(Formerly University of Pune)

Bachelors Degree in Data Science

(Faculty of Science and Technology)



Syllabi for B.Sc. (Data Science)

(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

Preamble

Welcome to the B.Sc.(Data Science) programme! This programme is designed to empower students with knowledge and skills required to thrive in an era of data science and technology. By choosing B.Sc. (Data Science) Programme, students enter into the dynamic field of data science and data analytics. Students will engage and build strong foundation in mathematics, statistics, computer science and ethical data practices. This programme not only equips students with technical expertise but also fosters a mindset of continuous learning, adaptability and ethical leadership.

As you navigate this syllabus, consider it a roadmap to your future in data science. Welcome to the world where data becomes insight and insight drives innovation.

Eligibility

- (a) Higher Secondary School Certificate (10+2) Science Stream or its equivalent examination
 OR
- (b) Three Years Diploma Course after S.S.C. (10th standard) of Board of Technical Education conducted by Government of Maharashtra or its equivalent.

Programme Outcomes:

- PO 1: The programme seeks to develop strong foundation in Mathematics, Statistics and Computer Science that demonstrate proficiency in basic programming languages and tools.
- PO 2: The programme aims to understand the principles of data storage and retrieval by acquiring knowledge of data type structures and basic data manipulation techniques.
- PO 3: The programme helps to learn database management techniques with design and management of databases as well as executing SQL queries for data retrieval and manipulation.
- PO 4: By applying advanced statistical methods and machine learning techniques, the students can analyze complex datasets, interpret and communicate findings effectively.
- PO 5: The programme also aims to understand and work with big data technologies and apply these technologies to process and analyze large-scale datasets.
- PO 6: The students can create clear and effective data visualizations using various tools and communicate complex findings through visual representations.
- PO 7: The programme also seeks to develop comprehensive projects by applying data science techniques to solve real-world problems that will improve the ability of learner to integrate knowledge and skills acquired throughout the programme.

- PO 8: Through hands-on projects, practical assignments, and exposure to state-of-the-art tools and technologies, programme aim to develop the technical proficiency and problem-solving skills necessary for success in the professional world.
- PO 9: Depending on the chosen track, students can develop expertise in data analytics with areas such as Business, Social Media, HR, Financial, Healthcare, Supply Chain & Logistics and Big Data etc.
- PO 10: The program include On Job Training, internships and research work that provides learners with practical experience, applying their knowledge to real-world challenges.
- PO 11: Graduates will be adept at presenting complex technical concepts clearly and effectively, both in written and oral forms, to various audiences.
- PO 12: The programme places a strong emphasis on ethical considerations, responsible use of technology, and awareness of the societal impact of data science and computing solutions.
- PO 13: The programme aim to produce graduates who approach their work with integrity and a sense of social responsibility.
- PO 14: Acknowledging the dynamic nature of computer science, the programme aim to inspire students for continuous learning and professional development, empowering them to adapt and thrive in the face of technological advancements; prepared them to adapt to new technologies and methodologies throughout their careers.
- PO 15: The students will be encouraged to think creatively and innovatively, exploring new ideas and approaches to solve data science related problems and advance the state of the art in the field.

Syllabus Structure as per NEP Guidelines

B.Sc. (Data Science) from 2024-25

FY (Level 4.5) SEMESTER I

Course Type	Course code	Course Name	Cre	dits	Teach Sche Hrs/W	me			ation e and ks
Type	couc		T H	P R	TH	PR	C E	E E	Total
Subject-	DS101T	Problem Solving and Python Programming	2	-	2	-	15	35	50
1	DS102P	Lab Course on DS101T (Python Programming)	-	2	-	4	15	35	50
Subject	DS103T	Descriptive Statistics	2	-	2	-	15	35	50
Subject- 2	DS104P	Lab Course on DS103T (Descriptive Statistics)	-	2	-	4	15	35	50
Subject-	DS105T	Computational Mathematics	2	-	2	-	15	35	50
3	DS106P	Lab Course on DS105T (Computational Mathematics)	-	2	-	4	15	35	50
GE/OE	OE101DS	Office Automation/ Computer Fundamentals/ Introduction to Google Tools	2	-	2	-	15	35	50
SEC	SEC101DS	Computer Organization	2	-	2	-	15	35	50
IKS	DS101IKS	Indian Knowledge System (Generic)	2	-	2	-	15	35	50
AEC	AEC101 MAR/HIN/ ENG	MIL-I (Hindi) / MIL-I (Marathi)/ MIL-I (English)	2	-	2	-	15	35	50
VEC	VEC101 ENV	EVS-I	2	-	2	-	50	-	50
	Total			6	16	12			550

Syllabus Structure as per NEP Guidelines

B.Sc. (Data Science) from 2024-25

FY (Level 4.5) SEMESTER II

Course Type	Course code	Course Name	Cre	dits	Scł	ching neme Week			ation e and ks
туре	Coue		T H	P R	TH	PR	C E	E E	Total
Subject	DS151T	Advanced Python Programming	2	-	2	-	15	35	50
Subject- 1	DS152P	Lab Course on DS151T (Advanced Python Programming)	-	2	-	4	15	35	50
Subject-	DS153T	Discrete Probability and Probability Distributions	2	-	2	-	15	35	50
2	DS154P	Lab Course on DS153T (Discrete Probability and Probability Distributions)	-	2	-	4	15	35	50
Subject-	DS155T	Graph Theory	2	-	2	-	15	35	50
3	DS156P	Lab Course on DS155T (Graph Theory)	-	2	-	4	15	35	50
GE/OE	OE151DSP	Office Automation/ Computer Fundamentals/ Introduction to Google Tools	-	2	-	4	15	35	50
SEC	SEC151DS	Lab Course on Excel and Advanced Excel	-	2	-	4	15	35	50
AEC	AEC101 MAR/HIN/ ENG	MIL-I (Hindi) / MIL-I (Marathi)/ MIL-I (English)	2	-	2	-	15	35	50
VEC	VEC101 ENV	EVS-II	2	-	2	-	50	-	50
CC	CC151PE/ NSS/ NCC	From University Basket	2	-	2	-	50	-	50
	Total		12	10	12	20			550

Savitribai Phule Pune University Syllabus Structure as per NEP Guidelines B.Sc. (Data Science) from 2024-25

SY (Level 5.0) SEMESTER III

Course Type	Course code	Course Name	Credits		Teacl Sche Hrs/V	eme		xamination cheme and Marks	
			T H	P R	TH	PR	C E	E E	Total
	DS201MJ	Database Management System	2	-	2	-	15	35	50
Major	DS202MJ	Data Structure-I	2	-	2	-	15	35	50
Core	DS203MJP	Lab Course on DS201MJ and DS202MJ	-	2	-	4	15	35	50
VSC	DS221VSC	Foundations of Data Science	2	-	2	-	15	35	50
FP/ OJT/ CEP	DS231FP	Mini Project	-	2	-	4	15	35	50
Minor	DS241MN	Probability Distribution and Modelling	2	-	2	-	15	35	50
	DS242MNP	Lab Course on DS241MN	-	2	-	4	15	35	50
GE/OE	OE201DS	Ecommerce/ Web Design/ Digital Marketing	2	-	2	-	15	35	50
IKS	DS201IKS	Computing in Ancient India	2	-	2	-	15	35	50
AEC	AEC201ENG	Soft Skills-I	2	-	2	-	15	35	50
СС	CC201PE/ NSS/ NCC	From University Basket	-	2	-	4	50	-	50
	Total				14	16			550

Syllabus Structure as per NEP Guidelines

B.Sc. (Data Science) from 2024-25

Course Type	Course code	Course Name	Credits		Sch	ching eme Week			ation e and ks
			T H	PR	TH	PR	C E	E E	Total
	DS251MJ	Relational Database Management System	2 2	-	2	_	Е 15	35	50
Major Core	DS252MJ	Data Structure-II	2	-	2	-	15	35	50
Core	DS253MJP	Lab Course on DS251MJ and DS252MJ	-	2	-	4	15	35	50
VSC	DS221VSC	Data Analytics	-	2	-	4	15	35	50
FP/ OJT/ CEP	DS231FP	Mini Project	-	2	-	4	15	35	50
Minor	DS241MN	Testing of Hypothesis and Sampling Distributions	2	-	2	-	15	35	50
	DS242MNP	Lab Course on DS241MN	-	2	-	4	15	35	50
GE/OE	OE251DSP	Ecommerce/ Web Design/ Digital Marketing	-	2	-	4	15	35	50
SEC	SEC251DSP	Software Engineering	2	-	2	-	15	35	50
AEC	AEC201ENG	Soft Skills-II	2	-	2	-	15	35	50
CC	CC201PE/ NSS/ NCC	From University Basket	-	2	-	4	50	-	50
		Total	10	12	10	24			550

SY (Level 5.0) SEMESTER IV

Syllabus Structure as per NEP Guidelines

B.Sc. (Data Science) from 2024-25

TY (Level 5.5) SEMESTER V

Course Type	Course code	Course Name	Credits		Sch	ching neme Week			ation e and ks
			Т	Р	TH	PR	С	Ε	Total
			Η	R			Ε	Ε	
	DS301MJ	NoSQL databases	4	-	4	-	30	70	100
	DS302MJ	R Programming	2	-	2	-	15	35	50
Major Core	DS303MJ	Foundations of Artificial Intelligence	2	-	2	-	15	35	50
Core	DS304MJP	Lab Course on DS301MJ (NoSQL databases)	-	2	-	4	15	35	50
	DS305MJP	Lab Course on DS302 (R Programming)	-	2	-	4	15	35	50
	DS310MJ	Business Analytics	2	-	2	-	15	35	50
Major	DS311MJP	Lab Course	-	2	-	4	15	35	50
Elective	OR					-			
	DS312MJ	Social Media Analytics	2	-	2	-	15	35	50
	DS313MJP	Lab Course	-	2	-	4	15	35	50
VSC	DS321VSCP	Lab Course on MATLAB	-	2	-	4	15	35	50
FP/CEP	DS331FP	Mini Project	-	2	-	4	15	35	50
Minor	DS341MN	Categorical Data Analysis	2	-	2	-	15	35	50
		Total	12	10	12	20			550
		Iotai	14	10	14	20			330

