SEMESTER I

DEPARTMENT OF MATHEMATICS

B.A/ B.Sc. (Prog.) with Mathematics as Non-Major

Category III

DISCIPLINE SPECIFIC CORE COURSE: TOPICS IN CALCULUS

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		
Topics in Calculus	4	3	1	0	Class XII pass with Mathematics	Nil

Learning Objectives

The primary objective of this course is to:

- Introduce the basic tools of calculus which are helpful in understanding their applications in many real-world problems.
- Understand/create various mathematical models in everyday life.

Learning outcomes

This course will enable the students to:

- Understand continuity and differentiability in terms of limits and graphs of certain functions.
- Describe asymptotic behaviour in terms of limits involving infinity.
- Use of derivatives to explore the behaviour of a given function locating and classify its extrema and graphing the function.
- Apply the concepts of asymptotes, and inflexion points in tracing of cartesian curves.
- Compute the reduction formulae of standard transcendental functions with applications.

SYLLABUS OF DSC

Theory

Unit – 1 **(20 hours)**

Limits, Continuity and Differentiability

Limit of a function, $\varepsilon - \delta$ definition of a limit, Infinite limits, Continuity and types of discontinuities; Differentiability of a function, Successive differentiation: Calculation of the nth derivatives, Leibnitz theorem; Partial differentiation, Euler's theorem on homogeneous functions.

Unit – 2 **(20 hours)**

Mean Value Theorems and its Applications

Rolle's theorem, Mean value theorems and applications to monotonic functions and inequalities; Taylor's theorem, Taylor's series, Maclaurin's series expansions of e^x, $\sin x$, $\cos x$, $\log(1+x)$ and $(1+x)^m$; Indeterminate forms.

Unit – 3 **(20 hours)**

Tracing of Curves and Reduction Formulae

Asymptotes (parallel to axes and oblique), Concavity and inflexion points, Singular points, Tangents at the origin and nature of singular points, Curve tracing (cartesian and polar equations). Reduction formulae for $\int \sin^n x\,dx, \int \cos^n x\,dx$, and $\int \sin^m x \cos^n x\,dx$ and their applications.

Practical component (if any) – NIL

Essential Readings

- Prasad, Gorakh (2016). Differential Calculus (19th ed.). Pothishala Pvt. Ltd. Allahabad.
- Prasad, Gorakh (2015). Integral Calculus. Pothishala Pvt. Ltd. Allahabad.

Suggestive Readings

- Apostol, T. M. (2007). Calculus: One-Variable Calculus with An Introduction to Linear Algebra (2nd ed.). Vol. 1. Wiley India Pvt. Ltd.
- Ross, Kenneth. A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian reprint.

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

B.Sc. (Physical Sciences/ Mathematical Sciences) with Mathematics as one of the Core Disciplines

Category III

DISCIPLINE SPECIFIC CORE COURSE: TOPICS IN CALCULUS

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		
Topics in Calculus	4	3	1	0	Class XII pass with Mathematics	Nil

Learning Objectives

The primary objective of this course is to:

- Introduce the basic tools of calculus which are helpful in understanding their applications in many real-world problems.
- Understand/create various mathematical models in everyday life.

Learning outcomes

This course will enable the students to:

- Understand continuity and differentiability in terms of limits and graphs of certain functions.
- Describe asymptotic behaviour in terms of limits involving infinity.
- Use of derivatives to explore the behaviour of a given function locating and classify its extrema and graphing the function.
- Apply the concepts of asymptotes, and inflexion points in tracing of cartesian curves.
- Compute the reduction formulae of standard transcendental functions with applications.

SYLLABUS OF DSC

Theory

Unit – 1 **(20 hours)**

Limits, Continuity and Differentiability

Limit of a function, $\varepsilon - \delta$ definition of a limit, Infinite limits, Continuity and types of discontinuities; Differentiability of a function, Successive differentiation: Calculation of the nth derivatives, Leibnitz theorem; Partial differentiation, Euler's theorem on homogeneous functions.

Unit – 2 **(20 hours)**

Mean Value Theorems and its Applications

Rolle's theorem, Mean value theorems and applications to monotonic functions and inequalities; Taylor's theorem, Taylor's series, Maclaurin's series expansions of e^x, $\sin x$, $\cos x$, $\log(1+x)$ and $(1+x)^m$; Indeterminate forms.

Unit – 3 **(20 hours)**

Tracing of Curves and Reduction Formulae

Asymptotes (parallel to axes and oblique), Concavity and inflexion points, Singular points, Tangents at the origin and nature of singular points, Curve tracing (cartesian and polar equations). Reduction formulae for $\int \sin^n x\,dx, \int \cos^n x\,dx$, and $\int \sin^m x \cos^n x\,dx$ and their applications.

Practical component (if any) – NIL

Essential Readings

- Prasad, Gorakh (2016). Differential Calculus (19th ed.). Pothishala Pvt. Ltd. Allahabad.
- Prasad, Gorakh (2015). Integral Calculus. Pothishala Pvt. Ltd. Allahabad.

Suggestive Readings

- Apostol, T. M. (2007). Calculus: One-Variable Calculus with An Introduction to Linear Algebra (2nd ed.). Vol. 1. Wiley India Pvt. Ltd.
- Ross, Kenneth. A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian reprint.

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 DEPARTMENT OF MATHEMATICS CATEGORY-IV

GENERIC ELECTIVES: FUNDAMENTALS OF CALCULUS

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		
Fundamentals of Calculus	4	3	1	0	Class XII pass with Mathematics	NIL

Learning Objectives

The Learning Objectives of this course is as follows:

- Understand the quantitative change in the behaviour of the variables and apply them on the problems related to the environment.

Learning Outcomes

Upon completion of this course, students will be able to:

- Understand continuity and differentiability in terms of limits.
- Describe asymptotic behavior in terms of limits involving infinity.
- Understand the importance of mean value theorems and its applications.
- Learn about Maclaurin's series expansion of elementary functions.
- Use derivatives to explore the behavior of a given function, locating and classifying its extrema, and graphing the polynomial and rational functions.

SYLLABUS OF GE

Theory

Unit – 1 **(20 hours)**

Continuity and Differentiability of Functions

Limits and continuity, Types of discontinuities; Differentiability of functions; Successive differentiation: Calculation of the nth derivatives, Leibnitz theorem; Partial differentiation, Euler's theorem on homogeneous functions.

Unit – 2 **(20 hours)**

Mean Value Theorems and its Applications

Rolle's theorem, Mean value theorems and applications to monotonic functions and inequalities; Expansion of functions: Taylor's theorem, Taylor's series, Maclaurin's series expansion of $e^x, \sin x, \cos x, \log(1+x)$ and $(1+x)^m$; Indeterminate forms.

Unit – 3 **(20 hours)**

Tracing of Curves

Concavity and inflexion points, Asymptotes (parallel to axes and oblique), Relative extrema, Tracing graphs of polynomial functions, rational functions, and polar equations.

Practical component (if any) – NIL

Essential Readings

- Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). Calculus (10th ed.). Wiley India Pvt. Ltd. New Delhi. International Student Version. Indian Reprint 2016.
- Prasad, Gorakh (2016). Differential Calculus (19th ed.). Pothishala Pvt. Ltd. Allahabad.

Suggestive Reading

- Thomas Jr., George B., Weir, Maurice D., & Hass, Joel (2014). Thomas' Calculus (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.

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

GENERIC ELECTIVES: THEORY OF EQUATIONS AND SYMMETRIES

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		
Theory of Equations and Symmetries	4	3	1	0	Class XII pass with Mathematics	NIL

Learning Objectives

The goal of this course is to acquaint students with certain ideas about:

- Integral roots, rational roots, an upper bound on number of positive or negative roots of a polynomial.
- Finding roots of cubic and quartic equations in special cases using elementary symmetric functions.
- Using Cardon's and Descartes' methods, respectively.

Learning outcomes

After completion of this course, the students will be able to:

- Understand the nature of the roots of polynomial equations and their symmetries.
- Solve cubic and quartic polynomial equations with special condition on roots and in general.
- Find symmetric functions in terms of the elementary symmetric polynomials.

SYLLABUS OF GE

Theory

Unit - 1 **(24 hours)**

Polynomial Equations and Properties

General properties of polynomials and equations; Fundamental theorem of algebra and its consequences; Theorems on imaginary, integral and rational roots; Descartes' rule of signs for positive and negative roots; Relations between the roots and coefficients of equations, Applications to solution of equations when an additional relation among the roots is given; De Moivre's theorem for rational indices, the nth roots of unity and symmetries of the solutions.

Unit - 2 **(16 hours)**

Cubic and Biquadratic (Quartic) Equations

Transformation of equations (multiplication, reciprocal, increase/diminish in the roots by a given quantity), Removal of terms; Cardon's method of solving cubic and Descartes' method of solving biquadratic equations.

Unit - 3 **(20 hours)**

Symmetric Functions

Elementary symmetric functions and symmetric functions of the roots of an equation; Newton's theorem on sums of the like powers of the roots; Computation of symmetric functions such as $\sum\alpha^2\beta$, $\sum\alpha^2\beta^2$, $\sum\alpha^2\beta\gamma$, $\sum\frac{1}{\alpha^2\beta\gamma}$, $\sum\alpha^{-3}$, $\sum(\beta+\gamma-\alpha)^2$, $\sum\frac{\alpha^2+\beta\gamma}{\beta+\gamma}$,... of polynomial equations; Transformation of equations by symmetric functions and in general.

Practical component (if any) – NIL

Essential Readings

- Burnside, W.S., & Panton, A.W. (1979). The Theory of Equations (11th ed.). Vol. 1. Dover Publications, Inc. (4th Indian reprint. S. Chand & Co. New Delhi).
- Dickson, Leonard Eugene (2009). First Course in the Theory of Equations. John Wiley & Sons, Inc. The Project Gutenberg eBook: http://www.gutenberg.org/ebooks/29785

Suggestive Reading

- Prasad, Chandrika (2017). Text Book of Algebra and Theory of Equations. Pothishala Pvt Ltd.

DEPARTMENT OF COMPUTER SCIENCE

BSc. Physical Sciences/ Mathematical Sciences with Computer Science as one of the Core disciplines

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		
Programming fundamentals using C++	4	3	0	1	Class XII pass	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- Introduce programming concepts using C++ to students.
- Develop structured as well as object-oriented programming skills using C++ programming language.
- Achieve competence amongst its students to develop correct and efficient C++ programs to solve problems spanning multiple domains.

Learning outcomes

This course will enable the students to:

- Write simple programs using built-in data types of C++.
- Implement arrays and user defined functions in C++.
- Write programs using dynamic memory allocation, handling external files, interrupts and exceptions.
- Solve problems spanning multiple domains using suitable programming constructs in C++.
- Solve problems spanning multiple domains using the concepts of object oriented programming in C++.

SYLLABUS OF DSC

Theory

Unit – 1 **(3 hours)**

Introduction to C++

Need and characteristics of Object-Oriented Programming, Structure of a C++ Program (main () function, header files, output, input, comments), compile and execute a simple program

Unit – 2 **(12 hours)**

Programming Fundamentals

Data types, Variables, Operators, Expressions, Arrays, Keywords, Decision making constructs, Iteration, Type Casting, Input-output statements, Functions, Command Line Arguments/Parameters

Unit – 3 **(9 hours)**

Object Oriented Programming

Concepts of Abstraction, Encapsulation. Creating Classes and objects, Modifiers and Access Control, Constructors, Destructors, Implementation of Inheritance and Polymorphism, Template functions and classes.

Unit – 4 **(9 hours)**

Pointers and References

Static and dynamic memory allocation, Pointer and Reference Variables, Implementing Runtime polymorphism using pointers and references.

Unit – 5 **(12 hours)**

Exception and File Handling

Using try, catch, throw, throws and finally; Nested try, File I/O Basics, File Operations

Practical **(30 hours)**

List of Practicals:

1. Write a program to compute the sum of the first n terms of the following series:

$$S = 1 - 2^n + 3^n - 4^n + \ldots$$

   The number of terms n is to be taken from the user through the command line. If the command line argument is not found then prompt the user to enter the value of n.

2. Write a program to display the following pattern:

A

BA

CBA

DCBA

The number of rows n, is to be taken from the user.

