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DEPARTMENT OF OPERATIONAL RESEARCH

SEMESTER-II

DISCIPLINE SPECIFIC CORE COURSE – 4: Advanced Linear Programming

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		
Advanced Linear Programming & DSC-4	4	3	0	1	Class XII Pass with Mathematics as one of the papers in Class XII	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To enrich the knowledge of students with advanced concepts and techniques of linear programming problem along with real life applications
- To make students understand the theoretical basics of different computational algorithms used in solving linear programming and related problems.

Learning outcomes

Students completing this course will be able to:

- Explain the relationship between a linear program and its dual, including strong duality and complementary slackness, and understand the economic interpretation of duality.
- Learn an alternative method for solving linear programming problems.
- Perform sensitivity analysis to identify the direction and magnitude of change of a linear programming model's optimal solution as the input data changes.
- Formulate specialized linear programming problems, namely transportation and assignment problems and describe theoretical workings of the solution methods for transportation and assignment problems, demonstrate solution process by hand and solver.

SYLLABUS OF DSC-4

Unit I (Weeks 1-5): Duality in linear programming, Duality theorems (Weak duality, Strong duality, Existence theorem and Complementary slackness conditions), Economic interpretation of duality, Dual simplex method.

Unit II (Weeks 6-7): Post Optimality Analysis (change in resource vector, change in cost vector, addition and deletion of a constraint, addition and deletion of a decision variable).

Unit III (Weeks 8-12): Transportation problem (TP) and its formulation, finding initial basic feasible solution of TP using North-West Corner rule, Least Cost method and Vogel's Approximation method, MODI method for finding optimal solution, Special cases in TP.

Unit IV (Weeks 13-15): Assignment problem (AP) and its formulation, Hungarian method for solving AP, Special cases in AP, Transhipment and Travelling salesmen problem.

Practical component (if any) -

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

1. Solution to linear programming problem through dual simplex method.
2. Computational sensitivity analysis with respect to changes in the cost vector.
3. Computational sensitivity analysis with respect to changes in the resource vector.
4. Solution of transportation problem.
5. Solution of assignment problem.
6. Solution of travelling salesman problem.

Essential/recommended readings

- Bazaraa, M. S., Jarvis, J. J. and Sherali. H. D. (2011). *Linear Programming and Network Flows* (4th ed.). John Wiley & Sons.
- Chandra, S., Jayadeva, Mehra, A. (2009). *Numerical Optimization with Applications*. Narosa Publishing House.
- Hadley, G. (2002). *Linear Programming.* Narosa Publishing House.
- Ravindran, A., Phillips, D. T. and Solberg, J. J. (2007). *Operations Research-Principles and Practice* (2nd ed.) (WSE), John Wiley & Sons.
- Taha, H. A. (2017). *Operations Research-An Introduction* (10th ed.). Pearson.
- Winston, W. L. and Venkataramanan, M. (2002). *Introduction to Mathematical Programming: Applications and Algorithms* (4th ed.). Duxbury Press.

Suggestive readings-Nil

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

DISCIPLINE SPECIFIC CORE COURSE – 5: Statistics

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		
Statistics & DSC-5	4	3	0	1	Class XII Pass with Mathematics as one of the papers in Class XII	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- The aim of this course is to acquaint the students with the fundamental concepts of Probability and Statistics, to provide an understanding of the processes by which real-life statistical problems are analysed
- To develop an understanding of the role of Statistics in Operational Research.

Learning Outcomes

Students completing this course will be able to:

- Quantify uncertainty using probability, learn how to find probability using the concepts of random variables and distribution functions, obtain characteristics of the underlying distributions, and study functional relationships between two random variables.
- Know various discrete and continuous probability distributions along with their characteristics and identify the situations where they provide realistic models.
- Know about the modes of convergence in probability theory.
- Define the functional relationship between two variables and gain a foothold in basic concepts of forecasting.

SYLLABUS OF DSC-5

Unit I (Week 1-2): Probability Axioms, Conditional Probability and Bayes' Theorem and its Applications.

Unit II (Week 3-7): Random Variables and Distributions, Expectation and Variance, Moment Generating Functions and Characteristic Function, Multidimensional Random Variable, Conditional Expectation and Conditional Variance. Joint, Marginal and Conditional Distributions. Independent Random Variables.

