Savitribai Phule Pune University

(Formerly University of Pune)

Four Year Degree Program in
Bachelor of Science (B.Sc)

With

Major: ARTIFICIAL INTELLIGENCE (AI) and MACHINE LEARNING (ML)

(Faculty of Science and Technology)

Syllabi for

(For Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System (CBCS) Syllabus
Under National Education Policy (NEP)

To be implemented from Academic Year 2024-2025

Title of the Course: B.Sc. (Artificial Intelligence and Machine Learning)

Preamble

The Bachelor of Science in Artificial Intelligence and Machine Learning (B.Sc (AI & ML)) and B.Sc (AI & ML) Honors and Research; program is designed to provide advanced education and training in the field of AI and ML. Driven by the combination of increased access to data, computational power, and improved algorithms, Artificial Intelligence (AI) technologies are entering the mainstream of technological innovation. These technologies include search, machine learning, natural language processing, robotics and computer vision.

This course will also introduce the field of Machine Learning, in particular focusing on the core concepts of supervised, unsupervised learning and reinforcement learning. In supervised learning we will discuss algorithms which are trained on input data labeled with a desired output, for instance an image of a face and the name of the person whose face it is, and learn a function mapping from the input to the output. Unsupervised learning aims to discover latent structure in input data where no output labels are available. Students will learn the algorithms which underpin many popular Machine Learning techniques, as well as developing an understanding of the theoretical relationships between these algorithms.

Eligibility

Passed Standard XII (10+2) or equivalent examination with Physics and Mathematics as compulsory subjects along with one of the Chemistry/ Biotechnology/ Biology/ Technical Vocational subject/ Computer Science/ Information Technology/ Informatics Practices/ Agriculture/ Engineering Graphics/ Business Studies from any recognized Board with a minimum of 50% marks or equivalent grade (45% marks or equivalent grade for Scheduled Caste/ Scheduled Tribes).

Programme Outcomes:

On the successful completion of the program, the following are the expected outcomes.

PO1: Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.

PO2: Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.

PO3: Identify problems where artificial intelligence techniques are applicable and demonstrate ability

to share in discussions of AI, its current scope and limitations, and societal implications.

PO4: Demonstrate proficiency in applying scientific method to models of machine learning.

PO5: Develop an appreciation for what is involved in Learning models from data by understanding a wide variety of learning algorithms and by understanding of the strengths and weaknesses of many popular machine learning approaches

PO6: To apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the ML models.

PO7: Consider the pros and cons when choosing ML / AI methods for different applications

PO8: Appreciate the underlying mathematical relationships within and across Machine Learning an AI

PO8: Conduct investigations of complex problems by using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO9: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

PO10: Communicate effectively on complex engineering activities with then engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give clear instructions.

Syllabus Structure as per NEP Guidelines

Major Course: - Artificial Intelligence and Machine Learning

Level:- 4.5 (First Year) SEMESTER I

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Subject-1	AIML-101-T	Object Oriented concepts and Programming using C++	2	--	2	-	15	35	50
	AIML-102-P	Practical based on AIML-101-T	--	2	--	4	15	35	50
Subject-2	MTS-101-T	Discrete Structures for Computer Science	2	--	2	-	15	35	50
	MTS-102-P	Practical based on MTS-101-T	--	2	--	4	15	35	50
Subject-3	STS-101-T	Notion of Statistical Data Analysis	2	--	2	-	15	35	50
	STS-102-P	Practical based on STS-101-T	--	2	--	4	15	35	50
GE /OE	OE-101-AIML-T	From University Basket*	2	--	2	--	15	35	50
SEC	SEC-101-AIML-T	Basic Probability theory and Discrete Distributions	2	--	2	--	15	35	50
IKS	AIML-101-IKS	Generic IKS	2	--	2	--	15	35	50
AEC	AEC-101-ENG	English	2	--	2	--	15	35	50
VEC	VEC-101-ENV	EVS-I	2	--	2	--	15	35	50
		Total	**16**	**06**	**16**	**12**			**550**

*Open Elective (OE) Subjects offered to students from other than science faculty are:

1. OE-101-CS-T : Office Automation I
2. OE-102-CS-T : Introduction to Computers and Basics of Internet
3. OE-103-CS-T : Introduction to Google Apps I
4. OE-104-CS-T : Introduction to Computers I

The students of B.Sc (AI &ML) will opt the subjects offered by other faculty given in University Basket

Level:- 4.5 (First Year) **SEMESTER II**

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Subject-1	AIML-151-T	Introduction to Python Programming	2	--	2	-	15	35	50
	AIML-152-P	Practical based on AIML-151-T	--	2	--	4	15	35	50
Subject-2	MTS-151-T	Graph Theory	2	--	2	-	15	35	50
	MTS-152-P	Practical based on MTS-151-T	--	2	--	4	15	35	50
Subject-3	STS-151-T	Continuous Probability Distributions and Testing of Hypothesis	2	--	2	-	15	35	50
	STS-152-P	Practical based on STS-151-T	--	2	--	4	15	35	50
GE /OE	OE-151-AIML-T	From University Basket*	2	--	2	--	15	35	50
SEC	SEC-151-AIML-T	Databases – I	2	--	2	--	15	35	50
AEC	AEC-151-ENG	English	2	--	2	--	15	35	50
VEC	VEC-151-ENV	EVS-II	2	--	2	--	15	35	50
CC	CC-151-PE/ NSS /NCC	From University Basket	2	--	2	--	15	35	50
		Total	**16**	**06**	**16**	**12**			**550**

*Open Elective (OE) Subjects offered to students from other than science faculty are:

1. OE-151-CS-T : Office Automation II
2. OE-152-CS-T : Computer Fundamentals
3. OE-153-CS-T : Introduction to Google Apps II
4. OE-154-CS-T : Introduction to Computers II

The students of B.Sc (AI &ML) will opt the subjects offered by other faculty given in University Basket

Exit option: Award of UG Certificate in Major with 44 credits and an additional 4 credits core as per university guidelines **OR** Continue with Major and Minor

Continue option: Student will select one subject among the (subject 2 and subject 3) as minor and subject 1 will be major subject.

Level:- 5.0 (Second Year) **SEMESTER III**

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Mandatory	AIML-201-MJ-T	Data Structures (using Python)	2	--	2	--	15	35	50
	AIML-202-MJ-T	Software Engineering	2	--	2	--	15	35	50
	AIML-203MJ-P	Lab course on AIML201MJ + AIML202MJ	--	2	--	4	15	35	50
VSC	AIML-221-VSC-P	Advanced Python Programming	--	2	--	4	15	35	50
IKS	AIML-201-IKS	Computing in Ancient India	2	--	2	--	15	35	50
FP/OJT/ CEP	AIML-231-FP	Mini Project	--	2	--	4	15	35	50
Minor	AIML-241-MN-T	Linear Algebra	2	--	2	--	15	35	50
	AIML-242-MN-P	Practical on AIML241MN	--	2	--	4	15	35	50
GE/OE	OE-201-AIML-T	From University Basket*	2	--	2	--	15	35	50
AEC	AEC-201-ENG	From University Basket	2	--	2	--	15	35	50
CC	CC-201-PE/NSS /NCC	From University Basket	2	--	2	--	15	35	50
		Total	**14**	**08**	**14**	**16**			**550**