Syllabus Structure as per NEP Guidelines

B.Sc. (Data Science) from 2024-25

Course	Course	Course Name	Cre	dits	Teac	hing	Exa	amin	ation
Туре	code				Sch	eme	Scheme and		
					Hrs/	Week		Marl	KS
			Т	Р	TH	PR	CE	Ε	Total
			Н	R				Ε	
	DS351MJ	Data Visualization and	4	-	4	-	30	70	100
		Modelling							
	DS352MJ	Artificial Intelligence in Data	2	-	2	-	15	35	50
Major		Science							
Core	DS353MJ	Data Security and Privacy	2	-	2	-	15	35	50
	DS354MJP	Lab on DS351MJT	-	2	-	4	15	35	50
	DS355MJP	Lab Course on DS352MJ	-	2	-	4	15	35	50
	DS360MJ	HR Analytics	2	-	2	-	15	35	50
	DS361MJP	Lab Course	-	2	-	4	15	35	50
Major Elective	OR								
Liective	DS362MJ	Financial Analytics	2	-	2	-	15	35	50
	DS363MJP	Lab Course	-	2	-	4	15	35	50
OJT	DS381OJT	On Job Training	-	4	-	8	30	70	100
Minor	DS391MN	Multivariate Analysis	2	-	2	-	15	35	50
		Total	12	10	12	20			550

TY (Level 5.5) SEMESTER VI

Savitribai Phule Pune University Syllabus Structure as per NEP Guidelines B.Sc. (Data Science) from 2024-25

(Level 6.0) SEMESTER VII (Honors with Research Degree)

Course	Course	Course Name	Cre	dits	Tea	ching	Ex	amir	ation
Туре	code				Scheme		Scheme and		e and
					Hrs/	Week		Mar	ks
			Т	Р	TH	PR	C	Ε	Total
			Н	R			Ε	Ε	
	DS401MJ	Machine Learning	4	-	4	-	30	70	100
Major	DS402MJ	Basics of Cloud Computing	2	-	2	-	15	35	50
Core	DS403MJP	Lab Course on DS401MJ	-	2	-	4	15	35	50
	DS404MJP	Lab Course on DS402MJ	-	2	-	4	15	35	50
	DS410MJ	Supply Chain & Logistics	2	-	2	-	15	35	50
		Analytics							
Major	DS411MJP	Lab Course	-	2	-	4	15	35	50
Elective	OR								
	DS412MJ	Healthcare Analytics	2	-	2	-	15	35	50
	DS413MJP	Lab Course	-	2	-	4	15	35	50
RP	DS431RP	Research Project	-	4	-	8	30	70	100
RM	DS441RM	Research Methodology	4	-	4	-	30	70	100
		Total	12	10	12	20			550

OR

(Level 6.0) SEMESTER VII (Honors Degree)

Course	Course	Course Name	Cre	dits	Tea	ching	Ex	amir	ation
Туре	code				Scheme		Scheme and		
					Hrs/	Week		Mar	ks
			Т	Р	TH	PR	С	Ε	Total
			Н	R			Е	Ε	
	DS401MJ	Machine Learning	4	-	4	-	30	70	100
Major	DS402MJ	Basics of Cloud Computing	2	-	2	-	15	35	50
Major Core	DS403MJP	Lab Course on DS401MJ	-	2	-	4	15	35	50
	DS404MJP	Lab Course on DS402MJ	-	2	-	4	15	35	50
	DS405MJ	Big Data Analytics	4	-	4	-	30	70	100
	DS410MJ	Supply Chain & Logistics	2	-	2	-	15	35	50
		Analytics							
Major	DS411MJP	Lab Course	-	2	-	4	15	35	50
Elective	OR								
	DS412MJ	Healthcare Analytics	2	-	2	-	15	35	50
	DS413MJP	Lab Course	-	2	-	4	15	35	50
RM	DS441RM	Research Methodology	4	-	4	-	30	70	100
		Total	16	6	16	12			550

Savitribai Phule Pune University Syllabus Structure as per NEP Guidelines

B.Sc. (Data Science) from 2024-25 (Level 6.0) SEMESTER VIII (Honors with Research Degree)

Course	Course	Course Name	Cre	dits	Teac	hing	Ex	amina	ntion
Туре	code				Sch	eme	Scheme and		and
					Hrs/	Week		Mark	s
			Т	Р	TH	PR	С	EE	Tota
			Н	R			Ε		1
	DS451MJ	Data Mining and Warehousing	4	-	4	-	30	70	100
Major	DS452MJ	Deep Learning	2	-	2	-	15	35	50
Core	DS453MJP	Lab Course on DS451MJ	-	2	-	4	15	35	50
	DS454MJP	Lab Course on DS452MJ	-	2	-	4	15	35	50
	DS460MJ	Geospatial Technology	2	-	2	-	15	35	50
Malar	DS461MJP	Lab Course	-	2	-	4	15	35	50
Major Elective	OR								
Lieuwe	DS462MJ	E-Commerce	2	-	2	-	15	35	50
	DS463MJP	Lab Course	-	2	-	4	15	35	50
RP	DS481RP	Research Project	-	8	-	16	60	140	200
		Total	8	14	8	28			550

OR

(Level 6.0) SEMESTER VIII (Honors Degree)

Course	Course	Course Name	Cre	dits	ts Teaching		Ex	amin	ation
Туре	code		Schen		neme	Scheme and		e and	
					Hrs/Week		Marks		
			Т	Р	TH	PR	С	Ε	Total
			Н	R			Ε	Ε	
	DS451MJ	Data Mining and Warehousing	4	-	4	-	30	70	100
Major	DS452MJ	Deep Learning	2	-	2	-	15	35	50
Core	DS453MJP	Lab Course on DS451MJ	-	2	-	4	15	35	50
Core	DS454MJP	Lab Course on DS452MJ	-	2	-	4	15	35	50
	DS455MJ	Natural Language Processing	4	-	4	-	30	70	100
	DS456MJ	Geospatial Technology	2	-	2	-	15	35	50
M	DS457MJP	Lab Course	-	2	-	4	15	35	50
Major Elective	OR								
Liective	DS458MJ	E-Commerce	2	-	2	-	15	35	50
	DS459MJP	Lab Course	-	2	-	4	15	35	50
OJT	DS481OJT	On Job Training	-	4	-	8	30	70	100
	Total			10					550

SavitribaiPhulePuneUniversity B.Sc. Data Science (Pattern 2024) Semester-I

DS101T : Problem Solving and Python Programming

No. of C	redits: 2	Teaching Scheme	Examination Sch	neme
		Theory:2 Hrs /Week	Continuous Evalu	ation:15 Marks
			End Semester:35	Marks
Prerequ	isites			
• B	asic knowledg	e of mathematics, logic.		
• P	uzzle solving A	Aptitude		
• K	Inowledge of p	roblem solving tools like algor	ithms, flowcharts and p	seudo codes will
b	e an added adv	antage		
Objectiv	ves			
• Т	o teach studen	ts systematic and efficient pro	blem-solving methods.	including proble
		hm design, and solution implei	-	8 F
	• •	olid understanding of the Pyth		lage, including i
	-	es, control structures, and func		
• T	o instill good	l programming habits, incluc	ling code readability,	commenting, ar
	ocumentation.			
• T	o nurture the	ability to think algorithmical	ly and express solution	ns as step-by-ste
р	rocesses using	Python programs.		
• T	o learn and un	derstand Object Oriented Prog	ramming	
• T	o improve de	bugging techniques and error	identification and cor	rection in Pytho
р	rograms.			
Course	Outcomes			
On Com	pletion of this o	course, student will be able to -	_	
CO1: Cr	eate clear and e	efficient algorithms for solving	a variety of problems.	
CO2: W1	rite Python pro	grams to implement algorithms	s and solve problems.	
CO3: Ide	entify and corre	ect errors in Python programs u	sing systematic debugg	ing techniques.
CO4: Un	derstand Object	ct Oriented Concepts in Pythor	l	
CO5: Le	arn and unders	tand modules and packages in	Python	
CO6: De	fine and demo	nstrate the use of built-in data	structures "lists" and "di	ctionary".
Unit		Name of Unit	Teaching	CO Targeted
No.			Hours	
1	Introduction	to Problem Solving	5	CO 1
1 1 What	t is problem so	lying?		<u> </u>
	lem solving ste			
	U	tion, characteristics, examples,	advantages and limitation	ons.
-		-	-	
	charts - definit thms.	tion, notations, examples, adva	antages and limitations,	Comparison with

1.5 Pseudo codes - notations, examples, advantages and limitations.

1.6 Introduction to Programming

1.7 Programming Languages as tools, programming paradigms, types of languages 1.8 Converting pseudo-code to programs.

1	Introduction to Python	10	CO1, CO2,
			CO3, CO6

1.1 History, feature of Python, setting up path, working with python Interpreter, basic syntax, variable and data types, operators

1.2 Conditional statements-If, If-Else, nested if-else, Examples.

1.3 Looping-For, While, Nested loops, Examples

1.4 Control Statements-Break, Continue, Pass.

1.5 String Manipulation-Accessing String, Basic Operations, String Slices, Function and Methods, Examples.

1.6 Lists-Introduction, accessing list, operations, working with lists, function & methods.

1.7 Tuple-Introduction, accessing tuples, operations working, function & methods, Examples.

1.8 Dictionaries-Introduction, Accessingvalues in dictionaries, working with dictionaries, properties, function, Examples.