3. Write a program to compute the factors of a given number using the default argument.
4. Write a menu driven program to perform the following operations on an array:
    a. Find the minimum, maximum and average of the array elements
    b. Search an element in the array using linear search
    c. Search an element in the array using binary search (both iterative and recursive versions)
    d. Display the address of every element of the array
5. Write a menu driven program to perform the following operations on a string:
    a. Calculate length of the string (use pointers)
    b. Check whether the first character of every word in the string is in uppercase or not
    c. Reverse the string
    d. Display the address of every character in the string
6. Create a class Triangle. Include overloaded functions for calculating the area of a triangle.
7. Create a template class TwoDim which contains x and y coordinates. Define default constructor, parameterized constructor and void print() function to print the coordinates. Now reuse this class in ThreeDim adding a new dimension as z. Define the constructors and void print() in the subclass. Implement main() to show runtime polymorphism.
8. Copy the contents of one text file to another file and display the number of characters copied.

Essential Readings

- Stephen Prata, C++ Primer Plus, 6th Edition, Pearson India, 2015.
- E Balaguruswamy, Object Oriented Programming with C++, 8th edition, McGraw-Hill Education, 2020.
- D.S. Malik, C++ Programming: From Problem Analysis to Program Design, 6th edition, Cengage Learning, 2013.

Suggestive Readings

- Herbert Schildt, C++: The Complete Reference, 4th Edition, McGraw Hill, 2003.
- A. B. Forouzan, Richard F. Gilberg, Computer Science: A Structured Approach using C++, 2nd edition, Cengage Learning, 2010.

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

LIST OF COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY DEPARTMENT OF COMPUTER SCIENCE

CATEGORY-IV

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

GENERIC ELECTIVES: PROGRAMMING USING C++

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Programming using C++ Code:	4	3	0	1	Class XII pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- Introduce programming concepts using C++ to students.
- Develop structured as well as object-oriented programming skills using C++ programming language.
- Achieve competence amongst its students to develop correct and efficient C++ programs to solve problems in their respective domains

Learning Outcomes

Upon completion of this course, students will be able to:

- Write simple programs using built-in data types of C++.
- Implement arrays and user defined functions in C++.
- Solve problems in the respective domain using suitable programming constructs in C++.
- Solve problems in the respective domain using the concepts of object oriented programming in C++.

SYLLABUS OF GE

Theory

Unit – 1 **(9 hours)**

Introduction to C++

Overview of Procedural and Object-Oriented Programming, Using main() function, Header Files, Compiling and Executing Simple Programs in C++.

Unit – 2 **(15 hours)**

Programming Fundamentals

Data types, Variables, Operators, Expressions, Arrays, Keywords, Decision making constructs, Iteration, Type Casting, Input-output statements, Functions

Unit – 3 **(21 hours)**

Object Oriented Programming

Concepts of Abstraction, Encapsulation. Creating Classes and objects, Modifiers and Access Control, Constructors, Destructors, Implementation of Inheritance and Polymorphism, Template functions and classes

Practical **(30 hours)**

List of Practicals:

1. Write a program to compute the sum of the first n terms of the following series:

   S = 1 - 2 + 3 - 4 + … n

   The number of terms n is to be taken from the user through the command line. If the command line argument is not found then prompt the user to enter the value of n.

2. Write a program to display the following pattern:

   1

   22

   333

4444

55555

The number of rows n, is to be taken from the user.

3. Write a program to compute the factors of a given number.
4. Write a menu driven program to perform the following operations on an array:
    a. Find the minimum, maximum and average of the array elements
    b. Search an element in the array using linear and binary search
5. Write a menu driven program to perform the following operations on a string:
    a. Calculate length of the string

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    b. Check whether the first character of every word in the string is in uppercase or not
    c. Reverse the string
6. Create a class Triangle. Include overloaded functions for calculating the area of a triangle.
7. Create a template class TwoDim which contains x and y coordinates. Define default constructor, parameterized constructor and void print() function to print the co-ordinates. Now reuse this class in ThreeDim adding a new dimension as z. Define the constructors and void print() in the subclass. Implement main() to show runtime polymorphism.

Essential Readings

- Stephen Prata, C++ Primer Plus, 6th Edition, Pearson India, 2015.
- E Balaguruswamy, Object Oriented Programming with C++, 8th edition, McGraw-Hill Education, 2020.
- D.S. Malik, C++ Programming: From Problem Analysis to Program Design, 6th edition, Cengage Learning, 2013.

Suggestive Reading

- Herbert Schildt, C++: The Complete Reference, 4th edition, McGraw Hill, 2003.
- A. B. Forouzan, Richard F. Gilberg, Computer Science: A Structured Approach using C++, 2nd edition, Cengage Learning, 2010.

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GENERIC ELECTIVES: PROGRAMMING WITH PYTHON

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		
Programming with Python Code:	4	3	0	1	Class XII pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- Introduce programming concepts using Python to students.
- Develop structured as well as object-oriented programming skills using Python.
- Achieve competence amongst its students to develop correct and efficient Python programs to solve problems in their respective domains.

Learning outcomes

On successful completion of the course, students will be able to:

- Write simple programs using built-in data structures in Python.
- Implement arrays and user defined functions in Python.
- Solve problems in the respective domain using suitable programming constructs in Python.
- Solve problems in the respective domain using the concepts of object oriented programming in Python.

SYLLABUS OF GE

Theory

Unit - 1 **(6 hours)**

Introduction to Programming

Problem solving strategies; Structure of a Python program; Syntax and semantics; Executing simple programs in Python.

Unit - 2 **(15 hours)**

Creating Python Programs

Identifiers and keywords; Literals, numbers, and strings; Operators; Expressions; Input/output statements; Defining functions; Control structures (conditional statements, loop control statements, break, continue and pass, exit function), default arguments.

Unit - 3 **(15 hours)**

Built-in Data Structures

Mutable and immutable objects; Strings, built-in functions for string, string traversal, string operators and operations; Lists creation, traversal, slicing and splitting operations, passing list to a function; Tuples, sets, dictionaries and their operations.

Unit - 4 **(9 hours)**

File and Exception Handling

File handling through libraries; Errors and exception handling.

Practical **(30 hours)**

List of Practicals:

1. WAP to find the roots of a quadratic equation.
2. WAP to accept a number 'n' and
    a. Check if 'n' is prime
    b. Generate all prime numbers till 'n'

c. Generate first 'n' prime numbers

d. This program may be done using functions.

3. WAP to create a pyramid of the character '*' and a reverse pyramid

```
    *
   ***
  *****
 *******
*********
```

```
*********
 *******
  *****
   ***
    *
```

4. WAP that accepts a character and performs the following:
   a. print whether the character is a letter or numeric digit or a special character
   b. if the character is a letter, print whether the letter is uppercase or lowercase
   c. if the character is a numeric digit, prints its name in text (e.g., if input is 9, output is NINE)
5. WAP to perform the following operations on a string
   a. Find the frequency of a character in a string.
   b. Replace a character by another character in a string.
   c. Remove the first occurrence of a character from a string.
   d. Remove all occurrences of a character from a string.
6. WAP to swap the first n characters of two strings.

7. Write a function that accepts two strings and returns the indices of all the occurrences of the second string in the first string as a list. If the second string is not present in the first string then it should return -1.
8. WAP to create a list of the cubes of only the even integers appearing in the input list (may have elements of other types also) using the following:
    a. 'for' loop
    b. list comprehension
9. WAP to read a file and
    a. Print the total number of characters, words and lines in the file.
    b. Calculate the frequency of each character in the file. Use a variable of dictionary type to maintain the count.
    c. Print the words in reverse order.
    d. Copy even lines of the file to a file named 'File1' and odd lines to another file named 'File2'.
10. Write a function that prints a dictionary where the keys are numbers between 1 and 5 and the values are cubes of the keys.
11. Consider a tuple t1=(1, 2, 5, 7, 9, 2, 4, 6, 8, 10). WAP to perform following operations:
    a. Print half the values of the tuple in one line and the other half in the next line.
    b. Print another tuple whose values are even numbers in the given tuple.
    c. Concatenate a tuple t2=(11,13,15) with t1.
    d. Return maximum and minimum value from this tuple
12. WAP to accept a name from a user. Raise and handle appropriate exception(s) if the text entered by the user contains digits and/or special characters.

Essential Readings

- Taneja, S., Kumar, N., Python Programming- A modular Approach, Pearson Education India, 2018.
- Balaguruswamy E., Introduction to Computing and Problem Solving using Python, 2nd edition, McGraw Hill Education, 2018.

Suggestive Reading

- Brown, Martin C., Python: The Complete Reference, 2nd edition, McGraw Hill Education, 2018.
- Guttag, J.V. Introduction to computation and programming using Python, 2nd edition, MIT Press, 2016.

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

DEPARTMENT OF OPERATIONAL RESEARCH

BSc. Physical Sciences/ Mathematical Sciences with Operational Research as one of the Core Disciplines

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 Operational Research and Linear Programming	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives

The Learning Objective of the course is to introduce:

- Basic concepts of Operational Research and Linear Programming to the students.

Learning Outcomes:

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

- Gain an understanding of key concepts of Operational Research and Linear Programming and their role in various organizations.
- Describe the basic concepts of convex analysis and explain the theoretical foundations of various issues related to linear programming modelling.
- Formulate real-world problems as a linear programming model and describe the theoretical workings of the graphical and simplex method, demonstrate the solution process by hand and solver.
- Implement advanced and more economic algorithm to solve linear programming problems.

SYLLABUS OF DSC-1

Theory

Unit – 1 **(9 hours)**

Basics of Operational Research: Origin & Development of Operational Research, Definition and Meaning of Operational Research, Different Phases of an Operational Research Study, Scope and Limitations of Operational Research, Mathematical Formulation of Real-Life Problems.

Unit – 2 **(15 hours)**

Introduction to Linear Programming, Linear Programming Problem Formulation, Solution by Graphical Method. Concepts of Basis and Basic Feasible solution. Convex sets, Extreme points, Hyperplanes and Halfspaces, Convex cones, Polyhedral sets and cones.

Unit – 3 **(9 hours)**

Theory of Simplex Method, Simplex Algorithm, Two phase Method, Charne's-M Method.

Unit – 4 **(12 hours)**

Degeneracy in Linear Programming, Charnes' Perturbation method, Revised Simplex method.

Practical **(30 hours)**

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

1. To solve Linear Programming Problem (LPP) using Graphical Method with
   (iv) Unbounded solution.
   (v) Infeasible solution.
   (vi) Alternative or multiple solutions.
2. Solution of LPP with simplex method.
3. Problem solving using Charnes-M method.
4. Problem solving using Two Phase method.
5. Illustration of following special cases in LPP using Simplex method
   (v) Unrestricted variables.
   (vi) Unbounded solution.
   (vii) Infeasible solution.
   (viii) Alternative or multiple solutions.
6. Solution to linear programming problem through revised simplex method.

Essential Readings

- Hadley, G. (2002). Linear programming. New Delhi: Narosa Publishing House.
- Hadley, G. (2002). Linear Algebra. New Delhi: Narosa Publishing House.
- Hillier, F.S., & Lieberman, G. J. (2010). Introduction to operations research- concepts and cases (9th ed.). New Delhi: Tata McGraw Hill (Indian print).
- Taha, H. A. (2017). Operations research - An Introduction (10th ed.). Pearson Education.
- Ravindran, A., Phillips, D. T., & Solberg, J. J. (2005). Operations research- principles and practice (2nd ed.). New Delhi: Wiley India (P.) Ltd. (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 DEPARTMENT OF OPERATIONAL RESEARCH

CATEGORY-IV

GENERIC ELECTIVES: INTRODUCTION TO OPERATIONAL RESEARCH AND 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		
Introduction to Operational Research and Linear Programming	4	3	0	1	Class XII pass with Mathematics	Nil

Learning Objectives

The Learning Objective of the course is to introduce:

- Basic concepts of Operational Research and Linear Programming to the students.

Learning Outcomes:

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

- Gain an understanding of key concepts of Operational Research and Linear Programming and their role in various organizations.
- Describe the basic concepts of convex analysis and explain the theoretical foundations of various issues related to linear programming modelling.
- Formulate real-world problems as a linear programming model and describe the theoretical workings of the graphical and simplex method, demonstrate the solution process by hand and solver.
- Implement advanced and more economic algorithm to solve linear programming problems.

SYLLABUS OF GE

Theory

Unit – 1 **(9 hours)**

Basics of Operational Research: Origin & Development of Operational Research, Definition and Meaning of Operational Research, Different Phases of an Operational Research Study, Scope and Limitations of Operational Research, Mathematical Formulation of Real-Life Problems.

Unit – 2 **(15 hours)**

Introduction to Linear Programming, Linear Programming Problem Formulation, Solution by Graphical Method. Concepts of Basis and Basic Feasible solution. Convex sets, Extreme points, Hyperplanes and Halfspaces, Convex cones, Polyhedral sets and cones.