*Open Elective (OE) Subjects offered to students from other than science faculty are:

1. OE-201-CS-T : E commerce I
2. OE-202-CS-T : Web Design I
3. OE-203-CS-T : Digital Marketing I

The students of B.Sc (AI &ML) will opt the subjects offered by other faculty given in University Basket

Level:- 5.0 (Second Year) **SEMESTER IV**

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Mandatory	AIML-251-MJ-T	Microservices using Python	2	--	2	--	15	35	50
	AIML-252-MJ-T	Artificial Intelligence - I	2	--	2	--	15	35	50
	AIML-253-MJ-P	Practical based on AIML251MJ + AIML252MJ	--	2	--	4	15	35	50
VSC	AIML-221-VSC-P	Databases – II	--	2	--	4	15	35	50
FP/OJT/ CEP	AIML-241-FP	Mini Project	--	2	--	4	15	35	50
Minor	AIML-241-MN-T	Logic	2	--	2	--	15	35	50
	AIML-242-MN-P	Practical based on AIML241MN	--	2	--	4	15	35	50
GE/OE	OE-251-AIML-T	From University Basket*	2	--	2	--	15	35	50
SEC	SEC-251-AIML-P	DAA - I (Brute Force, D&C, Greedy, Dynamic Programming)	--	2	--	4	15	35	50
AEC	AEC-251-SUB	From University Basket	2	--	2	--	15	35	50
CC	CC251PE/NSS/NCC	From University Basket	2	--	2	--	15	35	50
		Total	**12**	**10**	**12**	**20**			**550**

*Open Elective (OE) Subjects offered to students from other than science faculty are:

1. OE-251-CS-T : E commerce II
2. OE-252-CS-T : Web Design II
3. OE-253-CS-T : Digital Marketing II

Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4 credits core as per university guidelines **OR** Continue with Major and Minor

Level:- 5.5 (Third Year) **SEMESTER V**

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Mandatory	AIML-301-MJ-T	Artificial Intelligence - II	2	--	2	--	15	35	50
	AIML-302-MJ-T	Machine Learning Techniques – I (Supervised)	2	--	2	--	15	35	50
	AIML-303-MJ-T	Data Preparation and Visualization	2	--	2	--	15	35	50
	AIML-304-MJ-T	DAA - II (Backtracking, B&B, Randomized, P&NP and approximation algos)	2	--	2	--	15	35	50
	AIML-305-MJ-P	Practical based on AIML301MJ	--	2	--	4	15	35	50
	AIML-306-MJ-P	Practical based on AIML302MJ & AIML303MJ	--	2	--	4	15	35	50
Major Elective	AIML-310-MJ-T	Big Data Analytics	2	--	2	--	15	35	50
	AIML-311-MJ-P	Practical based on AIML306MJ	--	2	--	4	15	35	50
	OR								
	AIML-312-MJ-T	MEAN – I	2	--	2	--	15	35	50
	AIML-313-MJ-P	Practical based on AIML308MJ	--	2	--	4	15	35	50
	OR								
	AIML-314-MJ	Mobile app development	2	--	2	--	15	35	50
	AIML-315-MJ-P	Practical based on AIML310MJ	--	2	--	4	15	35	50
VSC	AIML-321-VSC-P	Linux Shell Scripting	--	2	--	4	15	35	50
FP / OJT/ CEP	AIML-331-FP	Project	--	2	--	4	15	35	50
Minor	AIML-341-MN-T	Calculus for ML	2	--	2	--	15	35	50
		Total	**12**	**10**	**12**	**20**			**550**

Level:- 5.5 (Third Year) SEMESTER VI

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Mandatory	AIML-351-MJ-T	Optimization Techniques	2	--	2	--	15	35	50
	AIML-352-MJ-T	Machine Learning Techniques – II	2	--	2	--	15	35	50
	AIML-353-MJ-T	Data Mining Techniques	2	--	2	--	15	35	50
	AIML-354-MJ-T	Evolutionary Algorithms (FL, GA)	2	--	2	--	15	35	50
	AIML-355-MJ-P	Practical based on AIML351MJ	--	2	--	4	15	35	50
	AIML-356-MJ-P	Practical based on AIML352MJ & AIML353MJ	--	2	--	4	15	35	50
Major Elective	AIML-360-MJ-T	Business Intelligence (Atoti)	2	--	2	--	15	35	50
	AIML-361-MJ-P	Practical based on AIML357MJ	--	2	--	4	15	35	50
	OR								
	AIML-362-MJ-T	MEAN II	2	--	2	--	15	35	50
	AIML-363-MJ-P	Practical based on AIML359MJ	--	2	--	4	15	35	50
	OR								
	AIML-364-MJ-T	Game Theory	2	--	2	--	15	35	50
	AIML-365-MJ-P	Practical based on AIML361MJ	--	2	--	4	15	35	50
VSC	AIML-371-VSC-P	Database Technologies (Unstructured Databases)		2		4	15	35	50
FP / OJT/ CEP	AIML-381-OJT	On Job Training	--	4	--	8	30	70	100
		Total	**10**	**12**	**10**	**24**			**550**

Honors with Research Degree

Level:- 6.0 (Fourth Year) **SEMESTER VII**

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Mandatory	AIML-401-MJ-T	Deep Learning – I	2	--	2	--	15	35	50
	AIML-402-MJ-T	Natural Language Processing - I	2	--	2	--	15	35	50
	AIML-403-MJ-T	Software Design and Software Architectures	2	--	2	--	15	35	50
	AIML-404-MJ-P	Practical based on AIML401MJ	--	2	--	4	15	35	50
	AIML-405-MJ-P	Practical based on AIML402MJ	--	2	--	4	15	35	50
Major Elective	AIML-410-MJ-T	Cloud computing	2	--	2	--	15	35	50
	AIML-411-MJ-P	Practical based on AIML406MJ	--	2	--	4	15	35	50
	OR								
	AIML-412-MJ-T	Theory of Computation (TCS)	2	--	2	--	15	35	50
	AIML-413-MJ-P	Practical based on AIML408MJ	--	2	--	4	15	35	50
	OR								
	AIML-414-MJ-T	C# .NET Programming	2	--	2	--	15	35	50
	AIML-415-MJ-P	Lab Course on CS410MJ	--	2	--	4	15	35	50
FP/OJT/ CEP/RP	AIML-431-RP	Research Project	--	4	--	8	30	70	100
RM	AIML-441-RM	Research Methodology	4	--	4	--	30	70	100
		Total	**12**	**10**	**10**	**20**			**550**

OR

Honors Degree

Level:- 6.0 (Fourth Year) **SEMESTER VII**

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Mandatory	AIML-401-MJ-T	Deep Learning	4	--	4	--	30	70	100
	AIML-402-MJ-T	Natural Language Processing – I	2	--	2	--	15	35	50
	AIML-403-MJ-T	Software Design and Software Architectures	4	--	4	--	30	70	100
	AIML-404-MJ-P	Practical based on AIML401MJ	--	2	--	4	15	35	50
	AIML-405-MJ-P	Practical based on AIML402MJ	--	2	--	4	15	35	50
Major Elective	AIML-410-MJ-T	Cloud computing	2	--	2	--	15	35	50
	AIML-411-MJ-P	Practical based on AIML406MJ	--	2	--	4	15	35	50
	OR								
	AIML-412-MJ-T	Theory of Computation (TCS)	2	--	2	--	15	35	50
	AIML-413-MJ-P	Practical based on AIML408MJ	--	2	--	4	15	35	50
	OR								
	AIML-414-MJ-T	C# .NET Programming	2	--	2	--	15	35	50
	AIML-415-MJ-P	Lab Course on CS410MJ	--	2	--	4	15	35	50
RM	AIML-441-RM	Research Methodology	4	--	4	--	30	70	100
		Total	**12**	**10**	**10**	**20**			**550**