1.9 Functions-Defining a function, Calling a function, types of function, function arguments, anonymous function, global & local variable, Examples

2	Classes, Objects and Inheritance	8	CO4
2.1 C	lasses and Objects		
	Classes as User Defined Data Type		
2.1.2	Objects as Instances of Classes		
2.1.3	Creating Class and Objects		
2.1.4	Creating Objects By Passing Values		
2.1.5	Variables & Methods in a Class		
2.2 Ir	nheritance		
2.2.1	Single Inheritance		
2.2.2	Multilevel		
2.2.3	Multiple Inheritance		
2.2.4	Hybrid Inheritance		
2.2.5	Hierarchical Inheritance		
2.2.6	IS-A Relationship and HAS-A Relationship		
3	Modules and Packages	7	CO5
3.1Bı	uilt in Modules		
3.1.1	Importing modules in python program		
3.1.2	Working with Random Modules.		
3.1.3	E.g built-ins, time, date time, calendar, sys, etc		
	ser Defined functions		
3.2.1	Structure of Python Modules		
	ackages		
	Predefined Packages		
3.3.2	User defined Packages		
	-		

- 1. How to solve it by Computer, R.G. Dromey, Pearson Education.
- 2. Mark Lutz, Programming Python, O'Reilly, 4th Edition, 2010
- 3. Dive into Python, Mike
- 4. Learning Python, 4th Edition by Mark Lutz
- 5. Programming Python, 4th Edition by Mark Lutz
- 6. Python Programming: An introduction to computer, John Zelle, 3rd Edition.
- 7. Data Science Essentials in Python: Collect, Organize, Explore, Predict, Value. Dmitry Zinoriev, The Pragmatic Programmers LLC, 2016
- 8. Introduction to Python Programming. Gowrishankar S., Veena A. CRC Press, Taylor & Francis Group, 2019

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-I

DS102P : Lab Course on DS101T (Python Programming)

No. of C	redits: 2	Teaching Scheme	Exan	nination Scheme	
		Practical: 4 Hrs/Week	Cont	inuous Evaluation	: 15 Marks
			End S	Semester:	35 Marks
Prerequi	sites		1		
• B	asic knowledg	e of logic and Python programn	ning conce	epts	
• K	nowledge of p	problem solving tools like algorit	thms, flow	charts and pseudo	codes will
be	e an added adv	vantage			
Objectiv	es				
• L	earn Programr	ning fundamentals using Python	l		
• U	nderstand the	concepts and usage data types, v	variables a	nd other basic ele	ments
• L	earn about usi	ng operators and control stateme	ents in Pytl	hon	
• L	earn about usi	ng arrays and strings in Python.			
• L	earn Object O	riented concepts in Python.			
• L	earn how to us	se modules in packages in Pytho	n Program	ming	
On Comp CO1: In		course, students will be able to - use of built-in data structures		nd "dictionary" '	'Tuples'' and
On Comp CO1: In "Sets". CO2; Im CO3: Im	pletion of this of the plement the plement programmer plement programmer plement programmer plement programmer plement programmer plement programmer progr		"lists" a	n. n Python.	Tuples" and
On Comp CO1: In "Sets". CO2; Im CO3: Im CO3: Im CO4: Im	pletion of this of the oplement the plement prograde plement plement prograde plement plement prograde plement pl	use of built-in data structures rams on Arrays and Strings rams on Object Oriented concept rams by importing modules and p Name of Unit	"lists" a	n. n Python. Hours C	O Targeted
On Comp CO1: In "Sets". CO2; Im CO3: Im CO4: Im Unit No. 1	pletion of this of the oplement the plement prograde plement prograde plement prograde plement prograde plement programeters of the plement pl	use of built-in data structures ams on Arrays and Strings ams on Object Oriented concept ams by importing modules and Name of Unit	"lists" at s in Pytho packages i	n. n Python. Hours Co 8 CO	O Targeted
On Comp CO1: In "Sets". CO2; Im CO3: Im CO4: Im Unit No. 1 a. W	pletion of this of the oplement the plement prograde plement	use of built-in data structures arms on Arrays and Strings arms on Object Oriented concept arms by importing modules and Name of Unit I to Python Language program to explore various data	"lists" at s in Pytho packages i	n. n Python. Hours Co 8 CO	O Targeted
On Comp CO1: In "Sets". CO2; Im CO3: Im CO4: Im Unit No. 1 a. W ty	pletion of this of plement the plement progr plement progr plement progr Introduction Vrite a Python pes and comp	use of built-in data structures ams on Arrays and Strings ams on Object Oriented concept ams by importing modules and Name of Unit to Python Language program to explore various data ound types.	"lists" at s in Pytho packages i	n. n Python. Hours Co 8 CO luding numeric ty	O Targeted
On Comp CO1: In "Sets". CO2; Im CO3: Im CO4: Im Unit No. 1 a. W ty b. W	pletion of this of plement the plement progr plement progr plement progr Introduction Vrite a Python pes and comp Vrite a Python	use of built-in data structures rams on Arrays and Strings rams on Object Oriented concept rams by importing modules and p Name of Unit Name of Unit to Python Language program to explore various data ound types. program to perform Input and O	"lists" at s in Pytho packages i a types inc	n. n Python. Hours Co 8 CO luding numeric ty rations.	O Targeted 1 pes, Boolear
On Comp CO1: In "Sets". CO2; Im CO3: Im CO4: Im Unit No. 1 a. W ty b. W c. W	pletion of this of plement the plement progr plement progr plement progr Introduction Vrite a Python pes and comp Vrite a Python	use of built-in data structures rams on Arrays and Strings rams on Object Oriented concept rams by importing modules and p Name of Unit Name of Unit to Python Language program to explore various data ound types. program to perform Input and C program to demonstrate loopir	"lists" at s in Pytho packages i a types inc	n. n Python. Hours Co 8 CO luding numeric ty rations.	O Targeted 1 pes, Boolean
On Comp CO1: In "Sets". CO2; Im CO3: Im CO4: Im Unit No. 1 a. W ty b. W c. W	pletion of this of plement the plement progr plement progr plement progr Plement progr Introduction Vrite a Python Vrite a Python Vrite a Python	use of built-in data structures rams on Arrays and Strings rams on Object Oriented concept rams by importing modules and p Name of Unit Name of Unit to Python Language program to explore various data ound types. program to perform Input and C program to demonstrate loopir	"lists" at s in Pytho packages i a types inc	n. n Python. Hours Co 8 CO luding numeric ty rations.	O Targeted 1 pes, Boolean eak statemen
On Comp CO1: In "Sets". CO2; Im CO3: Im CO4: Im Unit No. 1 a. W ty b. W c. W ar	Pletion of this of plement the plement progr plement progr plement progr Plement progr Introduction Vrite a Python Vrite a Python Vrite a Python d continue sta Functions	use of built-in data structures rams on Arrays and Strings rams on Object Oriented concept rams by importing modules and p Name of Unit Name of Unit to Python Language program to explore various data ound types. program to perform Input and C program to demonstrate loopir	"lists" and "lists	n. n Python. Hours Co 8 CO luding numeric ty rations. on and use of bre	O Targeted 1 pes, Boolean eak statemen
On Comp CO1: In "Sets". CO2; Im CO3: Im CO4: Im Unit No. 1 a. W ty b. W c. W ar 2 a. W	pletion of this of plement the plement progr plement progr plement progr plement progr Introduction Vrite a Python Vrite a Python Vrite a Python d continue sta Functions	use of built-in data structures rams on Arrays and Strings rams on Object Oriented concept rams by importing modules and p Name of Unit Name of Unit to Python Language program to explore various data ound types. program to perform Input and C program to demonstrate loopin atement.	"lists" and "lists	n. n Python. Hours Co 8 CO luding numeric ty rations. on and use of bre 8 CO	O Targeted 1 pes, Boolean eak statemen

3	List, Tuples, Dictionaries and Sets	12	CO1				
a.	Write a Python Program to create list, apply various func	tions to it.					
b.	Write a Python Program to demonstrate concept of aliasin	ng and cloni	ng.				
c.	Write a Python Program to implement tuples for storing	g data. Veri	fy the immutability				
	property on tuples.						
d.	Write a Python Program to implement Dictionary and operations on dictionaries.						
e.	Write a Python Program to create sets and various operations on it.						
4	Arrays and String	12	CO2				
a.	Write a Python Program to implement arrays for storing l	nomogeneou	is data items.				
b.	Apply indexing and slicing operations to access elements	of array.					
c.	Write a Python Program to demonstrate operations and pa	roperties of	string data types.				
d.	Write a Python Program implement and demonstrate th	e use of Me	mbership operators				
	and Identity operators						
5	Object Oriented Programming	12	CO3				
a.	Write a Python program to define classes and create obje	cts.	·				
b.	Program to implement the inheritance.						
b. с.	Program to implement the inheritance. Program to implement the polymorphism.						
		8	CO4				
c.	Program to implement the polymorphism.	-	CO4				
с. 6	Program to implement the polymorphism. Modules and Packages	modules.	CO4				
с. 6 а.	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined	modules.	CO4				
с. 6 а. b.	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined	modules.	CO4				
с. 6 а. b. Re	Modules and Packages Write Python program to import built in and user defined Write Python program to import built in and user defined	modules. packages.	CO4				
с. 6 а. b. Re	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined Write Python program to import built in and user defined eference Books How to solve it by Computer, R.G. Dromey, Pearson Ed	modules. packages. ucation.	CO4				
c. 6 a. b. Re 1. 2.	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined Write Python program to import built in and user defined eference Books How to solve it by Computer, R.G. Dromey, Pearson Ed	modules. packages. ucation.	CO4				
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c. 6 a. b. Re 1. 2. 3.	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined Write Python program to import built in and user defined eference Books How to solve it by Computer, R.G. Dromey, Pearson Ed Mark Lutz, Programming Python, O`Reilly, 4th Edition, Dive into Python, Mike	modules. packages. ucation.	CO4				
 c. 6 a. b. Re 1. 2. 3. 4. 	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined Write Python program to import built in and user defined Write Python program to import built in and user defined Peference Books How to solve it by Computer, R.G. Dromey, Pearson Ed Mark Lutz, Programming Python, O`Reilly, 4th Edition, Dive into Python, Mike Learning Python, 4th Edition by Mark Lutz	modules. packages. ucation. 2010					
 c. 6 a. b. Ree 1. 2. 3. 4. 5. 	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined Write Python program to import built in and user defined eference Books How to solve it by Computer, R.G. Dromey, Pearson Ed Mark Lutz, Programming Python, O`Reilly, 4th Edition, Dive into Python, Mike Learning Python, 4th Edition by Mark Lutz Programming Python, 4th Edition by Mark Lutz Python Programming: An introduction to computer, John Z	modules. packages. ucation. 2010 Zelle,3rd Ed	ition.				
 c. 6 a. b. Ree 1. 2. 3. 4. 5. 6. 	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined Write Python program to import built in and user defined eference Books How to solve it by Computer, R.G. Dromey, Pearson Ed Mark Lutz, Programming Python, O`Reilly, 4th Edition, Dive into Python, Mike Learning Python, 4th Edition by Mark Lutz Programming Python, 4th Edition by Mark Lutz Python Programming:An introduction to computer,John Z	modules. packages. ucation. 2010 Zelle,3rd Ed	ition.				
 c. 6 a. b. Ree 1. 2. 3. 4. 5. 6. 7. 	Program to implement the polymorphism. Modules and Packages Write Python program to import built in and user defined Write Python program to import built in and user defined eference Books How to solve it by Computer, R.G. Dromey, Pearson Ed Mark Lutz, Programming Python, O`Reilly, 4th Edition, Dive into Python, Mike Learning Python, 4th Edition by Mark Lutz Programming Python, 4th Edition by Mark Lutz Python Programming:An introduction to computer,John Z Data Science Essentials in Python: Collect, Organize, E	modules. packages. ucation. 2010 Zelle,3rd Ed Explore, Pres	ition. dict, Value. Dmitry				