Unit – 3 **(9 hours)**

Theory of Simplex Method, Simplex Algorithm, Two phase Method, Charne's-M Method.

Unit – 4 **(12 hours)**

Degeneracy in Linear Programming, Charnes' Perturbation method, Revised Simplex method.

Practical **(30 hours)**

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

1. To solve Linear Programming Problem (LPP) using Graphical Method with
   (i) Unbounded solution.
   (ii) Infeasible solution.
   (iii) Alternative or multiple solutions.
2. Solution of LPP with simplex method.
3. Problem solving using Charnes-M method.
4. Problem solving using Two Phase method.
5. Illustration of following special cases in LPP using Simplex method
   (i) Unrestricted variables.
   (ii) Unbounded solution.
   (iii) Infeasible solution.
   (iv) Alternative or multiple solutions.
6. Solution to linear programming problem through revised simplex method.

Essential Readings

- Hadley, G. (2002). Linear programming. New Delhi: Narosa Publishing House.
- Hadley, G. (2002). Linear Algebra. New Delhi: Narosa Publishing House.
- Hillier, F.S., & Lieberman, G. J. (2010). Introduction to operations research- concepts and cases (9th ed.). New Delhi: Tata McGraw Hill (Indian print).

- Taha, H. A. (2017). Operations research - An Introduction (10th ed.). Pearson Education.
- Ravindran, A., Phillips, D. T., & Solberg, J. J. (2005). Operations research- principles and practice (2nd ed.). New Delhi: Wiley India (P.) Ltd. (Indian print).

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

SEMESTER II

DEPARTMENT OF MATHEMATICS

B.Sc. (Prog.)/ BA (Prog.) with Mathematics as Non-Major
Category-III

DISCIPLINE SPECIFIC CORE COURSE – 2 (Discipline A-2): Elementary Linear Algebra

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		
Elementary Linear Algebra	4	3	1	0	Class XII pass with Mathematics	NIL

Learning Objectives: The objective of the course is:

- To introduce the concept of vectors in R^n.
- Understand the nature of solution of system of linear equations.
- To view the $m \times n$ matrices as a linear function from R^n to R^m and vice versa.
- To introduce the concepts of linear independence and dependence, rank and linear transformations has been explained through matrices.

Learning Outcomes: This course will enable the students to:

- Visualize the space R^n in terms of vectors and the interrelation of vectors with matrices.
- Familiarize with concepts of bases, dimension and minimal spanning sets in vector spaces.
- Learn about linear transformation and its corresponding matrix.

SYLLABUS OF DSC-2

UNIT – I: Euclidean Space R^n and Matrices **(18 hours)**

Fundamental operations with vectors in Euclidean space R^n, Linear combinations of vectors, Dot product and their properties, Cauchy-Schwarz inequality, Triangle inequality, Solving system of linear equations using Gaussian elimination, Application: Curve Fitting, Gauss-Jordan row reduction, Reduced row echelon form, Application: Solving several systems simultaneously, Equivalent systems, Rank and row space of a matrix, Eigenvalues, Eigenvectors, Eigenspace, Diagonalization, Characteristic polynomial of a matrix.

UNIT – II: Introduction to Vector Spaces **(12 hours)**

Definition, Examples and some elementary properties of vector spaces, Subspaces, Span, Linear independence and linear dependence of vectors, Basis and dimension of a vector space, Maximal linearly independent sets, Minimal spanning sets.

UNIT – III: Linear Transformations **(15 hours)**

Linear transformations: Definition, Examples and elementary properties, The matrix of a linear transformation, Kernel and range of a linear transformation, The dimension theorem, one-to-one and onto linear transformations, Invertible linear transformations, Isomorphic vector spaces.

Essential Reading

1. Andrilli, S., & Hecker, D. (2016). *Elementary Linear Algebra* (5th ed.). Elsevier India.

Suggestive Readings

- Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). *Linear Algebra and its Applications* (5th ed.). Pearson Education.
- Kolman, Bernard, & Hill, David R. (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.

(Category-IV)

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

GENERIC ELECTIVES (GE-2(i)): ANALYTIC GEOMETRY

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		
Analytic Geometry	4	3	1	0	Class XII pass with Mathematics	NIL

Learning Objectives: The course aims at:

- Identifying and sketching curves, studying three dimensional objects, their geometric properties and applications.
- Use of vector approach to three-dimensional geometry makes the study simple and elegant.

Learning Outcomes: This course will enable the students to:

- Learn concepts in two-dimensional geometry.
- Identify and sketch conics namely, ellipse, parabola and hyperbola.
- Learn about three-dimensional objects such as straight lines and planes using vectors, spheres, cones and cylinders.

SYLLABUS OF GE-2(i)

UNIT – I: Conic Sections **(15 hours)**

Techniques for sketching parabola, ellipse and hyperbola; Reflection properties of parabola, ellipse, hyperbola, and their applications to signals; Classification of quadratic equation representing lines, parabola, ellipse and hyperbola; Rotation of axes; Second degree equations.

UNIT – II: Vectors, Lines and Planes **(18 hours)**

Rectangular coordinates in 3-dimensional space, vectors viewed geometrically, vectors in coordinate systems and vectors determined by length and angle; Dot product; Projections; Cross product, scalar triple product, vector triple product and their geometrical properties; Parametric equations of lines, direction cosines and direction ratios of a line, vector and symmetric equations of lines, angle between two lines; Planes in 3-dimensional space, coplanarity of two lines, angle between two planes, distance of a point from a plane, angle between a line and a plane, distance between parallel planes; Shortest distance between two skew lines.

UNIT – III: Sphere, Cone and Cylinder **(12 hours)**

Equation of a sphere, plane section of sphere, tangents and tangent plane to a sphere; Equation of a cone, enveloping cone of a sphere, Reciprocal cones and right circular cone; Equation of a cylinder, enveloping cylinder and right circular cylinder.

Recommended Readings:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). *Calculus* (10th ed.). John Wiley & Sons Singapore Pte. Ltd. Indian reprint (2016) by Wiley India Pvt. Ltd. Delhi.
2. Narayan, Shanti & Mittal, P. K. (2007). *Analytical Solid Geometry*. S. Chand & Company Pvt Ltd. India.

Suggestive Readings:

- Bell, Robert J.T. (1972). *An Elementary Treatise on Coordinate Geometry of Three Dimensions*. Macmillan & Co. Ltd. London.
- George B. Thomas, Jr., & Ross L. Finney (2012). *Calculus and Analytic Geometry* (9th ed.). Pearson Indian Education Services Pvt Ltd. India.

GENERIC ELECTIVES (GE-2(ii)): INTRODUCTION TO LINEAR ALGEBRA

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		
Introduction to Linear Algebra	4	3	1	0	Class XII pass with Mathematics	NIL

Learning Objectives: The objective of the course is:

- To introduce the concept of vectors in R^n.
- Understand the nature of solution of system of linear equations.
- To view the $m \times n$ matrices as a linear function from R^n to R^m and vice versa.
- To introduce the concepts of linear independence and dependence, rank and linear transformations has been explained through matrices.

Learning Outcomes: This course will enable the students to:

- Visualize the space R^n in terms of vectors and the interrelation of vectors with matrices.
- Understand important uses of eigenvalues and eigenvectors in the diagonalization of matrices.
- Familiarize with concepts of bases, dimension and minimal spanning sets in vector spaces.
- Learn about linear transformation and its corresponding matrix.

SYLLABUS OF GE-2(ii)

UNIT – I: Vectors and Matrices **(18 hours)**

Fundamental operations and properties of vectors in R^n, Linear combinations of vectors, Dot product and their properties, Cauchy-Schwarz and triangle inequality, Orthogonal and parallel vectors; Solving system of linear equations using Gaussian elimination, and Gauss-Jordan row reduction, Reduced row echelon form; Equivalent systems, Rank and row space of a matrix; Eigenvalues, eigenvectors and characteristic polynomial of a square matrix; Diagonalization.

UNIT – II: Vector Spaces **(12 hours)**

Definition, examples and some elementary properties of vector spaces; Subspaces, Span, Linear independence and dependence; Basis and dimension of a vector space; Diagonalization and bases.

UNIT – III: Linear Transformations **(15 hours)**

Definition, examples and elementary properties of linear transformations; The matrix of a linear transformation; Kernel and range of a linear transformation, The dimension theorem, one-to-one and onto linear transformations.

Essential Reading

1. Andrilli, S., & Hecker, D. (2016). *Elementary Linear Algebra* (5th ed.). Elsevier India.

Suggestive Reading

- Kolman, Bernard, & Hill, David R. (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.

DEPARTMENT OF OPERATIONAL RESEARCH

BSc. (Physical Sciences/ Mathematical Sciences) with Operational Research as one of the Core Disciplines

Category IV

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	Basic Linear Programming

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 (12 Hours): Duality: 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 (09 Hours): Sensitivity Analysis: 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 (15 Hours): Transportation Problem (TP): 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 (09 Hours): Assignment problem (AP): 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.

Category-V

Common Pool of Generic Electives (GE) Courses offered by Department of Operational Research

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	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 (9 Hours): Production and Inventory Management, Introduction , Different types of costs in inventory system, Selective inventory classification (VED, XML, FNSD, ABC) and its use in controlling inventory.

Unit II (15 Hours): 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 (9 Hours): Probabilistic inventory models: Single period probabilistic inventory models with discrete and continuous demand.

Unit IV (12 Hours): Production Planning and Scheduling,:Introduction, Aggregate production plan, Formulation of lot size production problem: Wagner and Within 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.

DEPARTMENT OF COMPUTER SCIENCE

BSc. (Physical Sciences/ Mathematical Sciences) with Computer Science as one of the Core Disciplines

Category II

DISCIPLINE SPECIFIC CORE COURSE (DSC-2): Data Structures using C++

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		
DSC02: Data Structures using C++	**4**	**3**	**0**	**1**	**Class XII pass with Mathematics**	Nil

Learning Objectives

The course aims at developing the ability to use basic data structures like arrays, stacks, queues, lists, trees to solve problems. C++ is chosen as the language to understand implementation of these data structures.

Learning outcomes

On successful completion of the course, students will be able to:

- Compare two functions for their rates of growth.
- Understand abstract specification of data-structures and their implementation.
- Compute time and space complexity of operations on a data-structure.
- Identify the appropriate data structure(s) for a given application and understand the trade-offs involved in terms of time and space complexity.
- Apply recursive techniques to solve problems.

SYLLABUS OF DSC-2 UNIT – I (06 Hours)

Growth of Functions, Recurrence Relations. Functions used in analysis, asymptotic notations, asymptotic analysis, solving recurrences using recursion tree, Master Theorem.

UNIT – II (12 Hours)

Arrays, Linked Lists, Stacks, Queues, Deques. Arrays: array operations, applications, sorting, two-dimensional arrays, dynamic allocation of arrays; Linked Lists: singly linked lists, doubly linked lists, circularly linked lists, Stacks: stack as an ADT, implementing stacks using arrays, implementing stacks using linked lists, applications of stacks; Queues:

queue as an ADT, implementing queues using arrays, implementing queues using linked lists, double-ended queue as an ADT. Time complexity analysis of operations on all data structures.

UNIT – III (06 Hours)

Sorting: Insertion Sort, Count Sort and their complexity analysis.

UNIT – IV (03 Hours)

Recursion: Recursive functions, linear recursion, binary recursion.

UNIT – V (06 Hours)

Trees, Binary Trees. Trees: definition and properties, binary trees: definition and properties, traversal of binary trees and their time complexity analysis.

UNIT – VI (09 Hours)

Binary Search Trees, Balanced Search Trees: Binary Search Trees: insert, delete (by copying), search operations, time complexity analysis of these operations; Balanced Search Trees and (2,4) Trees: motivation and introduction.

UNIT – VII (03 Hours)

Binary Heap, Priority Queue: Binary Heaps: motivation and introduction, application of heaps - Priority Queues.

Practical component (if any) – 30 Hours

1. Perform matrix addition and multiplication.
2. Implement following recursive functions:
    a. Factorial of a number
    b. N^{th} fibonacci number
    c. Power function: x^y

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3. Implement singly linked lists.
4. Implement doubly linked lists.
5. Implement circular linked lists.
6. Implement stack data structure and its operations using arrays.
7. Implement stack data structure and its operations using linked lists.
8. Convert Prefix expression to Infix and Postfix expressions, and evaluate.
9. Implement queue data structure and its operations using arrays.
10. Implement queue data structure and its operations using linked lists.
11. Implement Binary Trees and its traversals.