Unit III (Week 8-12): Discrete and Continuous Probability Distributions (Binomial, Poisson, Geometric Negative binomial, Uniform, Exponential, Normal), Weak Law of Large Numbers, Strong Law of Large Numbers. Central Limit Theorem.

Unit IV (Week 13-15): Correlation and Regression: Karl Pearson's Coefficient of Correlation, Lines of regression, Introduction to Forecasting.

Practical component (if any) -

1. Practicals to Analyse frequency distribution using moments.
2. Practicals to demonstrate applications of Binomial, Poisson and Normal Distributions
3. Practicals to understand Fitting of discrete distributions-Binomial, Poisson, Negative Binomial
4. Fitting of continuous distributions-Exponential. Normal
5. Finding Karl Pearson's Correlation Coefficient using raw and grouped data
6. Analysis of data to be used for forecasting- graphically, using summary statistics , and various measures of forecasting accuracy that are used to help judge the appropriateness of a model
7. Regression Analysis and forecasting using Lines of regression

Essential/recommended readings

- Makridakis, S., Wheelwright, S. C., & Hyndman, R. J. (2008). *Forecasting methods and applications*. John Wiley & Sons.
- Devore, J. L. (2012). *Probability and Statistics for Engineering and the Sciences* (8th ed.) Cengage Learning.
- Feller, W. (2008). *An Introduction to Probability Theory and its Applications - Vol I* (3rd ed.). Wiley.
- Gupta, S.C, Kapoor, V K (2020). *Fundamentals of Mathematical Statistics* (12th Ed.) Sultan Chand and Sons.
- Hogg, R.V., Craig, A.T., and Mckean, J.W. (2019). *Introduction to Mathematical Statistics* (8th ed.). Pearson.
- Rohatgi, V. K., & Saleh, A. K. E. Md. (2015). *An Introduction to Probability and Statistics* (3nd ed.). Wiley.
- Ross, S. (2014). *Introduction to Probability Models* (11th ed.). Academic Press/Elsevier.

Suggestive readings

Nil

DISCIPLINE SPECIFIC CORE COURSE – 6: Python Programming for Business 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		
Python Programming for Business Modelling & DSC-6	4	3	0	1	Class XII Pass with Mathematics as one of the papers in Class XII	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the basic concepts of Python programming. The course will familiarize the students with Python's ability to handle different data formats such as numbers, strings, lists, dictionaries, sets, tuples, etc.
- The students will be made familiar with the concepts of loops. Modularization of code using inbuilt functions as well as user defined functions will also be explained.
- To introduce the basics for various useful libraries so as to equip the students with modern computing skills.

Learning outcomes

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

- Learn Python installation and configuration.
- Understand simple scripting using Python.
- Learn Syntax and Semantics of Python Programming.
- Understand different data types and arithmetical, logical and relational expressions in Python.
- Understand the control structures and functions in Python by writing codes for some real-world problems.
- Handle simple data structures, lists, dictionaries, sets and tuples.
- Modularize the code using inbuilt functions and user defined functions.
- Handle various managerial decision making related problems

SYLLABUS OF DSC-6

Unit I (Week 1-2)

Python installation, Basic Terminal Commands, interactive mode and script mode, Structure of a Program, Simple Python Script Writing, script execution, debugging errors and understanding simple programs in Python

Unit II (Week 3-5)

Identifiers and keywords; literals, numbers, and strings; Operators and expressions; Input and Output statements; control structures (conditional statements, loop control statements, break, Continue and pass).

Unit III (Week 6-8)
Introduction to Functions and its definition: Modules, built in and user-defined functions, passing arguments and returning values, default arguments, functions as data.

Unit IV (Week 9-11)
Data Structures like; Strings, Lists, Tuples, Sets, Dictionaries, Analysing their functions and basic operations.