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-I

DS103T : Descriptive Statistics

No. of C	redits: 02	Teaching Scheme	Exar	nination Sch	eme
		Theory: 2 Hours/Week	Cont	inuous Evalu	ation:15 Marks
			End	Semester : 35	Marks
Prerequi	isites				
• N	Iathematical ope	erations			
Objectiv	res				
• T	o acquaint stude	nts with some basic concepts in	n Statistic	cs	
• T	o introduce to so	ome elementary statistical meth	ods of an	alysis of data	L
• T	o identify the na	ture and type of data			
• T	o apply statistica	al tools to numerical and catego	orical data	a	
Course (Outcomes				
On Comp	pletion of this co	ourse, student will be able to –			
CO1: Ide	entify the different	nt types of variables and data.			
CO2:Co1	npute various m	easures of central tendency, dis	persion,		
	-	neasures of skewness and kurto			
		efficient between numerical va	riables.		
	linear regression				
	non-linear regre	ession lines.			
Unit		Name of Unit		Teaching Hours	CO Targeted
No.	-			02	CO1
1	11	ntraduction to Statistics			
1 Meaning		ntroduction to Statistics	ce Conc	-	
Meaning	of Statistics an	d its importance in data scien		ept of popul	ation and sample
Meaning Types of	of Statistics an characteristics (d its importance in data scien (variables and attributes), Type	s of data	ept of population (primary and	ation and sample secondary). Rav
Meaning Types of data and	of Statistics an characteristics (its classificatio	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distr	s of data	ept of population (primary and	ation and sample secondary). Rav
Meaning Types of data and	of Statistics an characteristics (its classificatio alative frequency	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distry distribution.	s of data ibution, g	ept of population (primary and	ation and sample secondary). Rav
Meaning Types of data and and cumu 2	of Statistics an characteristics (its classificatio alative frequency Measures of	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distr y distribution. Central Tendency and Dispe	s of data ibution, g	ept of popula (primary and grouped frequ 10	ation and sample secondary). Ray uency distribution
Meaning Types of data and and cumu 2 Measure	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distry distribution.	s of data ibution, g rsion tendency	ept of popula (primary and grouped frequent 10 of statistica	ation and sample secondary). Rav uency distribution CO2 1 data. Statistica
Meaning Types of data and and cum 2 Measure averages	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te Arithmetic mea	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distry distribution. Central Tendency and Dispe- endency: Concept of central	s of data ibution, g rsion tendency e of orig	ept of popula (primary and grouped frequent 10 of statistica in and scale),	ation and sample secondary). Ray uency distributio CO2 1 data. Statistica Geometric Mea
Meaning Types of data and and cumu 2 Measure averages and Har	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te Arithmetic mea	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distry distribution. Central Tendency and Dispe endency: Concept of central an (Definition, effect of chang median and mode, partition	s of data ibution, g rsion tendency e of orig	ept of popula (primary and grouped frequent 10 of statistica in and scale),	ation and sample secondary). Ray uency distributio CO2 1 data. Statistica Geometric Mea
Meaning Types of data and and cumu 2 Measure averages and Har ungroupe	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te Arithmetic mea monic Mean, r ed and grouped c	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distry distribution. Central Tendency and Dispe endency: Concept of central an (Definition, effect of chang median and mode, partition	s of data ibution, g rsion tendency e of orig values (1	ept of popula (primary and grouped frequent 10 of statistica in and scale),	ation and sample secondary). Ray uency distributio CO2 1 data. Statistica Geometric Mea
Meaning Types of data and and cumu 2 Measure averages and Har ungroupe Situation	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te Arithmetic mea monic Mean, r ed and grouped c s where one kind	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distry distribution. Central Tendency and Dispe Endency: Concept of central an (Definition, effect of chang median and mode, partition lata).	s of data ibution, g rsion tendency e of orig values (1 ner.	ept of popula (primary and grouped frequent of statistica in and scale), Definitions a	ation and sample secondary). Ray uency distributio CO2 1 data. Statistica Geometric Mea nd examples fo
Meaning Types of data and and cumu 2 Measure averages and Har ungroupe Situation Measure	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te Arithmetic mea monic Mean, r ed and grouped c s where one kind s of dispersion	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distry distribution. Central Tendency and Dispe endency: Concept of central an (Definition, effect of chang median and mode, partition lata). d of average is preferable to oth	s of data ibution, g rsion tendency e of orig values (1 her. nge, Sem	ept of popula (primary and grouped frequent 10 of statistica in and scale), Definitions a	ation and sample l secondary). Rav uency distributio CO2 l data. Statistica Geometric Mea nd examples fo e range (Quartil
Meaning Types of data and and cum 2 Measure averages and Har ungroupe Situation Measure deviation	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te Arithmetic mea monic Mean, r ed and grouped c s where one kind s of dispersion): Definition.	d its importance in data scient (variables and attributes), Type n. Ungrouped frequency distry distribution. Central Tendency and Dispe endency: Concept of central an (Definition, effect of chang median and mode, partition lata). d of average is preferable to oth a: Concept of dispersion. Rat	s of data ibution, g rsion tendency e of orig values (1 her. nge, Sem minimal	ept of popula (primary and grouped frequent of statistica in and scale), Definitions a hi-interquartil	ation and sample secondary). Ray uency distributio CO2 1 data. Statistica Geometric Mea nd examples fo e range (Quartil (without proof)
Meaning Types of data and and cumu 2 Measure averages and Har ungroupe Situation Measure deviation Variance	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te Arithmetic mea monic Mean, r ed and grouped c s where one kind s where one kind s of dispersion and standard de	d its importance in data scien (variables and attributes), Type n. Ungrouped frequency distry distribution. Central Tendency and Dispe endency: Concept of central an (Definition, effect of chang median and mode, partition lata). d of average is preferable to oth a: Concept of dispersion. Ran Mean deviation: Definition,	s of data ibution, g rsion tendency e of orig values (1 her. nge, Sem minimal nange of	ept of popula (primary and grouped frequent of statistica in and scale), Definitions a ni-interquartil ity property origin and sca	ation and sample secondary). Ray uency distributio CO2 1 data. Statistica Geometric Mea nd examples for e range (Quartil (without proof) ale. Mean square
Meaning Types of data and and cum 2 Measure averages and Har ungroupe Situation Measure deviation Variance deviation	of Statistics an characteristics (its classificatio alative frequency Measures of s of central te chrithmetic mean monic Mean, r ed and grouped c s where one kind s of dispersion and standard de c Definition, min	d its importance in data scient (variables and attributes), Type n. Ungrouped frequency distry distribution. Central Tendency and Dispe endency: Concept of central an (Definition, effect of chang median and mode, partition lata). d of average is preferable to oth a: Concept of dispersion. Rat Mean deviation: Definition, eviation: Definition, effect of cl	s of data ibution, g rsion tendency e of orig values (1 her. nge, Sem minimal hange of red devia	ept of popula (primary and grouped frequent of statistication and scale), Definitions at in interquartility property origin and scattion (without	ation and sample secondary). Ray uency distribution CO2 1 data. Statistica Geometric Mea nd examples for e range (Quartil (without proof ale. Mean square proof), Measure

coefficient of mean deviation, coefficient of variation(C.V.).

3 M	loments, Skewness and Kurtosis	04	CO3			
Moments: Raw mo	ments and Central Moments (Definition for	or for ungrou	uped and grouped			
data). Relation betwee	een Raw moments and Central Moments (up	to 4 th order w	vithout proof).			
Skewness: Concept	of skewness of frequency distribution,	positive sk	ewness, negative			
skewness, symmetric	c frequency distribution. Bowley's coefficie	ent of skewn	ess(Definition and			
Examples and Bowl	ey's coefficient of skewness lies between	-1 to 1 (with	hout proof)). Karl			
Pearson's coefficient	t of skewness (Definition and Examples). N	Aeasures of s	kewness based on			
moments (Definition	and Examples).					
Kurtosis: Concept of	of kurtosis, leptokurtic, mesokurtic and plat	ykurtic freque	ency distributions.			
Measures of kurtosis	based on moments (Definition and Example	es).				
4	Correlation and Regression	10	CO4, CO5			
Correlation: Bivaria	ate data, Scatter diagram and its interpretation	on. Concept	of Covariance and			
its properties. Corre	lation between two variables and its types	. Karl Pearso	on's coefficient of			
correlation (r) and it	ts computation for ungrouped data. Proper	ties of correl	ation. Spearman's			
rank correlation coef	ficient and its computation.					
Regression: Concept	Regression: Concept of dependent (response) and independent (predictor or regerssor)					
variables. Meaning of regression, connection between correlation and regression. Fitting of line						
$Y = \beta_0 + \beta_1 X, \beta_0$ and β_1 are regression coefficients which are estimated using least-square						
method. Properties of regression coefficients. Concept of explained and unexplained variation,						
coefficient of determ	coefficient of determination, standard error of an estimate of line of regression. Concept of					
reverse regression.						
5	Non-linear Regression	04	CO6			

Necessity and importance of fitting of non-linear regression. Fitting of second degree $curve(Y = a + bX + cX^2)$, Fitting of exponential curves of the type $Y = ab^x$ and $Y = ax^b$. Fitting of logistic curve.

- 1. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, Sixth Revised Edition, The World Press Pvt. Ltd., Calcutta.
- 2. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, Third Edition, Sultan Chand and Sons Publishers, New Delhi.
- 3. Neil, A. Weiss, (2016). Introductory Statistics, Tenth Edition, Pearson.
- 4. Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, NewDelhi.
- 5. Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentice Hall of India, NewDelhi.
- 6. W. and Cochran W. G.(1989). Statistical Methods, Eighth Ed. EastWest Press.
- 7. Mood, A. M. and Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, Ed. 3, McGraw Hill BookCompany.