Essential/recommended readings

1. Goodrich, M., Tamassia, R., & Mount, D., *Data Structures and Algorithms Analysis in C++,* 2nd edition. Wiley, 2011.
2. Cormen, T.H., Leiserson, C.E., Rivest, R. L., Stein C., *Introduction to Algorithms*, 3rd edition, Prentice Hall of India, 2010.
3. Drozdek, A., *Data Structures and Algorithms in C++*, 4th edition, Cengage Learning, 2012.

Suggestive readings

(i) Sahni, S. *Data Structures, Algorithms and applications in C++*. 2nd Edition. Universities Press, 2011.

(ii)Tanenbaum, A. M., Augenstein, M. J., & Langsam Y., *Data Structures Using C and C++*. 2nd edition. Prentice Hall of India, 2009.

Common Pool of Generic Electives (GE) Courses
Offered by Department of Computer Sciences
Category-IV

GENERIC ELECTIVES (GE-2a): Data Analysis and Visualization

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		
GE2a Data Analysis and Visualization using Python	**4**	**3**	**0**	**1**	**Class XII pass with Mathematics**	knowledge of Python

Learning Objectives

This course is designed to introduce the students to real-world data analysis problems, their analysis and interpretation of results in the field of exploratory data science using Python.

Learning outcomes

On successful completion of the course, students will be able to:

- Apply descriptive statistics to obtain a deterministic view of data
- Apply basic and advanced level statistical function on data
- Perform data handling using Numpy arrays
- Do data cleaning and transformation before extracting useful information
- Visualize data for ease of understanding the revealed information

SYLLABUS OF GE-2a

UNIT – I & II (09 Hours)

Introduction to basic statistics and analysis: Fundamentals of Data Analysis, Statistical foundations for Data Analysis, Types of data, Descriptive Statistics, Python Libraries: NumPy, Pandas, Matplotlib

Array manipulation using NumPy: NumPy array: Creating NumPy arrays, various data types of NumPy arrays

UNIT – I & II (09 Hours)

Introduction to basic statistics and analysis: contd..

Correlation and covariance, Linear Regression, Statistical Hypothesis Generation and Testing

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Unit 2 Array manipulation using Numpy: contd..

Indexing and slicing, swapping axes, transposing arrays, data processing using Numpy arrays

UNIT – III (15 Hours)

Data Manipulation using Pandas: Data Structures in Pandas: Series, Data Frame, Index objects, loading data into Panda's data frame, Working with Data Frames: Arithmetics, Statistics, Binning, Indexing, Reindexing, Filtering, Handling missing data, Hierarchical indexing, Data wrangling: Data cleaning, transforming, merging and reshaping

UNIT – IV (12 Hours)

Plotting and Visualization: Using Matplotlib to plot data: figures, subplots, markings, color and line styles, labels and legends, Plotting functions in Pandas: Lines, bar, Scatter plots, histograms, stacked bars, Heatmap

Practical component (if any) – 30 Hours

Use data set of your choice from Open Data Portal (https:// data.gov.in/, UCI repository) or load from scikit, seaborn library for the following exercises to practice the concepts learnt.

1. Load a Pandas data frame with a selected dataset. Identify and count the missing values in a data frame. Clean the data after removing noise as follows
   a. Drop duplicate rows.
   b. Detect the outliers and remove the rows having outliers
   c. Identify the most correlated positively correlated attributes and negatively correlated attributes
2. Import iris data using sklearn library or (Download IRIS data from: https://archive.ics.uci.edu/ml/datasets/iris or import it from sklearn.datasets)

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a. Compute mean, mode, median, standard deviation, confidence interval and standard error for each feature
b. Compute correlation coefficients between each pair of features and plot heatmap
c. Find covariance between length of sepal and petal
d. Build contingency table for class feature

3. Load Titanic data from sklearn library , plot the following with proper legend and axis labels:
   a. Plot bar chart to show the frequency of survivors and non-survivors for male and female passengers separately
   b. Draw a scatter plot for any two selected features
   c. Compare density distribution for features age and passenger fare

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   d. Use a pair plot to show pairwise bivariate distribution
4. Using Titanic dataset, do the following
   a. Find total number of passengers with age less than 30
   b. Find total fare paid by passengers of first class
   c. Compare number of survivors of each passenger class

Project students are encouraged to work on a good dataset in consultation with their faculty and apply the concepts learned in the course.

Essential/recommended readings

1. McKinney W. *Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython*. 2nd edition, O'Reilly Media, 2018.
2. Molin S. *Hands-On Data Analysis with Pandas*, Packt Publishing, 2019.
3. Gupta S.C., Kapoor V.K., *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons, 2020.

Suggestive readings

(i) Chen D. Y, *Pandas for Everyone: Python Data Analysis*, Pearson, 2018.

(ii) Miller J.D. *Statistics for Data Science,* Packt Publishing, 2017.

GENERIC ELECTIVES (GE-2b): Data Analysis and Visualization using Spreadsheet

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		
GE2b **Data Analysis and Visualization using Spreadsheet**	**4**	**3**	**0**	**1**	**Class XII pass with Mathematics**	**Nil**

Learning Objectives

This course is designed to inculcate statistical thinking about data to the students who have studied Mathematics up to Class 10^{th} ONLY. It gently introduces the students to basic statistics, and builds gradually to cover advanced functionalities for data analysis in spreadsheets. The objective is to enhance the knowledge of statistics and enable students to make sense of data by analyzing and visualizing it using spreadsheets, interpreting the results and gaining insights.

Learning outcomes

On successful completion of the course, students will be able to:

- Analyze and visualize data using spreadsheets
- Apply basic and advanced level statistical functions in spreadsheets
- Gain practical, hands-on experience of data analysis using spreadsheet

SYLLABUS OF GE-2b

UNIT – I (09 Hours)

Introduction to Basic Statistics

Fundamentals of Data Analysis, Statistical foundations for Data Analysis, Types of data, Descriptive Statistics, Correlation and covariance, Linear Regression.

UNIT – II (15 Hours)

Data Handling

Spreadsheet concepts, managing worksheets, formatting cells, entering data, Handling operators in formula, Cell referencing and naming of cells and cell ranges, Sorting, Multilayer sorting, Data validation, Find and Replace, Paste special, Filter and advanced filter, Formatting as table, Pivot tables, Formulae vs functions, Cell formulae vs Array formulae.

Mathematical functions, Statistical functions, Logical functions, Date and Time functions, Lookup and reference: Hlookup, and Vlookup, Index and Match functions, Text functions.

What–if-analysis: Goal-seek, Data tables, Scenario manager.

UNIT – III (12 Hours)

Data Analysis

Explore a data model: its content, and its structure, using the Power Pivot add-in. Learning DAX formula language. Create calculated fields and calculated measure for each cell, filter context for calculation, and explore several advanced DAX functions.

Cube formulas to retrieve data from data model.

UNIT – IV (09 Hours)

Data Visualization

Different types of charts including Pivot charts: Column, Line, Pie, Bar, Scatter charts. Fine tuning of charts: Chart Elements, Chart Styles, Chart Filters, Box Plot.

Practical component (if any) – 30 Hours

1. In a meeting of a marketing department of an organization it has been decided that price of selling an item is fixed at Rs. 40. It was resolved to increases the selling of more items and getting the profit of Rs. 50000/-. Use Goal Seek of find out how many items you will have to sell to meet your profit figure.
2. Create worksheet related to crop production of various crops in Indian stats in last five years (wheat, rice, pulses, soya-bean, and cane-sugar etc).
    i) Make a bar chart
    ii) Make a pie chart
    iii) Make a box plot

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3. Study and perform the various DAX functions to analyse the data.
4. Create workbook related to sales of Business Company having various product in last four quarters for 10 sales persons.
    i) Make a line graph to show the growth/decline in the sales
    ii) Show the graph of each sales person sales
    iii) Find the two sales persons done in last 2 quarters
    iv) Find the sales persons consistent in last four quarters
    v) Find the most popular product of the company and the current popular product of company.
5. Create a Pivot-table showing the Customer Names who placed orders with GSS during 2019-2022. For each customer, also show the total number of orders, Total Sales, and Total Profit. Add a Slicer or a Filter that can be used to show the information specifically for each Customer Segment. Use information from the Pivot- table to answer the following questions (Hint: Filter and sort the data in the Pivot- table to locate the answer):
    i) Which small business customer had the highest sales?
    ii) Which corporate customer placed the greatest number of orders in 2019-2022? How many orders were placed by the corporate customer?
    iii) Which consumer customer was the most profitable one?
    iv) What is the sales figure of the least profitable home office customer?
6. Consider the following worksheet: (enter 5 records)

FULL NAME	GRADE 1/2/3	BASIC SALARY	HRA	PF	GROSS	NET	VA	VA>HRA

HRA is calculated as follows:

Grade	HRA (% of basic)
1	40%
2	35%
3	30%

PF is 8% for all grades

VA is 15000, 10000, 7000 for Grades 1, 2 and 3.

Gross=Basic + HRA+VA

Net=Gross - PF

i) Find max, min and average salary of employees in respective Grade.
ii) Count no. of people where VA>HRA
iii) Find out most frequently occurring grade.
iv) Extract records where employee name starts with "A" has HRA>10000
v) Print Grade wise report of all employees with subtotals of net salary and also grand totals.
vi) Use subtotal command.

vii) Extract records where Grade is 1 or 2 and salary is between 10000 and 20000 both inclusive.

7. Create workbook related to sales of Business Company having various product in last ten quarters for 20 sales persons. Perform the following on workbook:
   i) Create and modify a Pivot-table
   ii) Apply Pivot-table styles and formatting
   iii) Filter a Pivot-table
   iv) Insert a slicer to filter a Pivot-table
   v) Create a Pivot Chart

8. Create a PivotTable showing Total Sales breakdown by Region, Product Category, and Product Sub-Category. Use information from the PivotTable to answer the following questions:
   i) What was the Total Sales figure included in this data set?
   ii) Which Product Category had the highest sales?

iii) Which Region had the lowest sales?
iv) What was the Total Sales of Appliances in Delhi?

9. You are required to prepare a payroll statement in the given format making maximum use of cell referencing facility:

Code	Name	Category	Is HRA to be Paid	Basic	DP	DA	HRA	TA	CCA	Gross
1			Y							
2			N							
	Total									

Required:

- Basic salary (Allow any Basic salary in the range of Rs.10000-35000)
- DP is 50% of Basic Salary.
- DA (as a Percentage of Basic + DP) is more than 35000 then 40% of basic else 30% of basic.

- HRA is to be paid @ 40% of (Basic plus DP) to those whom HRA payable is yes.
- TA is to be paid @ Rs. 800 PM if Basic Salary is Less than Rs.12000, otherwise the TA is Rs. 1000 PM)
- CCA is to be paid @ Rs. 300 PM if Basic Salary is less than Rs.12000/- otherwise the CCA is Rs. 500 PM)
- Gross salary is the sum of Salary and all other allowances
- Deduction: a) GPF 10% of (Basic +DP) subject to a minimum of Rs.2000/- b) IT 10% of Gross Salary
- Net salary is Gross salary minus total deductions.

10. Consider the following worksheet for APS 1st year students:

S.No.	Name	Physics	Chem	Bio	Maths	CS	Total	%	Grade

1									
2									
3									
4									
5									

The value of Grade is calculated as follows:

If % >=90	Grade A

If % >=80 & <90	Grade B
If % >=70 & <80	Grade C
If % >=60 & <70	Grade D

Otherwise, students will be declared fail.

Otherwise, students will be declared fail.

i) Calculate Grade using if function
ii) Sort the data according to total marks
iii) Apply filter to display the marks of the students having more than 65% marks.
iv) Enter the S.No. of a student and find out the Grade of the student using VLOOKUP.
v) Extract all records where name
   a) Begins with "A"
   b) Contains "A"
   c) Ends with "A"

Essential/recommended readings

1. Gupta, S.P., *Elementary Statistical Methods*, Sultan Chand and Sons, New Delhi, 2017.

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2. Goldmeier, J., *Advanced Excel Essentials*, Apress, 2014.
3. Slager, D., *Essential Excel 2016: A Step-by-Step Guide*, Apress, 2016.
4. Valerie M. Sue and Matthew T. Griffin, *Data Visualization and Presentation with Microsoft Office*, SAGE, 2016.
5. Schmuller, J., *Statistical Analysis with Excel for Dummies*, 4th edition., Wiley India Pvt Ltd., 2020.

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

SEMESTER III

DEPARTMENT OF COMPUTER SCIENCE

(Computer Science Courses for Undergraduate Programme of study with Computer Science discipline as one of the three Core Disciplines)

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		
DSE 01a PYTHON Programming for Data Handling	4	3	0	1	Pass in Class XII	NIL

Learning Objectives

The course introduces students to the concept of data handling using files and GUI designing. This would equip the students with knowledge to work on real world data from various applications and GUI development for effective data handling.