Honors with Research Degree

Level:- 6.0 (Fourth Year) **SEMESTER VIII**

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Mandatory	AIML-451-MJ-T	Deep Learning – II	2	--	2	--	15	35	50
	AIML-452-MJ-T	Natural Language Processing – II	2	--	2	--	15	35	50
	AIML-453-MJ-T	Cryptography	4	--	4	--	30	70	100
	AIML-454-MJ-P	Practical based on AIML451MJ	--	2	--	4	15	35	50
	AIML-455-MJ-P	Practical based on AIML452MJ	--	2	--	4	15	35	50
Major Elective	AIML-460-MJ-T	DevOps	2	--	2	--	15	35	50
	AIML-461-MJ-P	Practical Based on AIML456MJ	--	2	--	4	15	35	50
	OR								
	AIML-462-MJ-T	Data Analytics	2	--	2	--	15	35	50
	AIML-463-MJ-P	Practical Based on AIML458MJ	--	2	--	4	15	35	50
	OR								
	AIML-464-MJ-T	Computer Vision (Img Processing)	2	--	2	--	15	35	50
	AIML-465-MJ-P	Practical Based on AIML460MJ	--	2	--	4	15	35	50
FP/OJT/ CEP	AIML-481-RP	Research Project	--	8	--	16	60	140	200
		Total	**08**	**14**	**08**	**28**			**550**

OR

Honors Degree

Level:- 6.0 (Fourth Year) **SEMESTER VIII**

Course Type	Course code	Course Name	Credits		Teaching Scheme Hrs/Week		Examination Scheme and Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Mandatory	AIML-451-MJ-T	Deep Learning – II	4	--	4	--	30	70	100
	AIML-452-MJ-T	Natural Language Processing – II	2	--	2	--	15	35	50
	AIML-453-MJ-T	Cryptography	4	--	4	--	30	70	100
	AIML-454-MJ-P	Practical based on AIML451MJ	--	2	--	4	15	35	50
	AIML-455-MJ-P	Practical based on AIML452MJ	--	2	--	4	15	35	50
Major Elective	AIML-456-MJ-T	DevOps	2	--	2	--	15	35	50
	AIML-457-MJ-P	Practical Based on AIML456MJ	--	2	--	4	15	35	50
	OR								
	AIML-458-MJ-T	Theory of Computation (TCS)	2	--	2	--	15	35	50
	AIML-459-MJ-P	Practical based on AIML408MJ	--	2	--	4	15	35	50
	OR								
	AIML-460-MJ-T	C# .NET Programming	2	--	2	--	15	35	50
	AIML-461-MJ-P	Lab Course on CS410MJ	--	2	--	4	15	35	50
OJT	AIML-481-OJT	On Job Training	4	--	4	--	30	70	100
		Total	**12**	**10**	**10**	**20**			**550**

F.Y. B.Sc. (AI and ML)
Semester – I
AIML-101-T - Object Oriented Concepts and Programming using C++

No. of Credits: 2	Teaching scheme: Theory: 2 hrs/week	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Lectures: 30

Prerequisites: None

Objectives:
The course is designed to teach:

1. the syntax and semantics of the C++ programming language.
2. designing C++ classes for code reuse.
3. implementation of copy constructors and class member functions.
4. understand the concept of data abstraction and encapsulation.
5. apply function and operator overloading in C++.
6. how containment and inheritance promote code reuse in C++.
7. teach how inheritance and virtual functions implement dynamic binding with polymorphism.
8. designing and implementation of generic classes with C++ templates.
9. Use of exception handling in C++ programs.

Contents:

Unit	Contents	Number of lectures	Text Book
1	Object Oriented (OO) concepts- Features – abstraction, encapsulation, inheritance, polymorphism, advantages and applications of OO concepts Introduction to C++ - Data types, new operator and keywords, using namespace concept, cin and cout, Simple C++ program, introduction to reference variables, Classes and Objects, usage of 'this' pointer, access specifiers, defining data members and member functions	**8**	**1,2**
2	Array of objects, inline functions – concept and applications, call by reference, return by reference, function and operator overloading and default arguments, static class members, friend concept – Function, Class, constructors and destructors, types of constructors, memory allocation (new and delete operators), overloading unary and binary operators, overloading using friend function, type casting and type conversion.	**10**	**1,2**
3	Inheritance- Types of inheritance with examples, Constructors and destructor in derived classes, Virtual base classes, Virtual functions and Pure virtual functions, Abstract base classes, Managing Input and Output using C++: stream classes	**8**	**1,2,3**
4	Templates- Introduction to templates, Class templates, function templates and overloading of function templates,	**4**	**1,2,3**

	Templates with multiple parameters Exception Handling in - try, catch and throw primitives		

Course Outcomes:

After competing this course, a student will be able to:

1. Describe and explore programming basics and OOPs concepts
2. Understand tokens, expressions, and control structures, use functions and pointers in a C++ program, manage Input and Output Data
3. Explain arrays and strings and create programs using them
4. Implementing OOPs Concepts in C++: - Defining classes, describe and use constructors and destructors, static and friend classes, virtual and abstract classes
5. Implementing inheritance and polymorphism using C++
6. Demonstrate how to control errors with exception handling

Text books:

1. Robert Lafore, Object Oriented Programming in C++ 4e Paperback – 1, Pearson Education India; 4th edition (1 January 2008), ISBN13: 978-8131722824
2. Bjarne Stroustrup, C++ Programming Language, Pearson Education; 4th edition (31 May 2022); ISBN13: 978-9356060135
3. E. Balagurusamy, Object Oriented Programming with C++, 8th Edition, McGraw Hill, 2020, ISBN13: 978-9389949186

Reference Books:

1. Behrouz A. Forouzan, Richard F. Gilberg, C++ Programming: An Object-Oriented Approach, McGraw Hill, First Edition, 2022, ISBN: 978-9355321305
2. Herbert Schildt, The Complete Reference C++, McGraw Hill Education, 4th edition, 2017, ISBN: 978-0070532465
3. Stanley Lippman, Josée Lajoie, Barbara Moo, C++ Primer, Addison-Wesley, 5th edition, 2012, ISBN: 978-0321714114
4. Stephen Prata, C++ Primer Plus, Pearson Education India, 6th edition, 2015, ISBN: 978-9332546189

Format of theory paper for all F.Y. B.Sc (AI&ML) Computer science subjects

External Examination: 35 marks **Duration: 2.0 Hours**

Question No.	Total number of questions		Marks			Question Pattern
	Total	Compulsory	Each question	With Option Total Marks	Total Marks	
1	8	8	1	8	8	Theory
2	6	4	2	12	8	Theory+ Problems/ Programs
3	3	2	4	12	8	Theory+ Problems/ Programs
4	3	2	4	12	8	Theory+ Problems/ Programs
5	2	1	3	6	3	Theory+ Problems/ Programs
			Total Marks	50	35	