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-I

DS104P : Lab Course on DS103T (Descriptive Statistics)

No. of (Credits: 02	Teaching Scheme	Examination Scheme	
		Practical: 4 Hours/Week	Continuous Evaluation:1	5 Marks
			End Semester : 35 Marks	
Prerequ	isites			
	Mathematical of	perations		
Objecti	ves			
•	Fo acquaint stud	lents with some basic concepts	n Statistics	
•	To introduce to	some elementary statistical met	nods of analysis of data	
•	To identify the i	nature and type of data		
•	Го apply statisti	cal tools to numerical and categ	orical data	
Course	Outcomes			
On Con	pletion of this of	course, student will be able to -		
CO1: Id	entify the differ	ent types of variables and data.		
CO2:Co	mpute various	measures of central tendency, di	spersion,	
CO3: C	ompute various	measures of skewness and kurte	osis.	
CO4: Fi	nd correlation c	coefficient between numerical va	ariables.	
CO5: Fi	t linear regressi	on lines.		
CO6: Fi	t non-linear reg	ression lines.		
Sr.No.		List of Practical Assign	nments	Hours
1	Diagrammatic	representation and interpretatio	n of statistical data.	4
2	Graphical repr	resentation and interpretation of	statistical data	4
3	Tabulation			4
_	Computation of	of measures of central tendency	for grouped and ungrouped	
4	data			4
5	Computation of	of partition values for grouped a	nd ungrouped data.	4
6	Computation of	of measures of dispersion for gro	ouped and ungrouped data	4
_	Identification	the nature of probability distribu	tion based on measure of	
7	skewness and	kurtosis.		4
	Plotting of Sca	atter diagram and computation o	f correlation coefficient	
8	(ungrouped da	•		8
9	Computation of	of Spearman's Rank correlation	coefficient.	4
10	Fitting of simp Y).	ble linear regression model (for	both cases Y on X and X on	8

11	Fitting of second degree curve.	4
12	Fitting of exponential curve of type $Y = ab^x$, $Y = ax^b$.	8

- 1. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1983). Fundamentals of Statistics, Vol. 1, Sixth Revised Edition, The World Press Pvt. Ltd., Calcutta.
- 2. Gupta, S. C. and Kapoor, V. K. (1997). Fundamentals of Applied Statistics, Third Edition, Sultan Chand and Sons Publishers, New Delhi.
- 3. Neil, A. Weiss, (2016). Introductory Statistics, Tenth Edition, Pearson.
- 4. Purohit, S. G., Gore S. D., Deshmukh S. R. (2008). Statistics Using R, Narosa Publishing House, NewDelhi.
- 5. Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentice Hall of India, NewDelhi.
- 6. W. and Cochran W. G.(1989). Statistical Methods, Eighth Ed. EastWest Press.
- 7. Mood, A. M. and Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, Ed. 3, McGraw Hill BookCompany.

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-I

DS105T : Computational Mathematics

On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distribution. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targe Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian eliminethod. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, Tindependence, Linear dependence, Basis and Dimension of a vector space, Row space, C		redits: 2	Teaching Scheme	Examination Sch	neme
End Semester: 35 Marks Prerequisites • Basic Mathematics Skills Objectives • To understand the basic arithmetic operations on vectors and matrices, inc determinants, using technology where appropriate. • To solving systems of linear equations, using technology to facilitate row reduction. • To understand the basic terminology of linear algebra in Euclidean spaces, inc linear independence, spanning, basis, rank, nullity, subspace, and linear transformation • To understand find the eigen values and eigenvectors of a matrix or a transformation, and using them to diagonalize a matrix. • Enables to find projections and orthogonality among Euclidean vectors, includie Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and ICO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distril commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching No. Hours 1 1				Continuous Evalu	ation:15 Marks
Basic Mathematics Skills Objectives To understand the basic arithmetic operations on vectors and matrices, inc determinants, using technology where appropriate. To solving systems of linear equations, using technology to facilitate row reduction. To understand the basic terminology of linear algebra in Euclidean spaces, inc linear independence, spanning, basis, rank, nullity, subspace, and linear transformati To abstract notions of vector space and inner product space. To understand find the eigen values and eigenvectors of a matrix or a transformation, and using them to diagonalize a matrix. Enables to find projections and orthogonality among Euclidean vectors, includin Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and I CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distrit commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targ Hours 1				End Semester: 35	Marks
Basic Mathematics Skills Objectives To understand the basic arithmetic operations on vectors and matrices, inc determinants, using technology where appropriate. To solving systems of linear equations, using technology to facilitate row reduction. To understand the basic terminology of linear algebra in Euclidean spaces, inc linear independence, spanning, basis, rank, nullity, subspace, and linear transformati To abstract notions of vector space and inner product space. To understand find the eigen values and eigenvectors of a matrix or a transformation, and using them to diagonalize a matrix. Enables to find projections and orthogonality among Euclidean vectors, includin Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and I CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distril commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targ No. <u>1 System of Linear Equation A Vector Spaces S CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian eliminethod. <u>2 Vector Spaces S S CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space. </u></u>	Prerequ	isites		I	
Objectives • To understand the basic arithmetic operations on vectors and matrices, inc determinants, using technology where appropriate. • To solving systems of linear equations, using technology to facilitate row reduction. • To understand the basic terminology of linear algebra in Euclidean spaces, inc linear independence, spanning, basis, rank, nullity, subspace, and linear transformati • To understand the basic terminology of linear algebra in Euclidean spaces, inc linear independence, spanning, basis, rank, nullity, subspace, and linear transformati • To understand find the eigen values and eigenvectors of a matrix or a transformation, and using them to diagonalize a matrix. • Enables to find projections and orthogonality among Euclidean vectors, includin Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and ICO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distril commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elim	•		ematics Skills		
 To understand the basic arithmetic operations on vectors and matrices, inc determinants, using technology where appropriate. To solving systems of linear equations, using technology to facilitate row reduction. To understand the basic terminology of linear algebra in Euclidean spaces, inc linear independence, spanning, basis, rank, nullity, subspace, and linear transformati To abstract notions of vector space and inner product space. To understand find the eigen values and eigenvectors of a matrix or a transformation, and using them to diagonalize a matrix. Enables to find projections and orthogonality among Euclidean vectors, includin Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and ICO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distril commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targe Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.	Objectiv	ves			
 To understand find the eigen values and eigenvectors of a matrix or a transformation, and using them to diagonalize a matrix. Enables to find projections and orthogonality among Euclidean vectors, includin Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and I CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distril commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targe Hours I System of Linear Equation CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian eliminethod. I Vector Spaces CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space. 	d • T • T	eterminants, us o solving syste o understand	sing technology where appropri ems of linear equations, using te the basic terminology of linear	ate. echnology to facilitate r ar algebra in Euclidea	ow reduction. n spaces, includin
transformation, and using them to diagonalize a matrix. Enables to find projections and orthogonality among Euclidean vectors, includin Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distribution commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targe Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimimethod. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.	• T	o abstract notio	ons of vector space and inner pr	roduct space.	
 Enables to find projections and orthogonality among Euclidean vectors, includin Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and ICO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distribution, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit No. Teaching CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimination. CO2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space. Output Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Constraine of a vector space, Row space, C space. Conspace Constraine of a vector space, Row space,	• T	o understand	find the eigen values and	eigenvectors of a r	natrix or a line
Gram-Schmidt ortho normalization process and orthogonal matrices. Course Outcomes On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and I CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distril commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targ No. 6 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C	tr	ansformation,	and using them to diagonalize a	a matrix.	
On Completion of this course, student will be able to - CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and I CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distril commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targ No. Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian eliminethod. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C				e	ctors, including th
CO1: Solve systems of linear equations using methods by Gaussian elimination. CO2: Demonstrate understanding of the concepts of vector space, linear independence and 1 CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distril commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targ No. Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.			oourse, student will be able to		
CO2: Demonstrate understanding of the concepts of vector space, linear independence and CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distribution commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Vo. Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian eliminethod. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.	-	L		he Consist aliminatio	
CO3: Determine eigen values and eigenvectors and solve eigenvalue problems. CO4: Demonstrate understanding the use of truth tables and laws of identity, distribution CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Target Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimitethod. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.		-		=	
CO4: Demonstrate understanding the use of truth tables and laws of identity, distribution CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targe No. Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian eliminethod. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.				ector space, intear indep	ciluctice and basis
commutative, and domination. CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targ No. Hours CO1 Mot. Go (C01) Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method. CO1 Question Sector Spaces Sector Content of the properties of vector spaces, Linear combination, Transmitted of the properties of vector spaces, Linear combination, Transmitted of the properties of a vector space, Row space, Content of the properties of a vector space, Row space, Content of the properties of a vector space of the properties of a vector space, Row space, Content of the properties of a vector space of the properties o		termine eigen	values and eigenvectors and sol	lve eigenvalue problem	
CO5: Simplify and prove Boolean expressions, Compute sum of products and product of expansions. Unit Name of Unit Teaching CO Targe Hours No. Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space. Space.		emonstrate un	-		s.
expansions. Image: None of Unit Teaching Hours No. Hours CO Targe Hours 1 System of Linear Equation 6 CO1 Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method. 2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, Independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space. Source Space	CO4: D		derstanding the use of truth		s.
UnitName of UnitTeaching HoursCO Targ HoursNo.HoursHours1System of Linear Equation6CO1Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method.Co1, Co22Vector Spaces8CO1, CO2Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.Source Space	CO4: Do	ative, and domi	derstanding the use of truth ination.	tables and laws of id	s. lentity, distributiv
No.Hours1System of Linear Equation6Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method.2Vector Spaces8CO1, CO2Introduction to vector spaces, Some properties of vector spaces, Linear combination, I independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.	CO4: Do commuta CO5: Sin	ative, and domi mplify and pro	derstanding the use of truth ination.	tables and laws of id	s. lentity, distributiv
1System of Linear Equation6CO1Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method.2Vector Spaces8CO1, CO2Introduction to vector spaces, Some properties of vector spaces, Linear combination, I independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.8CO1, CO2	CO4: Do commuta CO5: Sin expansio	ative, and domi mplify and pro	derstanding the use of truth ination. ove Boolean expressions, Com	tables and laws of id	s. lentity, distributiv and product of su
Matrices, Determinants, Cramer's Rule, Echelon form, Row reduction, Gaussian elimi method. 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space. 8	CO4: Do commuta CO5: Sin expansio Unit	ative, and domi mplify and pro	derstanding the use of truth ination. ove Boolean expressions, Com	tables and laws of id pute sum of products a Teaching	s. lentity, distributiv
2 Vector Spaces 8 CO1, CO2 Introduction to vector spaces, Some properties of vector spaces, Linear combination, I independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.	CO4: Do commuta CO5: Sin expansio Unit No.	ntive, and domi mplify and pro- ns.	derstanding the use of truth ination. ove Boolean expressions, Com Name of Unit	tables and laws of id pute sum of products a Teaching Hours	s. lentity, distributiv and product of su CO Targeted
Introduction to vector spaces, Some properties of vector spaces, Linear combination, independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.	CO4: De commuta CO5: Sin expansio Unit No. 1	ative, and domi mplify and pro- ns. System of Li	derstanding the use of truth ination. ove Boolean expressions, Com Name of Unit near Equation	tables and laws of id pute sum of products a Teaching Hours 6	s. lentity, distributiv and product of su CO Targeted CO1
independence, Linear dependence, Basis and Dimension of a vector space, Row space, C space.	CO4: Do commuta CO5: Sin expansio Unit No. 1 Matrices	ative, and domi mplify and pro- ns. System of Li	derstanding the use of truth ination. ove Boolean expressions, Com Name of Unit near Equation	tables and laws of id pute sum of products a Teaching Hours 6	s. lentity, distributiv and product of su CO Targeted CO1
space.	CO4: De commuta CO5: Sin expansio Unit No. 1 Matrices method.	ntive, and domi mplify and pro- ns. System of Li , Determinants	derstanding the use of truth ination. ove Boolean expressions, Com Name of Unit near Equation s, Cramer's Rule, Echelon for	tables and laws of id pute sum of products a Teaching Hours 6 rm, Row reduction, G	s. lentity, distributiv and product of su CO Targeted CO1 aussian eliminatio
	CO4: De commuta CO5: Sin expansio Unit No. 1 Matrices method. 2	ative, and domi mplify and pro- ns. System of Li , Determinants Vector Space	derstanding the use of truth ination. ove Boolean expressions, Com Name of Unit near Equation s, Cramer's Rule, Echelon for es	tables and laws of id pute sum of products a Teaching Hours 6 rm, Row reduction, G 8	s. lentity, distributiv and product of su CO Targeted CO1 aussian eliminatio
3 Eigen values and Eigen vectors 8 CO3	CO4: De commuta CO5: Sin expansio Unit No. 1 Matrices method. 2 Introduct	ntive, and domi mplify and pro- ns. System of Li , Determinants Vector Space	derstanding the use of truth ination. ove Boolean expressions, Com Name of Unit near Equation s, Cramer's Rule, Echelon for es spaces, Some properties of v	tables and laws of id pute sum of products a Teaching Hours 6 rm, Row reduction, G 8 rector spaces, Linear c	s. lentity, distributiv and product of su CO Targeted CO1 aussian eliminatio CO1, CO2 combination, Line
	CO4: De commuta CO5: Sin expansio Unit No. 1 Matrices method. 2 Introduct independ	ntive, and domi mplify and pro- ns. System of Li , Determinants Vector Space	derstanding the use of truth ination. ove Boolean expressions, Com Name of Unit near Equation s, Cramer's Rule, Echelon for es spaces, Some properties of v	tables and laws of id pute sum of products a Teaching Hours 6 rm, Row reduction, G 8 rector spaces, Linear c	s. lentity, distributiv and product of su CO Targeted CO1 aussian eliminatio CO1, CO2 combination, Line

