MATLAB's Fuzzy Logic Toolbox.
3. Write a Program in MATLAB to Plot various Membership function**.**
4. Write program for Implementation of Fuzzy Inference System.
5. Write program to Implement Fuzzy Relations and apply Min-Max Composition in MATLAB.
6. Write program to Implement a Fuzzy Logic System with MATLAB's Fuzzy Logic Toolbox.
7. Write program to Define a fitness function to evaluate solutions.
8. Write program to apply Roulette Wheel Selection.
9. Write program to apply Tournament Selection.
10. Write program to apply single point and two-point crossover.
11. Write program to apply Bit Flip Mutation.
12. Write program to solve single-objective optimization problems using GA.
13. Write a program for maximizing $f(x) = x^2$ using GA. where x ranges from 0 to 31. Perform 5 iterations only.
14. Use Gatool and minimize the quadratic equation $f(x) = x^2 + 3x + 2$ within the range $-6 <= x <= 0$
15. Write program for Traveling Salesman using GA.

Essential Readings:

1. Rajasekaran, S. Vijayalakshmi Pai (2003), Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, PHI Learning.
2. Sivanandam, S. N., & Deepa, S. N. (2007). Principles of soft computing (with CD). John Wiley & Sons.
3. Volna, E. (2020). Introduction to soft computing.

4. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic - Theory and Applications (2008), Prentice Hall.
5. Priddy L.K., Keller E.P., Artificial Neural Networks: An Introduction (2005), SPIE Press.

Suggestive Readings:

1. Fausett, L. V. (2006). Fundamentals of neural networks: architectures, algorithms and applications. Pearson Education India.
2. Gen, M. Cheng R., Genetic Algorithms and Engineering Optimization John Wiley & Sons. 2000.
3. Ross J.T., Fuzzy Logic with Engineering Applications John Wiley & Sons, 2009 MATLAB Toolkit Manual.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CATEGORY-VI

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENT

GENERIC ELECTIVE (GE-8(a): QUALITY MANAGEMENT)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Quality Management GE-8(a)	4	3	1	0	-	Nil

Learning Objectives:

The Learning Objectives of this course are as follows:

- To impart knowledge of concepts related to quality management.

- To impart knowledge of popularly used tools for quality control and management of a plan.
- To develop practical skills for continuous quality improvement.

Learning Outcomes:

Students completing this course will be able to:

- Demonstrate understanding of total quality management philosophies, concepts, organization, practices, framework, and quality standards.
- Demonstrate understanding of quality management and problem-solving tools and techniques for product and process design.
- Apply statistical analysis tools for measuring and controlling quality.
- Illustrate use of process improvement methods and tools for process analysis and improvement to achieve performance excellence.
- Describe the concept and role of six sigma along with theoretical workings of the implementation of six sigma.

Syllabus of GE-8 (a):

Unit I: Introduction to Quality Management (12 Hours)
Concept of quality management, History, evolution, and importance of quality in organizations, Concepts of product and service quality, Principles, practices and techniques of quality management, Philosophies and frameworks of quality given by various Quality Gurus.

Unit II: Tools and Techniques for Quality Improvement (15 Hours)
Designing quality goods and services, Designing quality processes, Process control and improvement, Cost of quality, Tools: check sheet, flow charts, histograms, pareto analysis, Ishikawa diagram, scatter diagram, PDCA cycle.

Unit III: Statistical Quality Control (20 Hours)
Variation, Causes of variations (natural and assignable), Measurement system analysis, Statistical process control, Process capability measurement, Control charts for variable: mean charts, range charts, Control charts for attributes: p-charts, np-charts, c-charts, u-charts, Product control, Acceptable quality level, Average outgoing quality, Average outgoing quality limit, OC curve, Consumers risk, Producers risk, Acceptable sampling plan: Single sampling plan, Double sampling plan, Sequential sampling plan.

Unit IV: Six Sigma (13 Hours)
Introduction to six-sigma, Evolution of six-sigma, Principles of six-sigma, Statistical basis of 3.4 DPMO, Implementing six-sigma, Application of DMAIC, DMADV, Lean six-sigma and Lean six-sigma in services.

Practical component (if any) – Nil

Essential Readings:

1. Charantimath, P. M. (2011). Total Quality Management. Pearson Education India: India.

2. Gupta, S. C., & Kapoor, V. K. (2009). Fundamentals of applied statistics. India: Sultan Chand & Sons.
3. Besterfield, D. H., Besterfield-Michna, C., Besterfield, G. H., Besterfield-Sacre, M., Urdhwareshe, H., & Urdhwareshe, R. (2014). Total Quality Management (5th ed.). Pearson Education India.

Suggested Readings:

1. Montgomery, D. C. (2009). Introduction to statistical quality control. New York: John Wiley & Sons.

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GENERIC ELECTIVE (GE-8(b): SOFTWARE ENGINEERING)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Software Engineering (GE-8(b))	**4**	**3**	**0**	**1**	**---**	**Nil**

Learning Objectives:

The Learning Objectives of this course are as follows:

- To introduce the basic concepts of Software Engineering and related terminologies
- The students will be made familiar with the concepts of software development process, various life cycles and reliability assessment.
- To introduce various approaches for software project planning, Risk assessment & mitigation

Learning Outcomes:

Upon successful completion of this course the student will be able to:

- Understand software development life cycle, its various stages, and different approaches for software development projects.
- Know about Software Project management activities including planning, scheduling, risk management, etc.
- Comprehend various software testing approaches.
- Understand about the mathematical models for software reliability assessment and prediction
- Gain knowledge about tools and techniques of large-scale software systems development.

Syllabus of GE-8(b):

Unit I: Introduction **(12 Hours)**

Software Scope, Software Development Challenges, Software Engineering Discipline, Software Methodologies and Software development life-cycle Models, Introduction to Agile Software Engineering.

Unit II: Software Requirement Management, System Design and Testing (12 Hours)

Requirement Analysis and Modeling, Techniques, SRS: Needs, Characteristics and its Components, Design Principles, design specification, Cohesiveness and Coupling, Software Testing Fundamentals, , Software testing strategies, Validation Testing, System Testing, Black-Box Testing, White-Box Testing and their types.

Unit III: Software Project Management **(9 Hours)**

Estimation in Project Planning Process, Project Scheduling, Software Risks, Risk Identification, Risk Projection and Risk Refinement, Risk mitigation, monitoring & management-The RMMM Plan

Unit IV: Understanding Software Reliability **(12 Hours)**

Introduction to Software Reliability, Difference between Hardware and Software Reliability, Non-homogeneous Poisson Process based modeling, Software Quality Assurance, Quality Standards ISO 9000, Capability Maturity Model (CMM)

Practical component (if any) – **(30 Hours)**

- Problems related to Process Model
- Problems related to Requirement Analysis
- Problems related to Design Engineering
- Problems related to Project Management
- Problems related to Project Effort Estimation
- Problems related to Project Risk Management
- Problems related to Software Testing
- Problems related to Software Quality Assurance
- Software Reliability Prediction using mathematical models

Essential Readings:

1. Aggarwal, K. K., & Singh Y. (2005). Software engineering, New Age International.
2. Bell, D. (2005). Software Engineering for students. Pearson Education.
3. Jalote, P. (2012). An integrated approach to software engineering. Springer Science & Business Media.
4. Pressman, R. S. (2005). Software engineering: a practitioner's approach. Palgrave Macmillan.
5. Yamada, S. (2014). Software reliability modeling: fundamentals and applications. Tokyo: Springer.

Suggestive Readings: Nil

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.