Unit V (Week 12-15): Introduction to Core Libraries in Python : Numpy Library for Arrays (Creating and accessing One and Multi-Dimensional Array), Pandas Library for Data Processing (Basics of DataFrame), Matplotlib Library for Visualization (Pie Chart, Scatter Plot, Histogram, Bar Chart), SciPy Library for Statistics (for handling basic statistics like; Descriptive Statistics, Rank, Determining Homogeneity of Variances, Correlation), Using PuLP for solving Linear Programming Problems

Practical component (if any) –

1. Write a program to enter a name and display: "Hello, Name".
2. Write a program to compute the roots of a quadratic equation.
3. Write a program to print a pyramid **pattern** with 8 rows.
4. Write a menu driven program to enter a number and print whether the number is odd or even.
5. Write a program to build a **random number generator** that generates random numbers between 1 and 6 (simulates a dice).
6. Write a program that takes two **lists** and returns "True" if they have at least one common member.
7. Write a program to check if one **list** is reverse of another.
8. Write a program to check if a given **array** is Monotonic.
9. Write a program to find the maximum number out of 3 entered numbers. **(loop)**
10. Write a program to build a menu driven **calculator** and perform basic arithmetic operations between two numbers. (Addition, Subtraction, Multiplication and Division)
11. Write a program to create a **dictionary** and remove one key.
12. Write a program to enter 5 subject's marks and print the grades A/B/C/D. **(loop)**
13. Write a program to print a Fibonacci sequence. **(loop)**
14. Write a program in python to plot a **graph** for the function $y = x^2$.
15. Programmes related to creating and modifying List, Tuple and Dictionary.
16. Programmes to find correlation between dependent and independent variables.
17. Programme to develop a regression model on an existing data set.
18. Programmes for data visualization (Charts using plot() function, Pie Chart, Scatter Plot, Histogram, Bar Chart)
19. Programmes for handling descriptive statistics using SciPy.
20. Solution to linear programming problems using PuLP Library.
21. Solution to deterministic EOQ based models for Inventory Management

Essential/recommended readings

- Deitel, P. J. (2019). P*ython Fundamentals*. Pearson.
- Dierbach, C. (2012). *Introduction to computer science using python: a computational problem-solving focus.* Wiley Publishing.
- Elkner, J., Downey, A. B., & Meyers, C. (2016). *How to think like a computer scientist: learning with python*. Samurai Media Limited, United Kingdom.
- Guttag, J. V. (2013). *Introduction to computation and programming using Python*. MIT Press.
- Lambert, K. A. (2018*). Fundamentals of python: first programs*. Cengage Learning.
- Lutz, M., & Lutz, M. (1996). *Programming python* (volume 8). O'Reilly Media, Inc.
- Thareja, R. (2017). *Python programming using problem solving approach*. Oxford University Press.
- VanderPlas, J. (2016). *Python data science handbook: essential tools for working with data*. O'Reilly Media, Inc.

Suggestive readings: Nil

Category II

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

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

DISCIPLINE SPECIFIC CORE COURSE – 3: Advanced Linear Programming

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		
Advanced Linear Programming & DSC-3	4	3	0	1	Class XII Pass with Mathematics as one of the papers in Class XII	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To enrich the knowledge of students with advanced concepts and techniques of linear programming problem along with real life applications
- To make students understand the theoretical basics of different computational algorithms used in solving linear programming and related problems.

Learning outcomes

Students completing this course will be able to:

- Explain the relationship between a linear program and its dual, including strong duality and complementary slackness, and understand the economic interpretation of duality.
- Learn an alternative method for solving linear programming problems.
- Perform sensitivity analysis to identify the direction and magnitude of change of a linear programming model's optimal solution as the input data changes.
- Formulate specialized linear programming problems, namely transportation and assignment problems and describe theoretical workings of the solution methods for transportation and assignment problems, demonstrate solution process by hand and solver.

SYLLABUS OF DSC-3

Unit I (Weeks 1-5): Duality in linear programming, Duality theorems (Weak duality, Strong duality, Existence theorem and Complementary slackness conditions), Economic interpretation of duality, Dual simplex method.

Unit II (Weeks 6-7): Post Optimality Analysis (change in resource vector, change in cost vector, addition and deletion of a constraint, addition and deletion of a decision variable).

Unit III (Weeks 8-12): Transportation problem (TP) and its formulation, finding initial basic feasible solution of TP using North-West Corner rule, Least Cost method and Vogel's Approximation method, MODI method for finding optimal solution, Special cases in TP.