4	Boolean function	Q	CO4.CO5
-	Doolean Iuncion	0	04,003

Relations, Types of Relations, Equivalence relations, Digraphs of relations, Matrix representation and Composition of Relations, Transitive closure and Warshall's Algorithm, Poset, Hasse diagram, Boolean Functions : Introduction, Boolean variable, Boolean Function of degree n, Boolean identities, Definition of Boolean Algebra, Representation of Boolean Functions : Minterm, Maxterm Disjunctive normal form, Conjunctive normal Form.

- 1. Howard Anton, Chris Rorres, Elementary Linear Algebra, Application Version, Ninth Edition, Wiley, 11th edition.
- 2. K. Hoffman and R. Kunze, Linear Algebra, 2nd edition(2014), Prentice Hall of India, New Delhi.
- 3. Steven J. Leon, Linear Algebra with Applications, 4th edition(1994), Prentice Hall of India. New Delhi.
- 4. Discrete Mathematical Structures, by Kolman, Busby, Ross, Rehman, Prentice Hall

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-I

DS106P: Lab Course on DS105T (Computational Mathematics)

No. of C	Credits: 2	Teaching Scheme	Examination Scheme	
		Practical: 4 Hours/Week	Continuous Evaluation:15	Marks
			End Semester: 35 Marks	
Prerequ	isites			
• E	Basic Mathemati	e Skills		
Objectiv	ves			
d • T • T li	leterminants, usi To solve systems To understand th inear independer	e basic arithmetic operations on ng technology where appropriat of linear equations, using softw e basic terminology of linear alg nce, spanning, basis.	e. vare to facilitate row reduction gebra in Euclidean spaces, incl	
		ns of vector space and inner pro	-	n to
	liagonalize a ma	nd the eigenvalues and eigenvec trix.	tors of a matrix and using ther	11 10
	-	ify and prove Boolean expression	ons. Compute sum of products	and
р	product of sum e	xpansions.	_	
• 1	To know how to	use maxima software.		
Course	Outcomes			
On Com	pletion of this co	ourse, student will be able to -		
	•	stems of linear equations using 1	•	
		standing of the concepts of vec	tor space, linear independence	and basis.
		ues and eigenvectors problems.		
		se of truth tables and laws of ide	entity, distributive, commutativ	ve, and
dominati				C
		e Boolean expressions, Compute	e sum of products and product	of sum
expansio CO6: Sti		the problem based on theory by	vusing maxima software.	
Sr.No.		List of Practical Assign	nments	Hours
1	Problem Solvi	ng on Unit 1: System of Linear	Equation (Written)	4
2	Problem Solvi	ng on Unit 2: Vector Spaces (W	Vritten)	8
3	Problem Solvi	ng on Unit 3: Eigen values and	Eigen vectors (Written)	8
4	Problem Solvi	ng on Unit 4: Boolean functio	n (Written)	8
5	Software)	ng on Unit 1: System of Linear		8
6	Problem Solvi	ng on Unit 2: Vector Spaces (U	Using Maxima Software)	8
7	Problem Solvi Maxima Softw	ng on Unit 3: Eigen values and are)	l Eigen vectors (Using	8

	Problem Solving on Unit 4: Boolean function (Using Maxima Software) 8
Re	rence Books
1.	Ioward Anton, Chris Rorres, Elementary Linear Algebra, Application Version, Ninth
	Edition, Wiley, 11th edition.
2.	K. Hoffman and R. Kunze, Linear Algebra, 2nd edition(2014), Prentice Hall of India, New
	Delhi.
3.	teven J. Leon, Linear Algebra with Applications, 4th edition(1994), Prentice Hall of India.
	Jew Delhi.
4.	Discrete Mathematical Structures, by Kolman, Busby, Ross, Rehman, Prentice Hall

Savitribai Phule Pune University **B.Sc. Data Science (Pattern 2024)** Semester-I

SEC101DS: Computer Organization

No	of Credits:	Teaching Scheme	Examinat	ion Scheme	
110.	2	Theory: 2 Hours/Week	Continuou	s Evaluation	:15 Marks
	Z	Theory. 2 Hours/ week	End Semes	ster :35 Mark	CS
Prerequ	isites				
• 1	Number systems ar	nd basics of digital electronics.			
Objectiv	ves				
• 7	To revise about dif	ferent number systems, codes,	logic gates v	with truth tab	oles.
• 7	o understand com	binational and sequential circu	its of digital	electronics.	
• 7	To conceptualize th	ne basics of organizational and	architectura	l issues of a	digital computer
a	nd learn about var	ious data transfer techniques ir	n digital com	puter and the	e I/O interfaces.
• 7	To know how I/O a	devices are accessed and its pri	nciples and	to provide th	e knowledge on
Ι	nstruction Level P	arallelism.			
• 7	To study architect	ure			
Course	Outcomes				
On Com	pletion of this cou	rse, student will be able to -			
CO1: U	nderstand number	systems related to computer an	nd their inter	-conversion.	
CO2: Fa	miliar with digital	l circuits, their types, and appli	cations.		
CO3: U	nderstand CPU and	d Memory organizations for the	e fundament	als of compu	iter.
CO4: St	udy interfacing of	peripherals with CPU in serial	and parallel	l manner wit	h data
converto	ors.				
CO5:Stu	udy basics of micro	oprocessor architecture and con	ncept of pipe	elining	
Unit		Name of Unit		Teaching	CO Targeted
No.				Hours	
1	Digital Circuits			12	CO1, CO2
		Hexadecimal, BCD and their			
		gates, derived gates, positive a	-		-
circuits,	De-Morgan's theo	orem. Concept of K map and si	mplification	of single exp	pressions (upto 4
variables	s). Combinational	circuits: Half adder, full adder	er, half Subt	ractor, Multi	plexer (2:1 and
4:1), De	multiplexer (1:2 a	nd 1:4) using basic gates, Enco	oder - Decin	nal to BCD,	Decoder - 3 to 8
decoder.	Sequential circu	its: Concept of triggering, F	Flip-Flops: S	SR, JK, D	and T.Counters:
Synchro	nous and Asynchro	onous (3-bit), Shift registers: ty	pes and app	olications.	
2	CPU, Memory a	and I/O Organizations		12	CO3, CO4
CPU O	rganization: Fun	ctions of CPU, General regis	sters used i	n CPU: PC,	SP, instruction
pointer,	instruction registe	r, instruction decoder, flag, ge	neral purpo	se registers,	memory address
register,	memory byte regi	ster, General register organizat	ion of CPU,	Concept of	stack.
Memory	v organization: N	Iemory hierarchy, cache memo	ory and its a	ddress mapp	oing, Associative
memory	Virtual momory	N (1 1			
memory	, viituai memory,	Memory management through	segmentatio	on and paging	g.

I/O Organization: Block diagram of parallel interface and function of blocks, Concept of interrupt, IVT, Types of I/O transfer, CPU initiated, interrupt initiated, DMA (only concept),Data convertors:R-2RDAC, ADC (flash, successive approximation), Serial communication and types.

	.5	Architecture of Microprocessor and Parallel Processing	6	CO5
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Architecture of Microprocessor: Block diagram of 8086 and function of blocks, 8086 Registers, Numeric co-processor - concept, block diagram and functions of blocks.