F.Y. B.Sc. (AI and ML)
Semester – I
AIML-102-P: Practical based on AIML-101-T
(Object Oriented Concepts and Programming using C++)

No. of Credits: 2	Practicals per week: 1 (4 hrs)	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Practicals: 15

Pre-requisites: None

Objectives:
The course is designed to teach:

1. implementation of basic C++ class concepts – abstraction and encapsulation, creating objects
2. usage of access specifiers, static variables, static functions aliases, constants and namespaces
3. implementing function and operator overloading
4. implementing all types of inheritance
5. usage of exceptions to handle runtime errors
6. defining template and its usage

Contents:

Unit	Practical based on AIML-101-T
1	Simple C++ programs on variables, data types, input, output, decision statements
2	Simple C++ programs on loops, alias, const, standard namespace
3	Programs on using access specifiers, use of static variables, alias, const
4	Programs on creating classes and objects, implementing member functions and data with different access specifiers
5	Programs on using this pointer, constructors, destructors, Function - inline, static and constant
6	Programs related to creating and using array of objects
7	Programs based on Functions overloading
8	Programs based on operator overloading
9, 10	Programs on multilevel inheritance
11,12	Programs on multiple inheritance
13	Programs on virtual classes
14	Programs on exception handling
15	Programs based on templates

Note: A Lab book shall be prepared related to the practicals that a student needs to perform.

Course Outcomes:
After competing this course, a student will be able to:

1. Design classes and Create objects of classes
2. Use access specifiers to effectively manage access to data & functions in a class
3. Apply the concepts of object-oriented programming using C++
4. Demonstrate how to handle run-time errors with exception handling

References:

1. Robert Lafore, Object Oriented Programming in C++ 4e Paperback – 1, Pearson Education India; 4th edition (1 January 2008), ISBN13: 978-8131722824
2. Bjarne Stroustrup, C++ Programming Language, Pearson Education; 4th edition (31 May 2022); ISBN13: 978-9356060135
3. E. Balagurusamy, Object Oriented Programming with C++, 8th Edition, McGraw Hill, 2020, ISBN13: 978-9389949186

Format of Practical slips for all F.Y. B.Sc (AI&ML) Computer science practicals

External Examination: 35 marks **Duration: 3.0 Hours**

Question No.	Description	Marks
1	Program – 1 (Simple)	10
2	Program – 2 (Complex)	20
3	Viva	5
	Total	35

F.Y. B.Sc. (AI and ML)
Semester – I
MTS-101-T – Discrete Mathematics for Computer Science

No. of Credits: 2	Teaching scheme: Theory: 2 hrs/week	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Lectures: 30

Prerequisites: None

Objectives:
The course is designed to teach:

1. The basic concepts of sets, set operations, principle of inclusion-exclusion
2. The concepts of relations and its properties
3. Functions and its types
4. Elementary combinatorics
5. The concept of recurrence relations, modelling a recurrence relation and obtaining its solution

Unit	Contents	Number of lectures	Text Book
1	**Set Theory -** Revision of Describing Sets Mathematically, Set Membership, Equality of Sets, Finite and Infinite Sets, Power Set, Cartesian Product, Properties of Sets, Vector Implementations of Sets. **Operations on Sets**- Union and Intersection, Set Difference, Complements, and DeMorgan's Laws, Power Sets and Products **The Principle of Inclusion-Exclusion** - Finite Cardinality, Principle of Inclusion-Exclusion for Two Sets, Principle of Inclusion-Exclusion for Three Sets, Principle of Inclusion-Exclusion for Finitely Many Sets, Pigeon- hole principle and its applications, Generalized pigeon hole	**8**	**T1**
2	**Relations:** Properties of Binary Relations, Equivalence Relation, Transitive closure, Compatibility and Partial ordering relations, Poset and Hasse diagram, Functions: inverse Function, Composition of functions, Recursive Functions.	**8**	**T1**
3	**Elementary Combinatorics**: Basis of counting, basics Combinations & Permutations, addition and multiplication principle	**6**	**T1, T2**
4	**Recurrence Relations:** Introduction Recurrence relations and modelling of a recurrence relation, solving homogenous linear recurrence using characteristic polynomial, Solving recurrence relation by substitution, recurrence tree method, Masters' theorem	**8**	**T1**

Course Outcomes:
After completing the course, the student will be able to:

1. Use logical notation to define and reason mathematically about the fundamental data types and structures (such as numbers, sets) used in computer algorithms and systems.

2. Identify and Apply properties of combinatorial structures and properties - know the basic techniques in combinatorics and counting.
3. Analyze sets with operations, and identify their structure, reason and conclude properties about the structure based on the observations.
4. Gain the conceptual background needed to be able to identify recurrence relations, model recurrence relation and obtain a solution to it.

Text book:

1. Kenneth H. Rosen, *Discrete Mathematics and its Applications,* Tata McGraw Hill Publishers, seventh Edition, 2007
2. Ralph P. Grimaldi, *Discrete and Combinatorial Mathematics*, Pearson, 2006, 5th Edition, ISBN: 9788177584240

Reference Books:

1. Ronald Graham, Donald Knuth, and Oren Patashnik, *Concrete Mathematics*, Pearson Education Publishers, 2nd Edition, 1996.
2. Peter J. Cameron, *Combinatorics: Topics, Techniques, Algorithms*, Cambridge University Press, 1994 (reprinted 1996).

Format of theory paper for all F.Y. B.Sc (AI&ML) Mathematics subjects

External Examination: 35 marks **Duration: 2.0 Hours**

Question No.	Total number of questions		Marks			Question Pattern
	Total	Compulsory	Each question	With Option Total Marks	Total Marks	
1	6	5	2	12	10	Theory+Problems
2	5	3	5	25	15	Theory+Problems
3	2	1	10	20	10	Theory+Problems
	Total Marks			57	35	

F.Y. B.Sc. (AI and ML)
Semester – I
MTS-102-P – Practical course based on Discrete Mathematics for Computer Science (MTS-101-T)

No. of Credits: 2	Practicals per week: 1 (4 hrs)	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Practicals: 15

Pre-requisites: None

Objectives:
The course is designed to teach:

1. Solve problems based on set theory
2. Solve problems based on relations and functions
3. Solve problems based on elementary Combinatorics
4. Derive a recurrence relation, obtain a solution to a recurrence relation using different methods

Contents:

Unit	Practical based on MTS-101-T
1	Problems based on Set theory, Operations on sets
2,3	Problems based on Principle of Inclusion-exclusion
4,5	Problems based on Relations and Functions
6	Problems based on Pigeon hole principle
7,8	Problems based on Counting, Combinatorics
9 to 11	Problems based on Addition and multiplication principle
12 to 15	Problems based on Deriving a recurrence relation, solving a recurrence relation using different methods

Course Outcomes:
After competing this course, a student will be able to:

1. Solve problems on sets and set operations
2. Solve problems on relations and functions
3. Define recurrence relations and obtain solution to it
4. Solve problems related to counting and combinatorics

References:

1. Kenneth H. Rosen, *Discrete Mathematics and its Applications,* Tata McGraw Hill Publishers, seventh Edition, 2007
2. Ralph P. Grimaldi, *Discrete and Combinatorial Mathematics*, Pearson, 2006, 5th Edition, ISBN: 9788177584240

Format of Practical slips for all F.Y. B.Sc (AI&ML) Mathematics related practicals

External Examination: 35 marks **Duration: 3.0 Hours**

Slip consists of

(i) Question 1 – 5 x 2 =10 Marks
(ii) Question 2 – 5 x 2 = 10 Marks
(iii) Question 3 – 10 x1 = 10 Marks
(iv) Viva – 05 Marks

F.Y. B.Sc. (AI and ML)
Semester – I
STS-101-T – Notion of Statistical Data Analysis

No. of Credits: 2	Teaching scheme: Theory: 2 hrs/week	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Lectures: 30

Prerequisites: None

Objectives:
The course is designed to teach:

- methods in descriptive statistics
- the use of concepts in descriptive statistics as applied to real data
- methods for finding correlation between variables
- fitting an equation for prediction and apply the same for real data

Unit	Contents	Number of lectures	Text Book
1	**Data condensation and Graphical methods –** Raw data, attributes and variables, discrete and continuous variables. Presentation of data using frequency distribution and cumulative frequency distribution. (Construction of frequency is not expected) Graphical Presentation of frequency distribution – histogram, stem and leaf chart, less than and more than type ogive curves. Numerical problems related to real life situations.	**5**	**T1,T2,T3**
2	**Descriptive Statistics -** Measures of Central tendency: Mean, Mode, Median. Examples where each one of these is most appropriate. Partition values: Quartiles, Box-Plot. **Measures of Dispersion**: Range, Coefficient of range, Quartile deviation, Coefficient of quartile deviation, Variance, Standard Deviation, Coefficient of Variation. (for raw data, ungrouped frequency distribution and exclusive type grouped frequency distribution)	**7**	**T1,T2,T3**
3	**Moments** Raw and Central moments: definition, computations for ungrouped and grouped data (only up to first four moments). Relation between raw and central moments up to fourth order. Numerical problems related to real life situations.	**3**	**T1,T2,T3**
4	**Skewness, Kurtosis and its measures.** Concept of symmetric frequency distribution, skewness, positive and negative skewness. Measures of skewness-Pearson's measure, Bowley's measure, β_1, γ_1. Kurtosis of a frequency distribution, types of kurtosis: leptokurtic, platykurtic and mesokurtic, measure of	**5**	**T1,T2,T3**

	kurtosis (β_2,γ_2) based upon moments. Numerical problems related to real life situations.		
5	**Correlation and Linear Regression (for bivariate raw data)** Bivariate data, Scatter diagram. Correlation, Positive Correlation, Negative Correlation, Zero Correlation. Karl Pearson's coefficient of correlation (r), limits of r ($-1 \leq r \leq 1$), interpretation of r, Coefficient of determination (R^2), Auto-correlation coefficient upto lag 2. Meaning of regression. Fitting of line y = a+bx using least square method. Concept of residual plot and mean residual sum of squares. Numerical Problems	**10**	**T1,T2,T3,T4**

Course Outcomes:

After completing the course, the student will be able to:

- summarize data visually and numerically
- analyse a problem, identify methods in descriptive statistics and define the computing requirements appropriate to its solution
- identify correlation between variables, and fit an equation for prediction and apply the same for real data and assess data-based models
- execute statistical analysis with any software tool

Text Books

1) Statistical Methods, G.W. Snedecor, W.G. Cochran, John Wiley & sons, 1991, Eight Edition
2) Fundamentals of Applied Statistics, Gupta and Kapoor, S.Chand and Sons, New Delhi, 2014, Fourth Edition
3) An Introductory Statistics, Kennedy and Gentle.
4) Introduction to Linear Regression Analysis, Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, Wiley, 2012, Fifth Edition

Format of theory paper for all F.Y. B.Sc (AI&ML) Statistics subjects

External Examination: 35 marks **Duration: 2.0 Hours**

Question No.	Total number of questions		Marks			Question Pattern
	Total	Compulsory	Each question	With Option Total Marks	Total Marks	
1	5	5	1	5	5	Theory+Problems
2	5	3	4	20	12	Theory+Problems
3	5	3	4	20	12	Theory+Problems
4	2	1	6	12	6	Theory+Problems
	Total Marks			57	35	

F.Y. B.Sc. (AI and ML)
Semester – I
STS-102-P – Practical course based on STS-101-T : Notion of Statistical Data Analysis

No. of Credits: 2	Practicals per week: 1 (4 hrs)	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Practicals: 15

Pre-requisites: None

Objectives:
The course is designed to teach:

- the concept of descriptive statistics for real data.
- methods for finding correlation between variables.
- fitting of linear equation and nonlinear curve for prediction and apply the same for real data.
- implementation all above methods using R software.

Contents:

Unit	Practical based on STS-101-T
1, 2, 3	Introduction to R software.
4,5	Graphical methods of data presentation
6,7	Measures of Central Tendency and Dispersion.
8,9	Measures of moments, skewness and kurtosis
10,11	Corelation examples
12 to 15	Regression examples with plots

Course Outcomes:
After competing this course, a student will be able to:

1. Use various graphical methods to represent data
2. Obtain measures of central tendency on data sets
3. Obtain moments, skewness, kurtosis on data sets
4. Use R methods to extract the correlations in data sets
5. Apply regression on data sets

References:

1) Statistical Methods, G.W. Snedecor, W.G. Cochran, John Wiley & sons, 1991, Eight Edition
2) Fundamentals of Applied Statistics, Gupta and Kapoor, S.Chand and Sons, New Delhi, 2014, Fourth Edition
3) An Introductory Statistics, Kennedy and Gentle.
4) Introduction to Linear Regression Analysis, Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, Wiley, 2012, Fifth Edition

Format of Practical slips for all F.Y. B.Sc (AI&ML) Statistics related practicals

External Examination: 35 marks **Duration: 3.0 Hours**

1. Viva based on Project -05 Marks
2. Project Report – 10 Marks
3. R Program 1 – 10 Marks
   R Program 2 – 05 Marks
   R Program 3 – 05 Marks

F.Y. B.Sc. (AI and ML)
Semester – I
SEC-151-AIML-T: Basic Probability theory and discrete distributions
(Skill Enhancement course)

No. of Credits: 2	Teaching scheme: 2 hrs/week	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Lectures: 30

Pre-requisites: None

Objectives:

- To teach basic probability theory
- To teach basics of conditional probability, Bayes theorem and its applications
- To teach concepts of discrete random variables
- To teach the concept, types and use of discrete probability distributions

Contents:

Unit	Contents	Number of lectures	Text Book
1	**Basic Theory of Probability** Counting Principles, Permutations and Combinations, Deterministic and non-deterministic models. Random Experiment, Sample Spaces (finite and countably infinite) Events: types of events, Operations on events. Probability - classical definition, probability models, axioms of probability, probability of an event. Theorems of probability (with proof) i) $0 \leq P(A) \leq 1$ ii) $P(A) + P(A') = 1$ iii) $P(A) \leq P(B)$ when $A \subset B$ iv) $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ Numerical problems related to real life situations.	**5**	**5,6,7,8,9**
2	**Basic Notion of Probability Theory** Concepts and definitions of conditional probability, multiplication theorem $P(A \cap B)=P(A).P(B\|A)$ Bayes' theorem (without proof) Concept of Posterior probability, problems on posterior probability. Definition of sensitivity of a procedure, specificity of a procedure. Application of Bayes' theorem to design a procedure for false positive and false negative. Concept and definition of independence of two events. Numerical problems related to real life situations.	**10**	**5,6,7,8,9**
3	**Discrete Random variable and Standard Discrete Distributions-** Definition of a random variable and discrete random variable. Definition of probability mass function, distribution function and its properties. Definition of expectation and variance, theorem on expectation. Numerical problems related to real life situations.	**15**	**5, 6, 7**

	Discrete Uniform Distribution: definition, mean, variance. Bernoulli Distribution: definition, mean, variance, additive property. Binomial Distribution: definition, mean, variance, additive property. Geometric Distribution (p.m.f $p(x) = pq^x$, x = 0,1,2.....): definition, mean, variance. Poisson Distribution: definition, mean, variance, mode, additive property, limiting case of B (n, p) Illustration of real-life situations. Numerical problems related to real life situations		

Course Outcomes:

After successful completion of this course, student will be able to:

1. analyse a problem, identify the methods in basic probability theory
2. use of conditional probability
3. apply bayes theorem in real-life situations
4. identify the various distribution for given data sets

Text Books

1) Statistical Methods, G.W. Snedecor, W.G. Cochran, John Wiley & sons, 1991, Eighth Edition
2) Fundamentals of Applied Statistics, Gupta and Kapoor, S.Chand and Sons, New Delhi, 2014, Fourth Edition
3) An Introductory Statistics, Kennedy and Gentle.
4) Modern Elementary Statistics, Freund J.E., Pearson Publication, 2006, Twelfth Edition.
5) Probability, Statistics, Design of Experiments and Queuing theory with applications Computer Science, Trivedi K.S., Prentice Hall of India, New Delhi,2001, Second Edition.
6) A First course in Probability, Ross, Pearson Publication, 2013, Ninth Edition.
7) A First Course in Probability and Statistics, L. S. Prakasa Rao, World Scientific Publishing Co Pte Ltd, 2008.
8) Applied Probability Models, D. L. Minh, Brooks/Cole, 2000.

F.Y. B.Sc. (AI and ML)
Semester – II
AIML-151-T - Introduction to Python Programming

No. of Credits: 2	Teaching scheme: Theory: 2 hrs/week	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Lectures: 30

Prerequisites: None

Objectives:
The course is designed to teach:

1. the Python environment, data types, operators used in Python.
2. the use of control structures and numerous native data types with their methods.
3. the design and implement user defined functions, modules, and packages and exception handling methods.
4. creating and handling files in Python
5. Object Oriented Programming (OOP) Concepts
6. the semantics of Python programming language and illustrate the process of structuring the data using lists, dictionaries, tuples, strings and sets.

Contents:

Unit	Contents	Number of lectures	Text Book
1	**Introduction to Python:** use of Jupyter / IDLE/ CoLAB to develop programs, Features of Python, Limitations, Major Applications of Python **Python Data Types & Input/Output:** Keywords, Identifiers, Python Statement, Indentation, Documentation, Variables, Multiple Assignment, Understanding Data Type, Data Type Conversion, Python Input and Output Functions, Import command. **Operators and Expressions**: Operators in Python, Expressions, Precedence, Associativity of Operators, Non-Associative Operators, Interactive Mode and Script Mode, Order of Operations. **Control Structures**: Decision making statements, loops, control statements. **Python Native Data Types:** Numbers, Lists, Tuples, Sets, Dictionary, Functions & Methods of Dictionary	**8**	**1**
2	**Strings:** String as a sequence, traversal with a for loop, string slices and dices, strings Are immutable, searching, looping and counting, string methods, the in operator, string comparison, string operations **Python Functions**: Function calls, type conversion functions, math functions, user defined functions - definitions and uses, parameters and arguments, variables and parameters Are Local, stack diagrams, fruitful functions and void functions, importing with	**8**	**1,2**

	from, return values, composition, boolean functions, recursion, checking types		
3	**Python Modules**: Module definition, need of modules, creating a module, importing module, Path Searching of a Module, Module Reloading, Standard Modules, Python Packages. **Classes in Python**: OOPS Concepts, Classes and objects, Classes in Python, Constructors, Data hiding, Creating Classes, Instance Methods, Instances as return values, Special Methods, Class Variables, Inheritance, Polymorphism, Type Identification, Iterators, generators and decorators.	**12**	**1,2**
4	**File Management in Python**: Operations on files (opening, modes, attributes, encoding, closing), read() & write() methods, tell() & seek() methods, renaming & deleting files in Python, directories in Python. **I/O and Error Handling in Python**: Introduction, Data Streams, Creating Your Own Data Streams, Access Modes, Writing Data to a File, Reading Data from a File, Additional File Methods, Working with Directories. **Exception Handling:** Exceptions, Built-in exceptions, Exception handling, User defined exceptions in Python, Handling IO Exceptions, Errors, Run Time Errors, The Exception Model, Exception Hierarchy, Handling Multiple Exceptions.	**12**	**1,2**

Course Outcomes:

On successful completion of the course student shall be able to:

1. interpret the basic principles of Python programming language
2. articulate the Object-Oriented Programming concepts such as encapsulation, inheritance and polymorphism, code reuse as used in Python
3. solve, test and debug basic problems using python script
4. manipulate python programs by using the python data structures like lists, dictionaries, tuples, strings and sets.
5. design object-oriented programs with Python classes.
6. identify the commonly used operation involved in files for I/O processing
7. familiarize the handling of I/O Exceptions and usage of Directories, Identify the commonly used operations involving file systems and regular expressions.

Text Books:

1. Pooja Sharma, Programming in Python, BPB Publications, 2017, ISBN: 978-9386551276
2. R. NageswaraRao, Core Python Programming, Dreamtech Press, 3rd Edition, ISBN: 978-9390457151

Reference Books:

1. Dr. Marlapalli Krishna, S. Jaya Prakash, K. Varada Rajkumar, Basic Python Programming for Beginners, Bluerose Publishers Pvt. Ltd., 2021, ISBN: 978-9354720604

2. Martin C. Brown, Python: The complete Reference, McGraw Hill Education, 2018, ISBN: 978-9387572942
3. Martelli A., A. Ravenscroft, S. Holden, Python in a Nutshell, OREILLY.
4. Reema Thareja, Python Programming, OUP India, Oxford University Press India, 2nd edition, 2023, ISBN: 978-9354973765
5. Christos Manola, Dimitrios Xanthidis, Han-I Wang, Ourania K. Xanthidou, Handbook of Computer Programming with Python, CRC Press; 1st edition, 2022, ISBN: 978-0367687779

F.Y. B.Sc. (AI and ML)
Semester – II
AIML-152-P: Practical based on Introduction to Python Programming (AIML-151-T)

No. of Credits: 2	Practicals per week: 1 (4 hrs)	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Practicals: 15

Pre-requisites: None

Objectives:
The course is designed to teach:

1. The Use of Python IDE, data type, I/O
2. The use of decision statements and loop statements
3. Ways of Implementing functions, parameter passing, returning value from function and the types of functions
4. The use of strings and string manipulations
5. The use of arrays and array operations
6. Implementation of python modules
7. Handling files, reading and writing to files and other file operations
8. Implementing Object Oriented programming (OOP) concepts in Python

Contents:

Unit	Practical based on AIML-151-T
1, 2,3, 4	Python IDE, anaconda/pip, Basic python – datatypes, control statements – decision making, loops, Operators, I/O, native data types
5,6	Python functions
7,8	Python Strings and string manilation
9, 10	Python arrays and operations on arrays (slice n dice etc.)
11	Modules – standard modules, user defined
12, 13	File handling
14, 15	OOP concept implementation

Note: A Lab book shall be prepared related to the practicals that a student needs to perform.