Unit IV (Weeks 13-15): Assignment problem (AP) and its formulation, Hungarian method for solving AP, Special cases in AP, Transhipment and Travelling salesmen problem.

Practical component (if any) -

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

1. Solution to linear programming problem through dual simplex method.
2. Computational sensitivity analysis with respect to changes in the cost vector.
3. Computational sensitivity analysis with respect to changes in the resource vector.
4. Solution of transportation problem.
5. Solution of assignment problem.
6. Solution of travelling salesman problem.

Essential/recommended readings

- Bazaraa, M. S., Jarvis, J. J. and Sherali. H. D. (2011). *Linear Programming and Network Flows* (4th ed.). John Wiley & Sons.
- Chandra, S., Jayadeva, Mehra, A. (2009). *Numerical Optimization with Applications*. Narosa Publishing House.
- Hadley, G. (2002). *Linear Programming.* Narosa Publishing House.
- Ravindran, A., Phillips, D. T. and Solberg, J. J. (2007). *Operations Research-Principles and Practice* (2nd ed.) (WSE), John Wiley & Sons.
- Taha, H. A. (2017). *Operations Research-An Introduction* (10th ed.). Pearson.
- Winston, W. L. and Venkataramanan, M. (2002). *Introduction to Mathematical Programming: Applications and Algorithms* (4th ed.). Duxbury Press.

Suggestive readings-Nil

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

DISCIPLINE SPECIFIC CORE COURSE – 4: Statistics

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		
Statistics & DSC-4	4	3	0	1	Class XII Pass with Mathematics as one of the papers in Class XII	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- The aim of this course is to acquaint the students with the fundamental concepts of Probability and Statistics, to provide an understanding of the processes by which real-life statistical problems are analysed
- To develop an understanding of the role of Statistics in Operational Research.

Learning Outcomes

Students completing this course will be able to:

- Quantify uncertainty using probability, learn how to find probability using the concepts of random variables and distribution functions, obtain characteristics of the underlying distributions, and study functional relationships between two random variables.
- Know various discrete and continuous probability distributions along with their characteristics and identify the situations where they provide realistic models.
- Know about the modes of convergence in probability theory.
- Define the functional relationship between two variables and gain a foothold in basic concepts of forecasting.

SYLLABUS OF DSC-4

Unit I (Week 1-2): Probability Axioms, Conditional Probability and Bayes' Theorem and its Applications.

Unit II (Week 3-7): Random Variables and Distributions, Expectation and Variance, Moment Generating Functions and Characteristic Function, Multidimensional Random Variable, Conditional Expectation and Conditional Variance. Joint, Marginal and Conditional Distributions. Independent Random Variables.

Unit III (Week 8-12): Discrete and Continuous Probability Distributions (Binomial, Poisson, Geometric Negative binomial, Uniform, Exponential, Normal), Weak Law of Large Numbers, Strong Law of Large Numbers. Central Limit Theorem.

Unit IV (Week 13-15): Correlation and Regression: Karl Pearson's Coefficient of Correlation, Lines of regression, Introduction to Forecasting.

Practical component (if any) - NIL

1. Practicals to Analyse frequency distribution using moments.
2. Practicals to demonstrate applications of Binomial, Poisson and Normal Distributions
3. Practicals to understand Fitting of discrete distributions-Binomial, Poisson, Negative Binomial
4. Fitting of continuous distributions-Exponential. Normal
5. Finding Karl Pearson's Correlation Coefficient using raw and grouped data
6. Analysis of data to be used for forecasting- graphically, using summary statistics , and various measures of forecasting accuracy that are used to help judge the appropriateness of a model
7. Regression Analysis and forecasting using Lines of regression

Essential/recommended readings

- Makridakis, S., Wheelwright, S. C., & Hyndman, R. J. (2008). *Forecasting methods and applications*. John Wiley & Sons.
- Devore, J. L. (2012). *Probability and Statistics for Engineering and the Sciences* (8th ed.) Cengage Learning.
- Feller, W. (2008). *An Introduction to Probability Theory and its Applications - Vol I* (3rd ed.). Wiley.
- Gupta, S.C, Kapoor, V K (2020). *Fundamentals of Mathematical Statistics* (12th Ed.) Sultan Chand and Sons.
- Hogg, R.V., Craig, A.T., and Mckean, J.W. (2019). *Introduction to Mathematical Statistics* (8th ed.). Pearson.
- Rohatgi, V. K., & Saleh, A. K. E. Md. (2015). *An Introduction to Probability and Statistics* (3nd ed.). Wiley.
- Ross, S. (2014). *Introduction to Probability Models* (11th ed.). Academic Press/Elsevier.