Parallel Processing: Concept of parallelism, Parallel computer structures. Concept of pipelining, Pipelined computers, Instruction pipeline, Arithmetic pipeline, Concept of RISC and CISC. RISC pipelining.

- 1. Modern Digital Electronics, 4thedition, R P Jain, Tata McGraw Hill publication.
- 2. Digital Logic & Computer Design, Morris Mano, Pearson.
- 3. Computer Systems Architecture Moris Mano, 3rdEdition, Pearson
- 4. Computer Systems Organization & Architecture- John D. Carinelli Pearson publication.

Savitribai Phule PuneUniversity B.Sc. Data Science (Pattern 2024) Semester-II

DS151T : Advanced Python Programming

No. of C	redits: 2	Teaching Scheme	Examination S	cheme	
		Theory:2 Hrs /Week		luation:15 Marks	
			End Semester:35	5 Marks	
Prerequ	isites				
-		Python Programming Languag	e.		
		of computational mathematics			
Objectiv		1			
0		writing and manipulating files			
	•	• • •		Scikit-learn etc. in	
• To implement libraries like Pandas, NumPy,SciPy, Matplotlib, Scikit-learn etc. in Python.					
	-	concepts of GUI controls and	designing GUI appli	cations.	
	-	w the concepts of file handling	• • •		
	Outcomes		s, enception handling	•	
		waa atu dant will ba abla ta			
	L	urse, student will be able to -			
		writing into files using Pythor			
	• •	nent a program to solve a com mentation of libraries like Pa		Matplotlib Sailit	
	in Python.	mentation of noraries like Pa	iidas, Nuiiiry, Sciry,	Matpiotilo, Scikit-	
	-	eptions and files.			
		eptions and mes.			
Unit		Name of Unit	Teaching	CO Targeted	
No.		Name of Omt	Hours	CO Targettu	
1	File Handling		3	CO1	
	duction to Files			001	
	es of Files				
• 1	ing and Closing	a Text File			
1	ing to a Text File				
	ing from a Text				
	ng Offsets in a F				
1.7 Crea	ting and Traversi	ng a Text File			
	-	-			
2	Python Librar		17	CO2 & CO3	
	oduction to Pyth				
		NumPy, SciPy, Pandas, Stats	Models		
		Matplotlib, Seaborn, Plotly			
	-	Machine Learning- Scikit-lea	rn, XGBoost, Eli5		
		nsorFlow, Pytorch, Keras			
2.1.5 Na	tural Language F	Processing (NLP)- NLTK, Spa	Cy, Gensim		

2.2 Working with Tabular Numeric Data(Numpy with Python)

2.2.1 NumPy Arrays Creation Using array() Function

2.2.2 Array Attributes, NumPy Arrays Creation with Initial Placeholder Content

2.2.3 Integer Indexing, Array Indexing, Boolean ArrayIndexing, Slicing and Iterating in Arrays

Basic Arithmetic Operations on NumPy Arrays

2.2.4 Mathematical Functions in NumPy

2.2.5 Changing the Shape of an Array, Stacking and Splitting of Arrays, Broadcasting in Arrays.

2.3 Working with Data Series and Frames

2.3.1 Pandas Data Structures, Reshaping Data, Handling Missing Data

2.3.2 Combining Data, Ordering and Describing Data, Transforming Data, Taming Pandas File I/O

2.4 Plotting

Basic Plotting with PyPlot, Matplotlib, Getting to Know Other Plot Types, Plotting with Pandas

I undub					
3	Exception Handling	5	CO4		
3.1 Python Exception					
3.2 Common Exception					
3.3 Exce	3.3 Exception handling in Python (try-except-else)				
3.4 The	except statement with no exception				
3.5 Mult	iple Exception				
3.6 The	try-finally clause				
3.7 Cust	om Exception and assert statement				
4	GUI Programming	5	CO5		
4.1 Intro	duction				
4.2 Tkin	ter programming				
4.3 Tkin	ter widgets				
4.5 Fram	ie				
4.6 Butto)n				
4.7 Labe	1				
4.8 Entry	ý				
Reference Books					
1.Mark I	1.Mark Lutz, Programming Python, O'Reilly, 4th Edition, 2010				
2.Dive into Python, Mike					
3. Learn	3. Learning Python, 4th Edition by Mark Lutz				
4. Programming Python, 4th Edition by Mark Lutz					
5.Python	Programming: An introduction to computer, John Zelle, 3	ord Edition.			
6. Data	Science Essentials in Python: Collect, Organize, Ex	plore, Predic	t, Value. Dmitry		
Zinoriev	, The Pragmatic Programmers LLC, 2016				
7. Introc	luction to Python Programming. Gowrishankar S., Ve	ena A. CRC	Press, Taylor &		
	2 2010				

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-II

DS152P : Lab Course on DS151T (Advanced Python Programming)

10. UI C	redits: 2	Teaching Scheme	Examination Sc	heme
		Practical: 4 Hrs/Week	Continuous Evalu	ation: 15 Marks
			End Semester:	35 Marks
Prerequ	isites			
• P	ractical Knowled	ge of Python Programming.		
• P	rior knowledge o	f computational mathematics.		
Objectiv	/es			
• 1	o learn reading, v	writing and manipulating files		
		oraries like Pandas, NumPy	,SciPy, Matplotlib, S	cikit-learn etc. in
	ython.			
	-	concepts of GUI controls and	0 0 11	ations.
		w the concepts of file handling	g, exception handling.	
	Outcomes	maa atudant will ha ahla ta		
	-	urse, student will be able to -		
	-	writing into files using Pythor ent a program to solve a com		
	•	nentation of libraries like Par		Matplatlih Sailit
	. in Python.	inclitation of noralles like I a	nuas, nunn y, sen y,	Matpiotilo, Scikit-
	ow to handle exce	entions and files		
		-		
CO5: Do		ent GUI application	Hours	CO Targeted
CO5: Do Unit		-	Hours	CO Targeted
CO5: De Unit No.	esign and implem	ent GUI application	Hours	
CO5: Da Unit No. 1	esign and impleme File Handling	ent GUI application Name of Unit		CO Targeted CO1
CO5: Do Unit No. 1 a. A	esign and impleme File Handling Assignments on re	ent GUI application Name of Unit eading and writing files	8	
CO5: Do Unit No. 1 a. A	esign and impleme File Handling Assignments on re	ent GUI application Name of Unit eading and writing files excessing and manipulating file	8	
CO5: Da Unit No. 1 a. A b. A 2	File Handling Signments on reassignments on action of the second	ent GUI application Name of Unit eading and writing files eccessing and manipulating file	8 es	CO1
CO5: Da Unit No. 1 a. A b. A 2 a. A	esign and impleme File Handling Assignments on re	ent GUI application Name of Unit eading and writing files eccessing and manipulating file	8 es	CO1
CO5: De Unit No. 1 a. A b. A 2 a. A b. A	File Handling File Handling Assignments on re Assignments on ac Python Numpy Assignments on N	ent GUI application Name of Unit eading and writing files eccessing and manipulating file	8 es	CO1
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CO5: De Unit No. 1 a. A b. A 2 a. A b. A c. A d. A	File Handling File Handling Assignments on ac Python Numpy Assignments on N Assignments on N	ent GUI application Name of Unit eading and writing files eccessing and manipulating file umpy basics. umpy Arrays. umpy Linear Algebra umpy Statistics	8 es	CO1
CO5: De Unit No. 1 a. A b. A 2 a. A b. A c. A d. A	File Handling File Handling Assignments on re Assignments on action Python Numpy Assignments on N Assignments on N Assignments on N	ent GUI application Name of Unit eading and writing files eccessing and manipulating file umpy basics. umpy Arrays. umpy Linear Algebra umpy Statistics umpy Strings	8 es	CO1
CO5: Do Unit No. 1 a. A b. A 2 a. A b. A c. A d. A e. A	File Handling File Handling Assignments on action Python Numpy Assignments on N Assignments on N Assignments on N Assignments on N Assignments on N Assignments on N Assignments on N	ent GUI application Name of Unit eading and writing files eccessing and manipulating file umpy basics. umpy Arrays. umpy Linear Algebra umpy Statistics umpy Strings	8 es 12 8	CO1
CO5: Do Unit No. 1 a. A b. A 2 a. A b. A c. A d. A e. A 3	File Handling File Handling Assignments on action Python Numpy Assignments on N Assignments on N Assignments on N Assignments on N Assignments on N Assignments on N Assignments on N	ent GUI application Name of Unit eading and writing files eccessing and manipulating file umpy basics. umpy Arrays. umpy Linear Algebra umpy Statistics umpy Strings	8 es 12 8	CO1
CO5: De Unit No. 1 a. A b. A 2 a. A b. A c. A d. A c. A c. A d. A c. A	File Handling File Handling Assignments on action Python Numpy Assignments on N Assignments on N	ent GUI application Name of Unit eading and writing files eccessing and manipulating file umpy basics. umpy Arrays. umpy Linear Algebra umpy Statistics umpy Strings	es 12 8 SV files using Pandas 12 12	CO2 CO3 CO3
CO5: De Unit No. 1 a. A b. A 2 a. A b. A c. A d. A c. A d. A e. A 3 3 a	File Handling File Handling Assignments on re Assignments on act Python Numpy Assignments on N Assignments on N	ent GUI application Name of Unit ading and writing files ccessing and manipulating file umpy basics. umpy Arrays. umpy Linear Algebra umpy Statistics umpy Statistics umpy Strings	es 12 8 SV files using Pandas 12 12	CO2 CO3 CO3

Reference Books

1.Mark Lutz, Programming Python, O'Reilly, 4th Edition, 2010

2. Dive into Python, Mike

3. Learning Python, 4th Edition by Mark Lutz

4. Programming Python, 4th Edition by Mark Lutz

5.Python Programming: An introduction to computer, John Zelle, 3rd Edition.