Course Outcomes:
After competing this course, a student will be able to:

1. Solve simple problems using basic python
2. Use control statements for decision making and looping
3. Use arrays to store related data
4. Apply OOP concepts to solve problems related to real-world applications
5. Use files manipulation statements to store data on secondary device
6. Handle runtime-errors using exceptions
7. Use python IDE effectively

References:

1. Pooja Sharma, Programming in Python, BPB Publications, 2017, ISBN: 978-9386551276
2. R. NageswaraRao, Core Python Programming, Dreamtech Press, 3rd Edition, ISBN: 978-9390457151

F.Y. B.Sc. (AI and ML)
Semester – II
MTS-151-T – Graph Theory

No. of Credits: 2	Teaching scheme: Theory: 2 hrs/week	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Lectures: 30

Prerequisites: None

Objectives:
The course is designed to teach:

1. Basic concepts of Graphs viz. types, applications, definitions
2. Tree as a special type of graph
3. Tree traversals and use of trees
4. Graph coloring and its use

Contents:

Unit	Contents	Number of lectures	Text Book
1	**Introduction:** Definitions: Directed and undirected graphs. Hand shaking property and its problems. Real life applications Applications- Konigsberg bridge problem, Utility problem and travelling salesman problem. Definitions: Forests, Walks, trail, paths, Circuits, Cycles, Sub graphs, Induced and Spanning subgraphs, Connected graphs and Complement of a graph- Problems. Euler graphs and Hamiltonian graphs (no theorems) problems. Operations on graphs and Isomorphism of two graphs, problems. Planar, Dual Graphs and Matrix representation of Graphs, Kuratowski's graphs. Different representation of planar graph. Detection of planar graphs. Adjacency matrix, Incidence matrix, Sub-matrices of Incidence matrix on undirected and directed graphs	**10**	**T1, T2**
2	**Trees:** Definitions: Trees, Spanning trees, Some Properties of trees (no proofs). Rooted and binary tree. Spanning trees in a weighted graph. Traversal of Binary Tree, Pre-order and Post-order Traversal. Prefix codes, optimal tree. Cut – sets. Cut – sets in a graph. Fundamental Circuits and Cut – sets, Network Flows. Max- flow Mincut Theorem (statement only) and problems.	**6**	**T1, T2**
3	**Tree algorithms:** BFS, DFS, Minimum cost spanning tree problem: greedy algorithm - Kruskal's and Prims algorithms. Dijkstra's Shortest path algorithm.	**6**	**T1, T2**
4	**Coloring and Dominating sets:** Definition of Chromatic number. Chromatic Partitioning.	**8**	**T1, T2**

	Chromatic Polynomial. Finding Chromatic polynomial by Decomposition Theorem and by Multiplication Theorem (without Proofs). Dominating set. Minimal Dominating set. Domination number. Independent dominating set. Finding minimal dominating sets. Some applications of domination theory.		

Course Outcomes:

After competing this course, a student will be able to:

1. achieve command of the fundamental definitions and concepts of graph theory.
2. understand and apply the core theorems and algorithms, generating examples as needed
3. achieve an understanding of graph coloring
4. understand the concept of dominating sets
5. familiarize with the major viewpoints and goals of graph theory: classification and optimization

Text books:

1. Narasingh Deo, *Graph Theory with applications to engineering and Computer Science*, Printice Hall of India Private Limited, 2009. ISBN: 9788120301450

2. Douglas B. West, *Introduction to Graph Theory*, 2nd edition.

F.Y. B.Sc. (AI and ML)
Semester – II
MTS-152-P: Practical based on Graph Theory (MTS-151-T)

No. of Credits: 2	Practicals per week: 1 (4 hrs)	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Practicals: 15

Pre-requisites: None

Objectives:
The course is designed to teach:

1. Representation of different types of graphs
2. Graph traversals viz. DFS and BFS
3. Tree traversals and finding minimum cost spanning trees using various algorithms
4. Computing shortest path cost from a source vertex to all other vertices
5. methods to color vertices in a graph

Contents:

Unit	Practical based on MTS-151-T
1,2,3	Graph representations
4, 5	Graph traversals
6, 7	Tree traversals
8, 9	MCST – Prims and Kruskals algorithms
10, 11	Dijkstra's Shortest path
12	Graph Coloring
13-15	Dominating sets

Course Outcomes:
After competing this course, a student will be able to:

1. Understand various graph representations and implement them
2. Use graph traversals like DFS and BFS
3. Represent a tree and traverse it
4. Find MCST of a graph using Prims, Kruskals and Dijkstras' algorithms
5. Solve graph coloring problem and find minimal dominating sets

References:

1. Narasingh Deo, *Graph Theory with applications to engineering and Computer Science*, Printice Hall of India Private Limited, 2009. ISBN: 9788120301450
2. Douglas B. West, *Introduction to Graph Theory*, 2nd edition.

F.Y. B.Sc. (AI and ML)
Semester – II
STS-151-T – Continuous probability Distributions and Testing of Hypothesis

No. of Credits: 2	Teaching scheme: Theory: 2 hrs/week	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Lectures: 30

Prerequisites: None

Objectives:
The course is designed to teach:

- To teach continuous probability distributions and its applications.
- To teach various concepts of testing of hypothesis.
- To teach large and small sample tests.
- To teach various nonparametric tests.

Contents:

Unit	Contents	Number of lectures	Text Book
1	**Continuous Random Variable and Standard Continuous Probability Distributions** Definition of continuous random variable (r. v.) Probability density function (p.d.f.) Cumulative distribution function (c.d.f.), its properties. Calculation of mean, mode, median, variance, standard deviation for continuous r. v. Numerical problems related to real life situations. Uniform Distribution: statement of p.d.f., mean, variance, nature of probability curve. Exponential Distribution: statement of p.d.f. of the form, $f(x) = (1/\theta)\, e(-x/\theta)$, mean, variance, nature of probability curve, lack of memory property. Normal Distribution: statement of p.d.f., identification of parameters, nature of probability density curve, standard normal distribution, symmetry, distribution of aX+b, aX+bY+c where X and Y are independent normal variables, computations of probabilities using normal probability table, normal approximation to binomial and Poisson distribution , central limit theorem (statement only), normal probability plot. Pareto Distribution: p.d.f., mean, variance, applications. Numerical problems related to real life situations.	**10**	**1,2, 4**
2	**Testing of hypothesis** Definitions: population, sample, random sample from a probability distribution, parameter, estimator, statistic, sampling distribution of statistic, standard error of estimator.	**2**	**1,3,4,6**