Learning outcomes

On successful completion of the course, students will be able to:

- Learn constructs of Python language
- Perform data handling with files using Python.
- Design and implement GUI applications using Tkinter.

SYLLABUS OF DSE 01a

Unit 1 (15 Hours)

Introduction to Python Programming, Basic Constructs, and Python Built-in Data Structures: Introduction to Python programming language, Basic syntax, variables, and data types in Python, Functions and modular programming; Conditional statements (if, elif, else); Looping structures (for and while loops); Mutable and Immutable Data Structures, Strings-Indexing, slicing, traversal, operations; Lists-indexing, slicing, traversal, operations; tuples, dictionaries, and sets and their operations in Python

Unit 2 (5 Hours)

File Handling: Opening, reading, writing, and closing files; File modes and file object methods; Reading and writing text and binary files; Working with CSV files

Unit 3 (15 Hours)

Designing GUI Applications with Tkinter (15): What is Tkinter? Creating a Tkinter window, Layout managers, Tkinter widgets -Entry, Spinbox, Combobox, Checkbutton, Text, Button, LabelFrame; Implementing the application - LabelInput class, building of form, adding LabelFrame and other widgets, retrieving data from form, resetting form, building our application class.

Unit 4 (10 Hours)

Combining Python file handling and Tkinter: Creating a simple Tkinter application, Reading and writing to csv files in a Tkinter application

Essential/recommended readings

1. Taneja S., Kumar, N. Python Programming- A modular approach, 1st Edition, Pearson Education India, 2018,

2. Moore, Alan D. Python GUI Programming with Tkinter: Develop responsive and powerful GUI applications with Tkinter. Packt Publishing Ltd, 2021.

Additional References:

1. Guttag, J.V. Introduction to computation and programming using Python, 2nd edition, MIT

Online references/material:

1. https://docs.python.org/3/library/csv.html

Suggested Practical List (If any): (30 Hours)

Installing and setting up Python and relevant libraries; Python development environments (e.g., Anaconda, Jupyter Notebook)

1. Write a Python program to calculate the factorial of a number.
2. Write a Python program to generate prime numbers between 1 to n, where n is provided as input by the user.
3. Write a Python program to find the sum and average of numbers in a given list.
4. Given two sets, set1 and set2, write a Python program to find their union, intersection and difference.
5. Given a list of numbers, write a Python program to count the number of times an element occurs in a list and create a dictionary with *element:count* as *key:value* pairs.
6. Write a Python program to swap the first two and last two characters in a given string.
7. Write a Python program to create a text file having names of ten Indian cities.
8. Write a Python program to create a text file having atleast five lines about your college using `writelines()` function.

9. Write a Python program which reads the data from three input files having Employee Names and merges them into one output file.
10. Write a Python program to count the number of vowels in a file and write the *vowel : count* in a dictionary.
11. Write a Python program to create a CSV file having student data: RollNo, Enrollment No, Name, Course, Semester.
12. Write a Python program library to read the CSV file created in the above program and filter out records of II semester students.
13. Write a Python program using tkinter library to create a GUI to enter registration details for an event.
14. Write a Python program using tkinter library to create a calculator to perform addition, subtraction, multiplication and division of two numbers entered by the user.
15. Write a Python program using tkinter library to create an age calculator to calculate age when DOB is entered.
16. Write a Python program using tkinter library to read and write student data to and from a CSV file (refer question 11).

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

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		
Android Programming using Java	**4**	**3**	**0**	**1**	Pass in Class XII	NIL

Learning Objective

The course enables the students to understand Android architecture and its key features, making them competent to develop Android applications using Java.

Learning outcomes

On successful completion of the course, students will be able to:

- logically organize Java classes and interfaces using packages.
- understand the design of the Android operating system.
- design user interfaces using various dialog boxes, menus, etc.
- design Android applications with interaction among various activities/applications.

SYLLABUS OF DSE 01b

Unit 1 (15 hours)

Review of Object Oriented Programming and Java Fundamentals: Structure of Java programs, classes and objects, data types, type casting, looping constructs, inheritance.

Unit 2 (2 hours)

Interfaces: Interface basics, defining, implementing and extending interfaces.

Unit 3 (4 hours)

Packages: Basics of packages, creating and accessing packages.

Unit 4 (7 hours)

GUI Programming: AWT classes, event handling.

Unit 5 (5 hours)

Introduction to Android Programming: Introduction to Android Operating System, Android SDK, AVD, components of an Android Application, parcels, and bundles.

Unit 6 (6 hours)

User Interface Architecture: Android Architecture, Contexts in Android, Intents and Intent Filters, Activity Life Cycle, Activity Stack, Fragments, and Fragments Life Cycle.

Unit 7 (6 hours)

User Interface Design: Android Layouts, Views, Spinner, Menu, Toggle Buttons, Radio Buttons, Check Boxes, Alert Box, and Toasts.

Essential/recommended readings

1. Schildt H. Java: The Complete Reference. 12th edition. McGraw-Hill Education, 2021
2. Griffiths D. & Griffiths D. Head First Android Development. O'Reilly, 2017
3. Meier R. Professional AndroidTM 4 Application Development. John Wiley & Sons, Inc., 2012

Additional Resources:

1. Horstmann, C. S. Core Java - Vol. I – Fundamentals. 12th edition. Pearson Education, 2021
2. Murphy M. L. The Busy Coder's Guide to Android Development. CommonsWare, 2018
3. Phillips B., Stewart C., Hardy B. & Marsicano K. Android Programming: The Big Nerd Ranch Guide. Big Nerd Ranch, LLC, 2015
4. Sheusi J. C. Android Application Development for Java Programmers. Cengage Learning, 2013

Suggested Practical List (If any): (30 Hours)

1. Write a function to find whether a number is prime or not. Use this function to determine the nth prime number. Read n from the user.

2. Design a class Complex having a real part (x) and an imaginary part (y). Provide methods to perform the following on complex numbers:

   a. Add two complex numbers.

   b. Multiply two complex numbers.

   c. toString() method to display complex numbers in the form: x + i y

3. Create a class TwoDim which contains private members as x and y coordinates in package P1. Define the default constructor, a parameterized constructor and override toString() method to display the co-ordinates. Now reuse this class and in package P2 create another class ThreeDim, adding a new dimension as z as its private member. Define the constructors for the subclass and override toString() method in the subclass also. Write appropriate methods to show dynamic method dispatch. The main() function should be in a package P.

4. Write a program to create an Applet. Create a frame as a child of an applet. Implement mouseClicked( ), mouseEntered( ) and mouseExited( ) events for the applet. Frame is visible when mouse enters applet window and hidden when mouse exits from the applet window.

5. Write a program to display a string in a frame window with pink color as background.

6. Write a program to create an Applet that has two buttons named “Red” and “Blue”. When a button is pressed, the background color of the applet is set to the color named by the button’s label.

7. Create a “Hello World” application. That will display “Hello World” in the middle of the screen in the emulator. Also display “Hello World” in the middle of the screen in the Android Phone.

8. Create an Android application with a login module. (Check username and password).

9. Create a Spinner with strings taken from resource folder (res >> value folder) and on changing the spinner value, Image will change.

10. Create a Menu with 5 options and a selected option should appear in the text box.

11. Create an application with three option buttons, on selecting a button colour of the screen will change.

12. Create an Application to display various Activity and Fragment Life Cycle Methods.

13. Create an application with 2 fragments, one to set the background and other to set the fore-color of the text.

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

GENERIC ELECTIVES : Database Management Systems

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	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Database Management Systems	**4**	**3**	**0**	**1**	**Pass in class XII**	NIL	**Computer Science**

Learning Objectives

The course introduces the students to the fundamentals of database management systems and their applications. Emphasis is given to the popular relational database system. Students will learn about the importance of database structure and its design using entity relationship diagrams and a formal approach using normalization. Basic concepts of file indexing and transaction processing will be taught. The course would give students hands-on practice with structured query language to create, manipulate, and implement a relational database.

Learning outcomes

On successful completion of the course, students will be able to:

- Use relational database management software to create and manipulate the database.
- Create conceptual data models using entity relationship diagrams for modeling real-life situations and map it to corresponding relational database schema.
- Use the concept of functional dependencies to remove redundancy and update anomalies.
- Apply normalization theory to get a normalized database scheme to get anomalies free databases.
- Write queries in relational algebra.
- Implement relational databases and formulate queries for data retrieval and data update problems using SQL.
- Learn the importance of index structures and concurrent execution of transactions in database systems.

SYLLABUS

Unit 1 (5 hours)

Introduction to Database: Database, characteristics of database approach, data models, database management system, three-schema architecture, components of DBMS, data independence, and file system approach vs. database system approach

Unit 2 (8 hours)

Entity Relationship Modeling: Conceptual data modeling - motivation, entities, entity types, attributes, relationships, relationship types, constraints on relationship, Entity Relationship diagram as conceptual data model.

Unit 3 (11 hours)

Relational Data Model: Data anomalies, Relational Data Model - Characteristics of a relation, schema-instance distinction, types of keys, relational integrity constraints. Relational algebra operators like selection, projection, cartesian product, join and write simple queries using them.

Unit 4 (10 hours)

Structured Query Language (SQL): DDL to create database and tables, table constraints, DML, Querying in SQL to retrieve data from the database, aggregation functions group by and having clauses, generate and query views.

Unit 5 (11 hours)

Database Design: Mapping an Entity Relationship diagram to corresponding relational database scheme, functional dependencies and Normal forms, 1NF, 2NF, and 3NF decompositions and desirable properties of them.

Essential/recommended readings

1. Elmasri, R., Navathe, B. S., *Fundamentals of Database Systems*, 7th Edition, Pearson Education, 2016.
2. Murach J., *Murach's MySQL,* 3th Edition, Pearson, 2019.

Additional References

1. Connolly T. M., Begg C. E. *Database Systems: A Practical Approach to Design, Implementation, and Management*, 6th edition, Pearson, 2019.
2. Ramakrishnan R., Gehrke J. *Database Management Systems*, 3rd Edition, McGraw-Hill, 2014.
3. Silberschatz A., Korth H.F., Sudarshan S. *Database System Concepts*, 7th Edition, McGraw Hill, 2019.

Suggested Practical List (if any): (30 hours)

Practical exercises based on a given schema.

Create and use the following student-course database schema for a college to answer the given queries using the standalone SQL editor.

STUDENT	**Roll No**	**Student Name**	**Course ID**	**DOB**
	Char(6)	Varchar(20)	Varchar(10)	Date

COURSE	**CID**	**Course Name**	**Course Type**	**Teacher-in-charge**	**Total Seats**	**Duration**
	Char(6)	Varchar (20)	Char (8)	Varchar (15)	Unsigned int	Unsigned int

ADMISSION	**Roll No**	**CID**	**Date of Admission**
	Char(6)	Char(6)	**Date**

Here, Rollno (ADMISSION) and SID (ADMISSION) are foreign keys. Note that course type may have two values viz. Fulltime and Parttime and a student may enroll in any number of courses

1. Retrieve names of students enrolled in any course.
2. Retrieve names of students enrolled in at least one part time course.
3. Retrieve students' names starting with letter 'A'.
4. Retrieve students' details studying in courses 'computer science' or 'chemistry'.
5. Retrieve students' names whose roll no either starts with 'X' or 'Z' and ends with '9'
6. Find course details with more than N students enrolled where N is to be input by the user.
7. Update student table for modifying a student name.
8. Find course names in which more than five students have enrolled
9. Find the name of youngest student enrolled in course 'BSc(P)CS'

10. Find the name of most popular society (on the basis of enrolled students)
11. Find the name of two popular part time courses (on the basis of enrolled students)
12. Find the student names who are admitted to full time courses only.
13. Find course names in which more than 30 students took admission
14. Find names of all students who took admission to any course and course names in which at least one student has enrolled
15. Find course names such that its teacher-in-charge has a name with 'Gupta' in it and the course is full time.
16. Find the course names in which the number of enrolled students is only 10% of its total seats.
17. Display the vacant seats for each course
18. Increment Total Seats of each course by 10%
19. Add enrollment fees paid ('yes'/'No') field in the enrollment table.
20. Update the date of admission for all the courses by 1 year.
21. Create a view to keep track of course names with the total number of students enrolled in it.
22. Count the number of courses with more than 5 students enrolled for each type of course.
23. Add column Mobile number in student table with default value '9999999999'
24. Find the total number of students whose age is > 18 years.
25. Find names of students who are born in 2001 and are admitted to at least one part time course.
26. Count all courses having 'science' in the name and starting with the word 'BSc'.