Suggestive readings

Nil

Category III

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

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

DISCIPLINE SPECIFIC CORE COURSE – 2: Mathematical Modelling for Business

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		
Mathematical Modelling for Business & DSC-2	4	3	0	1	Class XII Pass with Mathematics as one of the papers in Class XII	Nil

Learning Objectives

The objective of this course is to introduce fundamental issues in production and inventory planning and at the same time, develop the students' modelling and analytical skills, and introduce the basic concepts in Marketing and its important role in Business.

Learning outcomes

After completion of the course, students will possess knowledge and skills required to

- Explain the meaning of Inventory control, various forms and functional role of Inventory
- Calculate the Economic Order Quantity (EOQ) for various deterministic inventory models.
- Understand quantity discount models in inventory management.
- Demonstrate solution methods for production scheduling problems
- Understand the role of marketing in an organization, different marketing decisions and scientific marketing analysis
- Derive joint optimization models of price, quality and promotional efforts
- Perform Brand switching analysis to find the equilibrium market share
- Formulate Media allocation problem for advertisement and apply the knowledge of various pricing strategies to grab maximum market share

SYLLABUS OF DSC-2

Unit I (Week 1-2): Inventory Management: Concepts and problems in inventory systems, Selective inventory classification and its use in controlling inventory, Different types of costs in inventory systems and method of their estimation.

Unit II (Week 3-8): Deterministic Inventory models with and without lead time, and with and without shortages. Determination of reorder level (ROL), Quantity discount models, Production scheduling problems.

Unit IV (Week 9-10): Concept of marketing and its role in an organization. Marketing decisions, scientific marketing analysis. Uses and limitations of mathematical models in marketing, Classification of market structure in competitive conditions.

Unit V (Week 11-15): Demand elasticity, Joint optimization of price, quality and promotional efforts. Pricing decisions, Media allocation for advertisement, Brand switching analysis.

Practical component (if any) -

1. Problems based on selective inventory classification (ABC and FNS analysis).
2. To find optimal inventory policy for deterministic inventory models.
3. To solve all units quantity discount model.
4. To solve Incremental quantity discount model.
5. Solution of procurement/production scheduling model.
6. Problems based on joint optimization of price, quality and promotional efforts.
7. Problems based on media allocation for advertisement.
8. Problems based on Brand switching analysis.

Essential/recommended readings

- Axsäter, S. (2015). *Inventory control* (3rd ed.). New York: Springer.
- Buffa, E. S., Sarin R. K. (2009). *Modern production/operations management* (8th ed.). New Delhi: Wiley India (Indian print).
- Hillier, F.S., Lieberman, G. J., Nag, B., & Basu, P. (2017). *Introduction to operations research- concepts and cases* (10th ed.). New Delhi: Tata McGraw Hill (Indian print).
- Hooley, G. J., & Hussey, M. K. (1999). *Quantitative methods in marketing* (2nd ed.). London: International Thomson Business Press.
- Johnson, L.A., & Montgomery, D.C. (1974). *Operations research in production planning, scheduling and inventory control*. New York: Wiley.
- Kotler P., & Keller, K. L. (2008), *Marketing management* (13th ed.). New Delhi: Pearson Education, Ltd.
- Naddor, E. (1966). *Inventory systems*. New York: Wiley.
- Waters, D. (2003). Inventory control and management (2nd ed.). West Sussex: John Wiley & Sons Ltd.

Suggestive readings:

- Silver, E. A., Pyke, D. F., & Peterson, R. (1998). *Inventory management and production planning and scheduling* (3rd ed). New Jersey: John Wiley & Sons, Inc.
- Taha, H. A. (2017). *Operations research-an introduction* (10th ed.). New Delhi: Pearson Prentice Hall (Indian print).