	Concept of null hypothesis and alternative hypothesis, critical region, level of significance, type I and type II error, one sided and two-sided tests, p-value.		
3	**Tests based on some distributions** **Tests based Normal distribution** Test for population mean, Test for equality of two population means, Test for population proportion Test for equality of two population proportions Numerical problems related to real life situations. **Tests based on t, Chi-square and F-distribution** Test for population mean for small sample size, Test for equality of two population means for small sample sizes, Paired t-test. Chi square test for goodness of fit. Test for independence of attributes, Test for significance of variation for a population. Test for equality of population variances Numerical problems related to real life situations.	**14**	**2,3,6**
4	**Non parametric Tests** RUN test, SIGN test, Kolmogrov - Smirnov test. Mann – Whitney test, Numerical problems related to real life situations.	**4**	**2,3,6**

Course Outcomes:

After successful completion of this course, student will be able to:

1. acquire knowledge on various continues probability distributions and its applications in real life situations.
2. understand the concept of Testing of Hypothesis.
3. understand the concept of Test of significance and apply the same to test Population parameters by using large and small sample tests.
4. Identify problems and apply appropriate non parametric test and interpret the conclusion.

- **References**

1) Statistical Methods, G.W. Snedecor, W.G. Cochran, John Wiley & sons, 1991, Eight Edition
2) Statistical Methods, J. Medhi, New Age International, 2016.
3) A First course in Probability, Ross, Pearson Publication, 2013, Ninth Edition.
4) Modern Elementary Statistics, Freund J.E., Pearson Publication, 2006, Twelfth Edition.
5) Probability, Statistics, Design of Experiments and Queuing theory with applications Computer Science, Trivedi K.S., Prentice Hall of India, New Delhi,2001, Second Edition.
6) A First Course in Probability and Statistics, L. S. Prakasa Rao, World Scientific Publishing Co Pte Ltd, 2008.
7) Applied Probability Models, D. L. Minh, Brooks/Cole, 2000.

F.Y. B.Sc. (AI and ML)
Semester – II
STS-152-P: Practical based on STS-151-T
(Continuous probability Distributions and Testing of Hypothesis)

No. of Credits: 2	Practicals per week: 1 (4 hrs)	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Practicals: 15

Pre-requisites: None

Objectives:
The course is designed to teach:

1. The problems based on continuous probability distributions
2. Testing of hypothesis – large sample tests
3. Testing of hypothesis – small sample tests
4. application of hypothesis on any open-source data

Contents:

Unit	Practical based on STS-151-T
1, 2	Problems based on continuous probability distributions
3, 4, 5	Problems based on testing of hypothesis – large sample tests
6, 7, 8	Problems Based on small sample tests - Chi square distribution, t and F distribution
9, 10	Problems based on non-parametric tests
11-15	Mini Project

Mini Project Guidelines:

1. Project is equivalent to three practicals may include data presentation, data analysis and interpretation.
2. For project purpose the students are expected to work in group of size not more than 5.
3. Attempt should be made to analyse data generated from real-life applications. Students may use any method (Questionnaires, interviews, data obtained from deployed sensors, CCTV camera, audio etc) to generate data for analysis.
4. A formal project report should be prepared by each student.

Course Outcomes:
After competing this course, a student will be able to:

1. Solve problems on continuous probability distributions
2. Apply large sample tests to test a hypothesis
3. Apply small sample tests to test a hypothesis
4. Apply the methods on a data set and use inference methods on large data sets

F.Y. B.Sc. (AI and ML)
Semester – II
SEC-151-AIML-T: Databases – I
(Skill Enhancement Course)

No. of Credits: 2	Teaching scheme: Theory: 2 hrs/week	Evaluation Pattern: Continuous Evaluation: 15 End Sem Evaluation: 35	Total Lectures: 30

Prerequisites: None

Objectives:
The course is designed to:

1. teach data processing using computers to students.
2. introduce principles of databases.
3. teach the conversion of ER model into relational tables
4. teach the basic concepts of data model, entity relationship model, database design
5. The course is designed to teach creation, manipulation, and querying of data in databases.
6. teach different normalization methods to model a database
7. introduce PostgreSQL for manipulating the data

Contents:

Unit	Contents	Number of lectures	Text Book
1	**Introduction of DBMS -** Overview, File system Vs. DBMS, Levels of abstraction, Data independence, Structure of DBMS, Users of DBMS, Advantages of DBMS	3	1
2	**Conceptual Design (E-R model) -** Overview of DB design, Conceptual Design using ER data model (entities, attributes, entity sets, relations, relationship sets), Constraints - Key constraints, Integrity constraints, referential integrity, unique constraint, Null/Not Null constraint, Domain, Check constraint, Mapping constraints, Keys Concept with Examples: Primary Key, Candidate Keys and Super Keys, Extended features – Specialization, Aggregation, Generalization, Structure of Relational Databases (concepts of a table, a row, a relation, a Tuple and a key in a relational database), Examples on ER Model.	10	1,2
3	**SQL -** Introduction, Basic structure, DDL and DML commands, Aggregate functions, Date and String functions, Null values, SQL mechanisms for joining relations (inner joins, outer joins and their types), Examples on SQL	9	3
4	**Relational Database Design –** Introduction to Relational-Database Design (undesirable properties of a RDB design), Functional dependencies (Basic concepts, F+, Closure of an Attribute set, Armstrong's AXIOMS), Keys Concept with Examples: Candidate Keys and Super Keys, Concept of Normalization, Normal forms - 1NF, 2NF, 3NF. Examples	8	1

Course Outcomes:

After competing this course, a student will be able to:

1. describe the fundamental elements of relational database management systems
2. analyse database requirements and identify the entities involved in the system along with their relationship to one another.
3. apply the basic concepts of relational data model, entity-relationship model, relational database design and SQL.
4. convert the ER-model to relational tables, design a relational database and develop SQL queries on data using PostgreSQL
5. apply database design techniques and tools to create a database schema and database instance for a database related software application.

Text books:

1) Database System Concepts, Henry F. Korth, Abraham Silberschatz, S. Sudarshan, Tata McGraw-Hill Education, ISBN:9780071289597
2) Fundamentals of Relational Database Management Systems - S. Sumathi & S. Esakkirajan, Springer Berlin Heidelberg New York, ISBN-13 978-3-540-48397-7
3) Beginning Databases with PostgreSQL: From Novice to Professional, Richard Stones, Neil Matthew, APress, Second Edition, ISBN: 9781590594780

Reference Books:

1) Database Management Systems, Raghu Ramakrishna, McGraw-Hill, Second Edition, ISBN:9780071254342
2) Database Systems, Shamkant B. Navathe, Ramez Elmasri, PEARSON, ISBN: 9780132144988
3) An introduction to Database systems, Bipin C Desai, Galgotia Publications
4) PostgreSQL, Korry Douglas, SAMS, Second Edition, ISBN:9780672327568
5) PostgreSQL Introduction and Concepts by Bruce Momjian, Addison Wesley, ISBN 0-201-70331-9
6) Practical PostgreSQL, By Joshua D. Drake, John C Worsley, O'Reilly, ISBN 1-56592-846-6