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

GENERIC ELECTIVES : Java 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	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
GE: Java Programming	**4**	**3**	**0**	**1**	**Pass in class XII**	NIL	**Computer Science**

Learning Objectives

This course is designed to develop understanding of object-oriented programming concepts like Classes, Objects, Inheritance and Polymorphism using Java. The course provides understanding of multithreading and exception handling in Java. It also introduces how to create Java applications with graphical user interface (GUI).

Learning outcomes

On completion of this course, the student will be able to:

- Understand the object-oriented concepts – Classes, Objects, Inheritance, Polymorphism– for problem solving.
- Create and handle multithreading.
- Handle program exceptions.
- Handle input/output through files.
- Create Java applications with a graphical user interface (GUI).

SYLLABUS OF GE

Unit 1 (6 hours)

Introductory Concepts: program, identifiers, variables, constants, primitive data types, expressions, Naming Conventions, Type casting, operators, control statements, structured data types, arrays, functions.

Unit 2 (13 hours)

Object Oriented Concepts: Abstraction, encapsulation, objects, classes, methods, constructors, inheritance, polymorphism, static and dynamic binding, Anonymous block, Static Data members, overloading and overriding, Usage of super and this keyword, Abstract classes, Interfaces and Packages, Access modifiers, Object class

Unit 3 (11 hours)

Multithreading: Creating Threads, Thread Priority, Blocked States, Extending Thread Class, Runnable Interface, Starting Threads, Thread Synchronization, Sync Code Block, Overriding Synced Methods, Thread Communication, wait, notify and notify all.

Unit 4 (8 hours)

Introduction to Exception handling: Exception and Error, Throw, try and catch Blocks, Exception handlers, java.lang Exceptions, Built-InExceptions.

Unit 5 (7 hours)

Introduction to File Handling: Byte Stream, Character Stream, File I/O Basics, File Operations, Serialization.

Essential/recommended readings

1. Cay S. Horstmann, *Core Java - Vol. I – Fundamentals*, 10th edition, Pearson, 2017.
2. James Gosling, Bill Joy, Guy L. Steele Jr, Gilad Bracha, Alex Buckley, *The Java Language Specification*, *Java SE* 7th edition, Addison-Wesley, 2011

Additional References

1. Herbert Schildt, *Java: The Complete Reference*, 10th edition, McGraw-Hill Education, 2018.

2 Richard Johnson, *An Introduction to Java Programming and Object-Oriented Application Development*, Thomson Learning, 2006.

3. Kathy Sierra and Bert Bates, *Head First Java*, 3rd edition, O'Reilly, 2022.

Suggested Practical List (If any): (30 Hours)

Practical exercises such as

1. Create a java program to implement stack and queue concepts.
2. Write a program to take input from command line arguments.
3. Write a java program to show static and dynamic polymorphism.
4. Write a java program to show multiple inheritance using interfaces.
5. Write a program in java to show the chaining of execution of construction.
6. Write a java program to show multithreaded producer and consumer applications.
7. write a program in java to synchronize the multithreaded application
8. Create a customized exception and also make use of all the exception keywords.
9. Write a program to show different ways to get input from user
10. Design a form using AWT components and the Frame container.

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

(Computer Science Courses for Undergraduate Programme of study with Computer Science discipline as one of the three Core Disciplines)

DISCIPLINE SPECIFIC CORE COURSE (DSC-3): Computer System Architecture

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		
DSC03: Computer System Architecture	**4**	**3**	**0**	**1**	**Passed 12th class with Mathematics**	NIL

Learning Objectives

This course introduces students to the fundamental concepts of digital computer organization, design, and architecture. It aims to develop a basic understanding of the building blocks of a computer system and highlights how these blocks are organized together to architect a digital computer system.

Learning outcomes

On successful completion of the course, students will be able to:

- Design combinatorial circuits using basic building blocks. Simplify these circuits using Boolean algebra and Karnaugh maps. Differentiate between combinational circuits and sequential circuits.
- Represent data in binary form, convert numeric data between different number systems, and perform arithmetic operations in binary.
- Determine various stages of the instruction cycle and describe interrupts and their handling.
- Explain how the CPU communicates with memory and I/O devices.
- Simulate the design of a basic computer using a software tool.

SYLLABUS OF DSC-3

Unit 1 (9 hours)

Digital Logic Circuits: Digital Logic Gates, Flip flops and their characteristic table, Logic circuit simplification using Boolean algebra and Karnaugh map, Don't care conditions, Combinational circuits, Introduction to Sequential Circuits

Unit 2 (7 hours)

Digital Components: Decoders, Encoders, Multiplexers, Binary Adder, Binary Adder Subtractor, Binary Incrementor, Registers, and Memory Units

Unit 3 (13 hours)

Data Representation: Binary representation of both numeric and alphanumeric data, representation of numeric data in different number systems, (Binary, Octal, Decimal and Hexadecimal), conversion from one number system to another, complements, representation of signed and unsigned numbers, addition and subtraction of signed and unsigned numbers and overflow detection.

Unit 4 (9 hours)

Basic Computer Organization and Design: Stored program organization, Computer registers, Instruction set and their completeness, Instruction cycle, Memory reference instructions, Register reference instructions, Input- Output reference instructions, Interrupt cycle, Addressing modes.

Unit 5 (7 hours)

Input-Output Organization: I/O interface, I/O vs. Memory Bus, Isolated I/O, Memory Mapped I/O, Direct Memory Access.

Essential/recommended readings

1. M. Morris Mano, *Computer System Architecture*, 3rd edition, Pearson Education, 2017.
2. Linda Null, Julia Lobur, *Essentials of Computer Organization and Architecture*, 5th Edition, 2019.

Additional References

1. D. Comer, *Essentials of Computer Architecture,* 2nd edition, CRC Press, 2017.

Suggested Practical List (If any): (30 Hours)

Practical exercises such as

(Use Simulator – CPU Sim 3.6.9 or any higher version for the implementation)

1. Create a machine based on the following architecture:

Registers

IR	DR	AC	AR	PC	I	E
16 bits	16 bits	16 bits	12 bits	12 bits	1 bit	1 bit

Memory 4096 words	

16 bits per word	Instruction format 15 12 11 0

Opcode	Address

Basic Computer Instructions

Memory Reference			Register Reference	
Symbol	Hex		Symbol	Hex
AND	0xxx	Direct Addressing	CLA	7800
ADD	1xxx		CLE	7400
LDA	2xxx		CMA	7200
STA	3xxx		CME	7100
			HLT	7001

Refer to Chapter-5 for a description of the instructions.

Design the register set, the memory, and the instruction set. Use this machine for the assignments in this section.

1. Implement fetch sequence
2. Write an assembly program to simulate the addition of two numbers when one is stored in memory and another is entered by the user.
3. Write an assembly program to simulate addition of two numbers when both numbers are taken as inputs from user.
4. Write an assembly program to simulate subtraction of two numbers when one number is stored in memory and another is entered by the user.
5. Write an assembly program to simulate subtraction of two numbers when both numbers are taken as inputs from user
6. Write an assembly program to simulate the following logical operations on two user-entered numbers.

   i.AND

   ii.OR

   iii.NOT

7. Write an assembly language program to simulate the machine for following register reference instructions and determine the contents of AC, E, PC, AR and IR registers in decimal after the execution:

   i. CLE

   ii. CLA

   iii. CMA

   iv. CME

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

DEPARTMENT OF OPERATIONAL RESEARCH

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 – 3: 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-3)	4	3	0	1	Passed 12th class with Mathematics	Linear Programming

Learning Objectives

To acquaint students with different mathematical modelling techniques applicable in various businesses viz., inventory control, marketing management, and network flow analysis.

Learning outcomes

On successful completion of the course, students will be able to:

- Explain the meaning of Inventory control, its various forms, and the functional role of Inventory.
- Calculate the Economic Order Quantity (EOQ) for various Deterministic Inventory models.
- Comprehend inventory models with All Units Quantity Discounts
- Gain an understanding of the basic concepts and issues in marketing and their application in business decisions.
- Gain an understanding of network analysis and related mathematical models.
- Use standard methodologies for solving network flow problems.

SYLLABUS OF DSC-5

Unit I: Introduction to Inventory Management **(18 Hours)**

Concept and significance of inventory management, Different types of costs in the inventory system. 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 for all the models. Inventory models with All Units Quantity Discounts.

Unit II: Fundamentals for Marketing Management **(15 Hours)**

Nature, Scope, and Importance of Marketing, Basic concepts, Marketing Environment, Consumer Behaviour, Market Classification based on Competitive Conditions, Product Mix, Pricing Strategies, Media allocation for advertisement, Brand switching analysis, Concept of Measurement of Elasticity of Demand, Factors Affecting Elasticity of Demand, Income Elasticity of Demand, Cross Elasticity of Demand, Advertising Elasticity of Demand.

Unit III: Network Analysis **(12 Hours)**

Understanding of network components, Construction of network diagram, Introduction to Network flow problems and their applications: Shortest path problem, Travelling salesman problem, minimum spanning tree.

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

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

- To find optimal inventory policy for deterministic inventory models without shortages.
- To find optimal inventory policy for deterministic inventory models without shortages.
- To solve all units quantity discounts model.
- Finding shortest path in a network.
- Solving a travelling salesman problem.
- Finding minimum spanning tree in a network.
- Problems based on media allocation for advertisement.
- Problems based on Brand switching analysis.

Essential/recommended readings

- Bazaraa, M. S., Jarvis, J. J., & Sherali, H. D. (2011). Linear programming and network flows. John Wiley & Sons.
- Hadley, G., & Whitin, T. M. (1963). *Analysis of inventory systems*. Prentice-Hall.
- Waters, D. (2008). *Inventory control and management.* (2nd Edition). John Wiley & Sons.
- Kotler P., & Keller, K. L. (2008), *Marketing management* (13th ed.). New Delhi: Pearson Education, Ltd.

Suggestive readings: Nil

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

COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES

BSc. Physical Sciences/ Mathematical Sciences with Operational Research as one of the three Core Disciplines

DISCIPLINE SPECIFIC ELECTIVE (DSE): SIMULATION MODELLING & APPLICATIONS

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		
Simulation Modelling and Applications (DSE-1(a))	4	3	0	1	Passed 12th class with Mathematics	Probability and Statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- To acquaint students with the fundamentals of Simulation modelling
- Develop the students' analytical skills
- Introduce simulation techniques applicable in different situations

Learning outcomes

On successful completion of the course, students will be able to:

- Know the basics of simulation modelling and its scope.
- Gain knowledge of Event Type Simulation and its applications in real life.
- Understand the various methods of random number generation.
- Understand and use Monte Carlo Simulation.
- Apply Simulation Technique in Inventory Control, Queuing Systems.
- Use Simulation in Finance and Investment, Maintenance Problems and Networks.

SYLLABUS OF DSE-1(a)

Unit I: Introduction to Simulation **(18 Hours)**

What is Simulation, Process of Simulation, Advantages and Limitations of Simulation, Classification of Simulation Models, Continuous Event Type Simulation, Discrete Event Simulation: Components and Organization, Application of discrete event simulation in single server queueing system, inventory model and insurance risk model.

Unit II : Random Number Generation **(12 Hours)**

Pseudo Random Number Generators – Mixed Congruence Method, Multiplicative Congruential Method, Additive Congruential Method, the inverse transform method, Discrete and Continuous Distributions, Box Muller Method.

Unit III: Applications in Inventory and Queuing **(9 Hours)**

Monte Carlo Simulation, Application of Simulation in Inventory Control, Simulation of Queueing Systems.

Unit IV: Applications in Project Management **(6 Hours)**

Simulation of Maintenance Problems, Applications of Simulation in Finance and Investment, Simulation of Job Sequencing, Simulation of Networks.

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

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

- Modelling randomness in Excel: Pseudo Random Number generators
- Generation of U (0,1)
- Simulating M/M/1 Queues
- Monte Carlo Simulation
- Simulation in Inventory Control
- Forecasting using Simulation
- Simulation in Queueing System using Monte Carlo Simulation
- Simulation in Finance and Investment

Essential/recommended readings

- Fishman, G.S. (1996). *Monte Carlo-Concepts, Algorithms and Applications*, Springer
- Taha, H.A. (2018), *Operations Research, An Introduction, 10h Edition*, Pearson.
- Sheldon M. Ross (2008), *Simulation, 4thEd*, Elsevier.
- Averill M. Law and W. David Kelton (2003), *Simulation Modeling and Analysis*, 3rd Ed., Tata McGraw-Hill.