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

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

GENERIC ELECTIVES (GE-2): Production and Inventory 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
		Lecture	Tutorial	Practical/ Practice		
Production and Inventory Management & GE-2	4	3	0	1	Class XII Pass with Mathematics as one of the papers in Class XII	Nil

Learning Objectives

The objective of this course is to introduce fundamental concepts in production and inventory management and at the same time, develop the students' modelling and analytical skills.

Learning outcomes

After completion of the course, students will possess knowledge and skills required to

- Gain an understanding of key concepts of Production and Inventory management and its role in various organizations.
- Apply selective inventory control techniques and understand its significance.
- Determine optimal order quantity for various deterministic and probabilistic inventory models.
- Understand quantity discount models in inventory management.
- Formulate and develop Production Planning and Scheduling models.
- To apply and extend production and inventory models to analyse real world systems.

SYLLABUS OF GE-2

Unit I (Week 1-3): Introduction to Production and Inventory Management, Different types of costs in inventory system, Selective inventory classification (VED, XML, FNSD, ABC) and its use in controlling inventory.
Unit II (Week 4-10): Deterministic continuous review models: Economic order quantity (EOQ) model with and without shortages, Finite replenishment rate Inventory models without and with planned shortages. Determination of reorder point, Quantity discount models.
Unit III (Week 11-12): Probabilistic inventory models: Single period probabilistic inventory models with discrete and continuous demand.
Unit IV (Week 13-15): Introduction to Production Planning and Scheduling, Aggregate production plan, Formulation of lot size production problem: Wagner and Whitin algorithm. Basic concepts of Just-in-Time (JIT) and Material Requirement Planning (MRP).

Practical component (if any) -

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

1. Problems based on selective inventory classification. (ABC and FNS analysis)
2. To find optimal inventory policy for EOQ model.
3. To find optimal inventory policy for EOQ model with finite supply.
4. To find optimal inventory policy for EOQ model with backorders.
5. To solve all units quantity discounts model.
6. To solve Incremental quantity discount model
7. To find optimal inventory policy for Probabilistic inventory model with discrete demand.
8. To find optimal inventory policy for Probabilistic inventory model with continuous.
9. Solution of procurement/production scheduling model.

Essential/recommended readings

- Axsäter, S. (2015). *Inventory control* (3rd Edition). Springer.
- Buffa, Elwood S., & Sarin, Rakesh, K. (2009). *Modern Production/Operations Management* (8th ed.). Wiley, India.
- Hadley, G., & Whitin, T. M. (1963). *Analysis of inventory systems*. Prentice-Hall.
- Heizer, J., & Render, B. (2011). *Operations Management* (10th ed.). Pearson's Publication.
- Johnson, L.A., & Montgomery, D.C. (1974) *Operations Research in Production Planning, Scheduling and Inventory Control*. Wiley, New York.
- Waters, D. (2008). Inventory control and management. (2nd ed.). John Wiley & Sons.

Suggestive readings

- Naddor, E. (1966). *Inventory Systems*. Wiley.
- Silver, E. A., Pyke, D. F., & Peterson, R. (1998). Inventory management and production planning and scheduling (3rd ed.). Wiley.

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

Nomenclature of certificate/diploma/degrees:

- ✓ After securing 44 credits (from semester I and II), by completing one year of study of the UG Programme with Operational Research as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Undergraduate Certificate in** Operational Research**.**

- ✓ After securing 88 credits (from semester I, II, III & IV), by completing two years of study of the UG Programme with Operational Research as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Diploma in** Operational Research**.**

- ✓ After securing 132 credits (from semester I to VI), by completing three years of study of the UG Programme with Operational Research as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Bachelor of Science (Honours) in** Operational Research**.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG Programme with Operational Research as a single core discipline and writes dissertation, the student shall be awarded **Bachelor of Science (Honours with Research) in** Operational Research**.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG Programme with Operational Research as a single core discipline and engages in Academic Project/Entrepreneurship, the student shall be awarded **Bachelor of Science (Honours with Academic Project/Entrepreneurship) in** Operational Research**.**