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 ELECTIVE (DSE):
PRODUCTION AND OPERATIONS 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		
Production and Operations Management (DSE-1(b))	4	3	1	0	Passed 12th class with Mathematics	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students understand the strategic significance of Production and Operations Management in service and manufacturing organizations.
- To acquaint them with fundamental concepts, functions and applications of discipline, so as to deal with different types of problems faced by operations managers, and common decision-making approaches.

Learning Outcomes

On successful completion of the course, students will be able to:

- Gain an understanding of basic concepts of Production and Operations management and differentiate between them.
- Analyse the factors affecting Facility Capacity, Location, and Layout.
- Understand the Production planning and Material Requirement Planning techniques.
- Comprehend basic concepts in Just in time (JIT) Manufacturing System, Operations scheduling and Quality management.

SYLLABUS

Unit I: Introduction to Production and Operations Management (POM) (6 Hours)
Overview of Production System, Objectives of Operations Management, Scope of Operations Management, Types of Production Systems, Production Design Process and Process choices. Framework for Managing Operations; Strategic Operations Management.

Unit II: Facility Location, Layout and Capacity (12 Hours)
Factors Influencing Plant Location, Single Facility Location Problem, Multi Facility Location Problem, Models for Facility Location Problem. Facility Layout decision- importance and benefits of layout planning, different types of layouts. Capacity Planning – Measures of capacity, factors affecting demand forecasting and capacity planning, short and long-term capacity planning.

Unit III: Production Planning (12 Hours)
Aggregate planning, Master Production Schedule. Introduction to MRP and MRP II. Lot sizing in MRP systems – Lot for lot method, economic quantity method, periodic order quantity method, part period balancing, Wagner – Whitin approach. Introduction to modern productivity techniques – Just in Time (JIT), Kanban system. Inventory Control – basic concepts, Classification of Inventory System, EOQ Model.

Unit IV: Operations Scheduling and Quality Management (15 Hours)
Flow Shop Scheduling- Introduction, Single Machine Scheduling, n jobs m machines, Johnsons' rule. Quality Management: Introduction, Statistical process control, control charts, Total Quality Management (TQM), Six sigma, ISO 9000 and other ISO series.

Practical component (if any) –Nil

Essential/recommended readings

- Bedi, K. (2013). *Production & Operations Management.* 3rd edition. Oxford University Press.
- Everett E. Adam, Ronald J Ebert (1995). *Production and Operations Management: Concepts, Models, and Behavior*. Fifth edition. PHI Learning Pvt. Ltd
- Gaither, N., & Frazier, G. (2002). *Operations management*. South-Western/Thomson Learning.
- Heizer,J., Render, B., Munson, C., & Sachan, A. (2017). *Operations Management*. Twelfth edition. Pearson Education.

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 ELECTIVE : BUSINESS FORECASTING

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 Forecasting	4	3	0	1	Passed 12th class with Mathematics	Probability and Statistics

Learning Objectives

The objective of this course is to introduce both managerial and technical aspects of business forecasting to students and expose them to its practical applications.
The Learning Objectives of this course are as follows:

- To introduce both managerial aspect of business forecasting
- Develop the students' ability to understand the technical aspect for business forecasting and its applications
- Introduce various forecasting techniques helpful for better decision making

Learning outcomes

On successful completion of the course, students will be able to:

- Gain an understanding of key concepts of Business Forecasting and its applications.
- Develop analytical methodologies that make prediction of future events of interest to business and industry.
- Make well-informed decisions that require forecasting of relevant variables.
- Identify relevant information to support model selection in scenarios where issues of time
- Predict relationships among business and economic variables for supporting short-term and long-term planning.

SYLLABUS OF DSE-1(c)

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

Introduction to Business Forecasting, Importance of forecasting, Different types of forecasting methods, Identification of appropriate technique for forecasting, Applications of forecasting methods in industry, Practical issues in forecasting.

Unit II: Time Series Modeling **(15 Hours)**

Time series and its components, modelling and forecasting trend, modelling and forecasting seasonality, characterising cycles in times series, forecasting cycles, Forecasting models with trend seasonality and cycle.

Unit III: Regression Modeling **(9 Hours)**

Simple linear regression and multiple linear regression models and their applications in business.

Unit IV: Some Related Concepts **(9 Hours)**

Stationary and non-stationary time series, Autoregressive (AR) Forecasting model, Moving average (MA) model, Autoregressive moving average model (ARMA), Autoregressive integrated moving average (ARIMA) model, Random walk model. Applications of these models in business.

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

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

- Plot and visualize time series data.
- Fitting of trend by using Method of semi averages.
- Fitting of trend by Moving Average Method.
- Measurement of Seasonal indices using method of simple average.
- Measurement of Seasonal indices using Ratio-to-Trend method.
- Measurement of Seasonal indices using Ratio-to-Moving Average method.
- Measurement of seasonal indices using Link Relative method.
- To find cyclical variations using percentage of trend method and relative cyclical residual method.
- Fitting a simple linear regression model for forecasting.
- Fitting a multiple linear regression model for forecasting.

Essential/recommended readings

- Makridakis, S., Wheelwright, S. C., & Hyndman, R. J. (2008). *Forecasting methods and applications*. John wiley & sons.
- Pindyck, R. S., & Rubinfeld, D. L. (1976). *Econometric models and economic forecasts*. McGraw-Hill.
- Butler, W. F., Kavesh, R. A., & Platt, R. B. (Eds.). (1974). *Methods and techniques of business forecasting*. Prentice Hall.
- Diebold, F. X. (2004). *Elements of Forecasting*. Thompson: South Western. Ohio, USA.

Suggestive readings

- Hanke, J. E., & Wichern, D.W. (2014). *Business Forecasting.* Pearson.
- Gujarati, D. N. (2004). *Basic econometrics. (4th ed.),* McGraw-Hill.

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

GENERIC ELECTIVES (GE): QUEUING AND RELIABILITY THEORY

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		
Queuing and Reliability Theory	4	3	0	1	Passed 12th class with Mathematics	Probability and Statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students understand the basic idea of random variables and their associated probability distributions as it is a prerequisite.
- To enrich students with the concept of stochastic processes and its applications in the field of queuing theory.
- To make students learn the mathematical theory of queuing systems.
- To introduce students with the concept of system reliability and make them learn to evaluate reliability of various system configurations.
- To provide students hands-on experience of the queuing and reliability models through practical sessions using certain software.

Learning outcomes

On successful completion of the course, students will be able to:

- Understand the concepts and mathematical theory related to queuing systems & system reliability required to understand, analyse and solve any real-world problem.
- Learn the concepts of stochastic processes, Markov processes, Markov chains and apply these mathematical models in real-life problems.
- Evaluate the performance metrics of any queuing system.
- Compute the system reliability of any type of system-configuration.
- Make use of software for problem analysis.

SYLLABUS

Unit I : Basic characteristics of a queueing system **(12 Hours)**

Kendall's notation, performance measures of a queueing system, Little's formula, Traffic intensity, Some general results for G/G/1 and G/G/c queueing models, Introduction to stochastic processes, Markov chain and Markov process, pure-birth process, pure-death process, birth-death process.

Unit II: Markovian queuing models **(15 Hours)**

single & multiple servers, finite & infinite system capacity, and finite & infinite population size, Cost analysis, Applications of queuing theory.

Unit III: Basic tools of Reliability **(9 Hours)**

Reliability function, and related concepts like hazard rate, mean time to failure (MTTF), classes of lifetime distributions, and hazard rate of Exponential and Weibull distributions.

Unit IV: System Reliability **(9 Hours)**

Reliability, hazard rate and MTTF of various system configurations- series, parallel, mixed configuration, k out of n system and stand-by system.

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

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

- Finding measures of performance for deterministic queuing system.
- Finding measures of performance for M/M/1 queuing system with infinite capacity.
- Finding measures of performance for M/M/1 queuing system with finite capacity.
- Finding measures of performance for M/M/c queuing system with infinite capacity.
- Finding measures of performance for M/M/c queuing system with finite capacity.
- Finding measures of performance for any Markovian queuing system with multiple servers and with finite/infinite capacity.
- Measuring reliability of different types of system configuration.
- Measuring reliability, hazard rate and MTTF of different types of system configuration.

Essential/recommended readings

- Medhi J. (2009), *Stochastic Processes* (3rd Edition), New Delhi: New age science Ltd.
- Gross D., Shortle J. F, Thompson J. M., & Harris C. M. (2008), *Fundamentals of Queuing Theory* (4th edition), New Jersey: John Wiley & Sons, inc.
- Trivedi K. S. (2016), *Probability & Statistics with Reliability, Queuing & Computer Science applications*, New Jersey: John Wiley & Sons, Inc
- Srinath L. S., (2005), *Reliability Engineering*, New Delhi, East West Press.
- Rausand M. & Hoyland A. (2003), *System Reliability Theory: Models, Statistical Methods & Applications* (2nd ed.), New Jersey, John Wiley & Sons, Inc.

- Hiller F. S., Lieberman G. J., Nag B., Basu P. (2017). *Introduction to Operations Research- Concepts & Cases* (10th edition), New Delhi, Tata McGraw-Hill (Indian Print).
- Taha, H. A. (2019). *Operations Research-An Introduction* (10th ed.). New Delhi: Pearson Prentice Hall (Indian print).

Suggestive readings-Nil

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

DEPARTMENT OF MATHEMATICS

B.Sc. (Physical Sciences/Mathematical Sciences) with Mathematics as one of the Core Discipline

Category-III

DISCIPLINE SPECIFIC CORE COURSE – A-3: DIFFERENTIAL EQUATIONS

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		
Differential Equations	4	3	1	0	Class XII pass with Mathematics	Nil

Learning Objectives

The primary objective of this course is to introduce:

- Ordinary and partial differential equations.
- Basic theory of higher order linear differential equations, Wronskian and its properties.
- Various techniques to find the solutions of above differential equations which provide a basis to model complex real-world situations.

Learning Outcomes

This course will enable the students to:

- Solve the exact, linear, Bernoulli equations, find orthogonal trajectories and solve rate problems.
- Apply the method of undetermined coefficients and variation of parameters to solve linear differential equations.
- Solve Cauchy-Euler equations and System of linear differential equations.
- Formulate and solve various types of first and second order partial differential equations.

SYLLABUS of Discipline A-3

Unit – 1 **(15 hours)**

Ordinary Differential Equations

First order ordinary differential equations: Basic concepts and ideas, First order Exact differential equations, Integrating factors and rules to find integrating factors, Linear equations and Bernoulli equations, Initial value problems, Applications of first order differential equations: Orthogonal trajectories and Rate problems; Basic theory of higher order linear differential equations, Wronskian and its properties.

Unit – 2 **(12 hours)**

Explicit Methods of Solving Higher-Order Linear Differential Equations

Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations, Method of undetermined coefficients, Method of variation of parameters, Two-point boundary value problems, Cauchy-Euler equations, System of linear differential equations.

Unit – 3 **(18 hours)**

First and Second Order Partial Differential Equations

Classification and Construction of first-order partial differential equations, Method of characteristics and general solutions of first-order partial differential equations, Canonical forms and method of separation of variables for first order partial differential equations; Classification and reduction to canonical forms of second-order linear partial differential equations and their general solutions.

Essential Readings

1. Myint-U, Tyn and Debnath, Lokenath (2007). Linear Partial Differential Equations for Scientist and Engineers (4th ed.). Birkhäuser. Indian Reprint.
2. Ross, Shepley L. (1984). Differential Equations (3rd ed.). John Wiley & Sons.

Suggestive Readings

- Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equations and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson Education.
- Kreyszig, Erwin. (2011). Advanced Engineering Mathematics (10th ed.). Wiley India.
- Sneddon I. N. (2006). Elements of Partial Differential Equations. Dover Publications.

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

DSE Courses of B.Sc. (Physical Sciences/Mathematical Sciences) Sem-III

DISCIPLINE SPECIFIC ELECTIVE -1(i): COMBINATORICS

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		
Combinatorics	4	3	1	0	Class XII pass with Mathematics	Nil

Learning Objectives

The primary objective of this course is to:

- Introduce various techniques of permutations, combinations and inclusion-exclusion.
- Learn basic models of generating functions and recurrence relations in their application to the theory of integer partitions.

Learning Outcomes

After completing the course, student will:

- Enhance the mathematical logical skills by learning different enumeration techniques.
- Be able to apply these techniques in solving problems in other areas of mathematics.
- Be trained to provide reasoning and arguments to justify conclusions.

SYLLABUS OF DSE-1(i)

Unit - 1 **(15 hours)**

Basics of Combinatorics

Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial coefficients, Multinomial coefficients, Counting subsets of size k; Set-partitions, The inclusion-exclusion principle and applications.

Unit - 2 **(18 hours)**

Generating Functions and Recurrence Relations

Generating functions: Generating function models, Calculating coefficients of generating functions, Polynomial expansions, Binomial identity, Exponential generating functions.
Recurrence relations: Recurrence relation models, Divide-and-conquer relations, Solution of linear recurrence relations, Solutions by generating functions.

Unit – 3 **(12 hours)**

Partition

Partition theory of integers: Ordered partition, Unordered partition, Ferrers diagram, Conjugate of partition, Self-conjugate partition, Durfee square, Euler's pentagonal theorem.

Essential Readings

1. Sane, Sharad S. (2013). Combinatorial Techniques. Hindustan Book Agency (India).
2. Tucker, Alan (2012). Applied Combinatorics (6th ed.). John Wiley & Sons, Inc.

Suggested Readings

- Brualdi, Richard A. (2009). Introductory Combinatorics (5th ed.). Pearson Education Inc.
- Cameron, Peter J. (1994). Combinatorics: Topics, Techniques, Algorithms. Cambridge University Press.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE-1(ii): ELEMENTS OF NUMBER THEORY

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		
Elements of Number Theory	4	3	1	0	Class XII pass with Mathematics	Nil

Learning Objectives

The primary objective of this course is to introduce:

- The Euclidean algorithm and linear Diophantine equations, the Fundamental theorem of arithmetic and some of the open problems of number theory viz. the Goldbach conjecture.
- The modular arithmetic, linear congruence equations, system of linear congruence equations, arithmetic functions and multiplicative functions, e.g., Euler's Phi-function.
- Introduction of the simple encryption and decryption techniques, and the numbers of specific forms viz. Mersenne numbers, Fermat numbers etc.

Learning Outcomes

This course will enable the students to:

- Get familiar with the basic number-theoretic techniques.
- Comprehend some of the open problems in number theory.
- Learn the properties and use of number-theoretic functions and special types of numbers.
- Acquire knowledge about public-key cryptosystems, particularly RSA.

SYLLABUS OF DSE-1(ii)

Unit – 1 **(12 hours)**

Divisibility and Prime Numbers

Revisiting: The division algorithm, divisibility and the greatest common divisor. Euclid's lemma; The Euclidean algorithm, Linear Diophantine equations; The Fundamental theorem of Arithmetic, The sieve of Eratosthenes, Euclid theorem and the Goldbach conjecture; The Fibonacci sequence and its nature.

Unit – 2 **(21 hours)**

Theory of Congruences and Number-Theoretic Functions

Congruence relation and its basic properties, Linear congruences and the Chinese remainder theorem, System of linear congruences in two variables; Fermat's little theorem and its generalization, Wilson's theorem and its converse; Number-theoretic functions for sum and the number of divisors of a positive integer, Multiplicative functions, The greatest integer function; Euler's Phi-function and its properties.

Unit – 3 **(12 hours)**

Public Key Encryption and Numbers of Special Form

Basics of cryptography, Hill's cipher, Public-key cryptosystems and RSA encryption and decryption technique; Introduction to perfect numbers, Mersenne numbers and Fermat numbers.

Essential Reading

1. Burton, David M. (2011). Elementary Number Theory (7th ed.). McGraw-Hill Education Pvt. Ltd. Indian Reprint 2017.

Suggestive Readings

- Jones, G. A., & Jones, J. Mary. (2005). Elementary Number Theory. Springer Undergraduate Mathematics Series (SUMS). Indian Reprint.
- Robbins, Neville (2007). Beginning Number Theory (2nd ed.). Narosa Publishing House Pvt. Ltd. Delhi.
- Rosen, Kenneth H. (2011). Elementary Number Theory and its Applications (6th ed.). Pearson Education. Indian Reprint 2015.

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

DISCIPLINE SPECIFIC ELECTIVE COURSE - DSE-1(iii): THEORY OF EQUATIONS AND SYMMETRIES

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		
Theory of Equations and Symmetries	4	3	1	0	Class X pass with Mathematics	Nil

Learning Objectives

The goal of this paper is to acquaint students with certain ideas about:

- Integral roots, rational roots, an upper bound on number of positive or negative roots of a polynomial.
- Finding roots of cubic and quartic equations in special cases using elementary symmetric functions.
- Using Cardon's and Descartes' methods, respectively.

Learning Outcomes

After completion of this paper, the students will be able to:

- Understand the nature of the roots of polynomial equations and their symmetries.
- Solve cubic and quartic polynomial equations with special condition on roots and in general.
- Find symmetric functions in terms of the elementary symmetric polynomials.

SYLLABUS OF DSE-1(iii)

Unit – 1 **(18 hours)**

Polynomial Equations and Properties

General properties of polynomials and equations; Fundamental theorem of algebra and its consequences; Theorems on imaginary, integral and rational roots; Descartes' rule of signs for positive and negative roots; Relations between the roots and coefficients of equations, Applications to solution of equations when an additional relation among the roots is given; De Moivre's theorem for rational indices, the *n*th roots of unity and symmetries of the solutions.

Unit – 2 **(12 hours)**

Cubic and Biquadratic (Quartic) Equations

Transformation of equations (multiplication, reciprocal, increase/diminish in the roots by a given quantity), Removal of terms; Cardon's method of solving cubic and Descartes' method of solving biquadratic equations.

Unit – 3 **(15 hours)**

Symmetric Functions

Elementary symmetric functions and symmetric functions of the roots of an equation; Newton's theorem on sums of the like powers of the roots; Computation of symmetric functions such as $\sum\alpha^2\beta,\ \sum\alpha^2\beta^2, \sum\alpha^2\beta\gamma, \sum\frac{1}{\alpha^2\beta\gamma}, \sum\alpha^{-3}, \sum(\beta+\gamma-\alpha)^2,\ \sum\frac{\alpha^2+\beta\gamma}{\beta+\gamma},\ldots$ of polynomial equations; Transformation of equations by symmetric functions and in general.

Essential Readings

1. Burnside, W.S., & Panton, A.W. (1979). The Theory of Equations (11th ed.). Vol. 1. Dover Publications, Inc. (4th Indian reprint. S. Chand & Co. New Delhi).
2. Dickson, Leonard Eugene (2009). First Course in the Theory of Equations. John Wiley & Sons, Inc. The Project Gutenberg eBook: http://www.gutenberg.org/ebooks/29785

Suggestive Readings

- Prasad, Chandrika (2017). Text Book of Algebra and Theory of Equations. Pothishala Pvt Ltd.

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 DEPARTMENT OF MATHEMATICS
Category-IV

GENERIC ELECTIVES-GE-3(i): DIFFERENTIAL EQUATIONS

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		
Differential Equations	4	3	1	0	Class XII pass with Mathematics	Nil

Learning Objectives

The primary objective of this course is to introduce:

- Ordinary and partial differential equations.
- Basic theory of higher order linear differential equations, Wronskian and its properties.
- Various techniques to find the solutions of above differential equations which provide a basis to model complex real-world situations.

Learning Outcomes

This course will enable the students to:

- Solve the exact, linear, Bernoulli equations, find orthogonal trajectories and solve rate problems.
- Apply the method of undetermined coefficients and variation of parameters to solve linear differential equations.
- Solve Cauchy-Euler equations and System of linear differential equations.
- Formulate and solve various types of first and second order partial differential equations.

SYLLABUS OF GE-3(i)

Unit – 1 **(15 hours)**

Ordinary Differential Equations

First order ordinary differential equations: Basic concepts and ideas, First order Exact differential equations, Integrating factors and rules to find integrating factors, Linear equations and Bernoulli equations, Initial value problems, Applications of first order differential equations: Orthogonal trajectories and Rate problems; Basic theory of higher order linear differential equations, Wronskian and its properties.

Unit – 2 **(12 hours)**

Explicit Methods of Solving Higher-Order Linear Differential Equations

Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations, Method of undetermined coefficients, Method of variation of parameters, Two-point boundary value problems, Cauchy-Euler equations, System of linear differential equations.

Unit – 3 **(18 hours)**

First and Second Order Partial Differential Equations

Classification and Construction of first-order partial differential equations, Method of characteristics and general solutions of first-order partial differential equations, Canonical forms and method of separation of variables for first order partial differential equations; Classification and reduction to canonical forms of second-order linear partial differential equations and their general solutions.

Essential Readings

1. Myint-U, Tyn and Debnath, Lokenath (2007). Linear Partial Differential Equations for Scientist and Engineers (4th ed.). Birkhäuser. Indian Reprint.
2. Ross, Shepley L. (1984). Differential Equations (3rd ed.). John Wiley & Sons.

Suggestive Readings

- Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equations and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson Education.
- Kreyszig, Erwin. (2011). Advanced Engineering Mathematics (10th ed.). Wiley India.
- Sneddon I. N. (2006). Elements of Partial Differential Equations. Dover Publications.

GENERIC ELECTIVES-GE-3(ii): LATTICES AND NUMBER THEORY

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		
Lattices and Number Theory	4	3	1	0	Class XII pass with Mathematics	Nil

Learning Objectives

The primary objective of this course is to introduce:

- The concepts of ordered sets, lattices, sublattices and homomorphisms between lattices.
- Distributive lattices along with Boolean algebra and their applications in the real-world.
- Divisibility theory of congruences along with some applications.
- The number-theoretic functions and quadratic reciprocity law.

Learning Outcomes

This course will enable the students to:

- Understand the notion of ordered sets. Learn about lattices, distributive lattices, sublattices and homomorphisms between lattices.
- Become familiar with Boolean algebra, Boolean polynomials, switching circuits and their applications.
- Learn the concept of Karnaugh diagrams and Quinn–McCluskey method which gives an aid to apply truth tables in real-world problems.

- Learn about some fascinating properties of prime numbers, and some of the open problems in number theory, viz., Goldbach conjecture etc.
- Know about modular arithmetic and number-theoretic functions like Euler's Phi-function.
- Find quadratic residues and nonresidues modulo primes using Gauss's Quadratic Reciprocity Law.

SYLLABUS OF GE-3(ii)

Unit – 1 **(21 hours)**

Partially Ordered Sets and Lattices

Definitions, Examples and basic properties of partially ordered sets, Order isomorphism, Hasse Diagram, Maximal and minimal elements, Dual of an ordered set, Duality principle; Statements of Well Ordering Principle and Zorn's Lemma; Lattices as ordered sets, Lattices as algebraic structures, Sublattices, Products and homomorphisms, Distributive lattices, Boolean algebras, Boolean polynomials, Minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, Switching circuits and applications.

Unit – 2 **(12 hours)**

Divisibility and Theory of Congruences

The division algorithm: GCD, The Euclidean algorithm, Diophantine equation $ax + by = c$ Primes: The Fundamental Theorem of Arithmetic, Infinitude of primes, Twin primes and Goldbach conjecture.

The theory of congruences: Basic properties and applications, Linear congruences and the Chinese Remainder Theorem, Fermat's Little Theorem and Wilson's Theorem.

Unit – 3 **(12 hours)**

Number-Theoretic Functions, Primitive roots and Quadratic Reciprocity Law

Number-Theoretic Functions: Sum and number of divisors, Euler's Phi-function and Euler's generalization of Fermat's Little Theorem.

Primitive roots: The order of an integer modulo n, and primitive roots of an integer.

Quadratic Reciprocity Law: Quadratic residue and nonresidue, Euler's Criterion, The Legendre symbol and its properties and Quadratic Reciprocity Law.

Essential Readings

1. Davey, B A., & Priestley, H. A. (2002). Introduction to Lattices and Order (2nd ed.), Cambridge University Press, Cambridge.
2. Lidl, Rudolf & Pilz, Günter. (1998). Applied Abstract Algebra (2nd ed.), Undergraduate Texts in Mathematics, Springer (SIE), Indian Reprint 2004.
3. Burton, David M. (2012). Elementary Number Theory (7th ed.), Mc-Graw Hill Education Pvt. Ltd. Indian Reprint.

Suggestive Readings

- Rosen, Kenneth H. (2019). Discrete Mathematics and its Applications (8th ed.), Indian adaptation by Kamala Krithivasan. McGraw-Hill Education. Indian Reprint 2021.
- Goodaire, Edgar G., & Parmenter, Michael M. (2006). Discrete Mathematics with Graph Theory (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint 2018.
- Jones, G. A., & Jones, J. Mary. (2005). Elementary Number Theory. Springer Undergraduate Mathematics Series (SUMS). Indian Reprint.