6. Data Science Essentials in Python: Collect, Organize, Explore, Predict, Value. Dmitry Zinoriev, The Pragmatic Programmers LLC, 2016

7. Introduction to Python Programming. Gowrishankar S., Veena A. CRC Press, Taylor & Francis Group, 2019

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024)

DS153T : Discrete Probability and Probability Distributions

No. of C	redits: 02	Teaching Scheme	Exan	nination Sch	eme
		Theory: 2 Hours/Week	Conti	nuous Evalu	ation:15 Marks
			End S	Semester : 35	Marks
Prerequ	isites				
• E	asics of Set the	ory, Mathematical operations			
Objectiv	ves				
• T	o revise the bas	sic concepts of probability, axiom	natic theo	ory of probab	ility.
• T	o understand th	e concept of random variable			
• T	o study probabi	ility distribution (univariate and b	oivariate)	discrete ran	dom variables,
e	xpectation and a	moments of probability distribution	on		
• T	o find marginal	l distribution and conditional dist	ribution	of bivariate f	requency
d	istribution				
• T	o find condition	nal mean of bivariate frequency d	listributio	on	
• T	o find variance,	, covariance and correlation of bi	variate fi	requency dist	ribution
Course	Outcomes				
On Com	pletion of this c	ourse, student will be able to –			
CO1: Fin	nd the probabilit	ties of events and its expectation,	mean, v	ariance, etc.	
CO2:Dis	tinguish betwee	en random and non-random exper	riments		
CO3:Ide	ntify the nature	of distribution			
CO4: Fir	nd marginal dist	ribution and conditional distribut	ion		
CO5: Fir	nd mean of marg	ginal distribution and conditional	mean of	bivariate fre	quency
distributi	ion				
CO6: Fir	nd correlation of				
		f bivariate frequency distribution			
Unit No.		f bivariate frequency distribution Name of Unit		Teaching Hours	CO Targeted
		x v			CO Targeted CO1, CO2
No. 1	In	Name of Unit		Hours 07	CO1, CO2
No. 1 Basics o	In	Name of Unit htroduction to Probability Experiments/Models, Ideas of		Hours 07	CO1, CO2
No. 1 Basics of models. 1 Definition	In of Probability: Random Experi ons: Sample s	Name of Unit htroduction to Probability Experiments/Models, Ideas or ment. pace, Discrete sample space:	f determ	Hours 07 hinistic and nd countably	CO1, CO2 non-deterministi
No. 1 Basics of models. 1 Definition	In of Probability: Random Experi ons: Sample s	Name of Unit ntroduction to Probability Experiments/Models, Ideas of ment.	f determ	Hours 07 hinistic and nd countably	CO1, CO2 non-deterministi
No. 1 Basics of models. 1 Definition Elementa	In of Probability: Random Experi ons: Sample sp ary event, Comp	Name of Unit htroduction to Probability Experiments/Models, Ideas or ment. pace, Discrete sample space:	f determ finite an t, Impos	Hours 07 hinistic and hd countably sible event.	CO1, CO2 non-deterministi infinite, Even
No. 1 Basics of models. Definition Elementa Occurre	In of Probability: Random Experi ons: Sample sp ary event, Comp nce of events	Name of Unit ntroduction to Probability Experiments/Models, Ideas of ment. pace, Discrete sample space: plement of an event, Certain even	f determ finite an t, Impos in event	Hours 07 hinistic and nd countably sible event. . Algebra o	CO1, CO2 non-deterministr infinite, Even f events and it
No. 1 Basics of models. 1 Definition Elementa Occurrenta representa	In of Probability: Random Experi ons: Sample sp ary event, Comp ary event, Comp ary event theorem	Name of Unit htroduction to Probability Experiments/Models, Ideas of ment. pace, Discrete sample space: plement of an event, Certain even Concept of occurrence of a	f determ finite an at, Impos an event wing even	Hours 07 hinistic and hd countably sible event. . Algebra o ents (i) at leas	CO1, CO2 non-deterministing infinite, Even f events and in st one of the give
No. 1 Basics of models. 1 Definition Elementa Occurrent represent events, (a	In of Probability: Random Experi ons: Sample sp ary event, Comp nce of events tation in set theo ii) none of the g	Name of Unit ntroduction to Probability Experiments/Models, Ideas of ment. pace, Discrete sample space: plement of an event, Certain even Concept of occurrence of a ory notation. Occurrence of follow	f determ finite an at, Impos an event wing event events,	Hours 07 hinistic and nd countably sible event. . Algebra o ents (i) at leas (iv) mutually	CO1, CO2 non-determinist: infinite, Even f events and it st one of the give
No. 1 Basics of models. I Definition Elementa Occurrent representa events, (a (v) mutu	In of Probability: Random Experi ons: Sample sp ary event, Comp ary event, Comp ary event, Comp ary event, Comp ary event, Comp ang events tation in set theo tation in set theo tation in set theo ally exhaustive	Name of Unit htroduction to Probability Experiments/Models, Ideas of ment. pace, Discrete sample space: plement of an event, Certain even Concept of occurrence of a ory notation. Occurrence of follow given events, (iii) all of the given	f determ finite an at, Impos an event wing events, events, t of the g	Hours 07 hinistic and nd countably sible event. . Algebra o ents (i) at leas (iv) mutually iven events.	CO1, CO2 non-determinist infinite, Even f events and in t one of the give exclusive event
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No. 1 Basics of models. I Definition Elementa Occurrent representa events, (1) (v) mutu Classical equiprob	In of Probability: Random Experi ons: Sample sp ary event, Comp nce of events tation in set theo ii) none of the g ally exhaustive definition of pr able and non-ec	Name of Unit htroduction to Probability Experiments/Models, Ideas of ment. pace, Discrete sample space: plement of an event, Certain event Concept of occurrence of a ory notation. Occurrence of follow given events, (iii) all of the given events, (vi) exactly one event our robability and its limitations. Pro	f determ finite an at, Impos an event wing events, of t of the g bability	Hours 07 inistic and ind countably sible event. . Algebra o ents (i) at leas (iv) mutually iven events. model, proba	CO1, CO2 non-deterministing infinite, Even f events and in st one of the give exclusive event bility of an even

axiomatic definition such as $P(AUB) = P(A) + P(B) - P(A \cap B)$. Generalization $P(AUBUC), 0 \le P(A) \le 1, P(A) + P(A') = 1, P(\Phi) = 0$ and when $A \subseteq B$ then $P(A) \le 1$

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2	Conditional Probability	05	CO2				
Definitio	n of conditional probability of an event. Results on con	ditional prob	ability. Definition				
of indep	endence of two events $P(A \cap B) = P(A)P(B)$. Pairw	vise indepen	dence and mutual				
independ	lence for three events. Multiplication theorem	$P(A \cap B)$	= P(A) P(B A).				
Generali	zation to $P(A \cap B \cap C)$. Partition of the sample	espace, prio	or and posterior				
probabili	ties.Proof of Bayes' theorem. Applications of Bayes' the	eorem in reall	ife.				
3	Univariate Probability Distributions and its	9	CO2				
3	Mathematical Expectation	9	CO3				
Univariate Probability Distributions defined on Discrete Sample Space: Concept and							
definition of a discrete random variable. Probability Mass Function (pmf) and cumulative							
Distribution Function (<i>cdf</i>), $F(\cdot)$ of discrete random variable, properties of <i>cdf</i> . Mode and							
median o	of a univariate discrete probability distribution.						
Mathem	natical Expectation: Definition of expectation (me	ean) of a	random variable,				
expectati	ion of a function of a random variable, Moment G	enerating Fu	nction (mgf) and				
Cumulat	ive Generating Function (cgf). Properties of mgf and cgf.						
Definitio	ns of variance, standard deviation (SD) and Coefficient	of variation ((CV) of univariate				
probabili	ty distribution, effect of change of origin and scale	on mean, v	variance and SD.				
Definitio	n of raw, central and factorial raw moments of univariat	e probability	Distributions and				
their inte	rrelations (without proof). Coefficients of skewness and	kurtosis base	d on moments.				
4	Mathematical Expectation for Bivariate	9	CO4, CO5,				
-	Frequency Distribution	,	CO6				
Definitio	n of raw and central moments, mgf and cgf. Theorem	is on expecta	ations of sum and				
product	of two jointly distributed random variables. Condition	nal expectation	on. Definitions of				
condition	hal mean and conditional variance. Definition of covaria	ance, coeffici					
independence and uncorrelatedness of two variables. Variance of linear combination of							
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-							
variables Referen	lence and uncorrelatedness of two variables. Variants, $Var(aX + bY)$, $Var(aX + bY + C)$ and its generalize Books	zation.	combination of				
variables Referen	Hence and uncorrelatedness of two variables. Variants, $Var(aX + bY)$, $Var(aX + bY + C)$ and its generalized	zation.	combination of				
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SavitribaiPhule Pune University B.Sc. Data Science (Pattern 2024) Semester-II

DS154P : Lab Course on DS153T (Discrete Probability and Probability Distributions)

	Practical: 4 Hours/Week	Continuous Evaluation	
		Continuous Evaluation	:15 Marks
		End Semester : 35 Mar	ks
isites			
asics of Set the	ory, Mathematical operations		
es			
o understand th	e concept of random variable		
o study probabi	lity distribution (univariate and	d bivariate) discrete random	variables,
-			
-	distribution and conditional d	istribution of bivariate freque	ency
	covariance and correlation of	bivariate frequency distribut	ion
-	_		
-		periments	
-			
-			
	ginal distribution and condition	hal mean of bivariate frequen	cy
	61. :		
a correlation of	· ·		TT
Calculation of			Hours
	probability for different events	s based on real life	4
	methometical expectation and	varianco	4
	•		4
	ar and conditional distribution	or bivariate probability	4
	conditional expectation and co	nditional variance	4
	1		4
			4
			+
	the contration coefficient Das	cu on orvariate probability	8
distrinution			0
distribution Model samplin	g from the given probability d	istributions	12
	asics of Set the res o understand the o study probability pectation and in o find marginal istribution o find condition o find condition o find condition o find variance, Dutcomes pletion of this condition of the probability tinguish between tify the nature and marginal dist ind mean of marginal distribution of Situations. Calculation of Obtain marginal distribution Calculation of Calculation of Calculation of Calculation of Calculation of	asics of Set theory, Mathematical operations res to understand the concept of random variable to study probability distribution (univariate and xpectation and moments of probability distribu- to find marginal distribution and conditional di- istribution to find conditional mean of bivariate frequency to find variance, covariance and correlation of Dutcomes pletion of this course, student will be able to – ad the probabilities of events and its expectation tinguish between random and non-random exp ntify the nature of distribution ad marginal distribution and conditional distribu- ad mean of marginal distribution and conditional distribu- ad correlation of bivariate frequency distribution and correlation of probability for different events situations. Calculation of mathematical expectation and Obtain marginal and conditional distribution distribution Calculation of conditional expectation and conditional Calculation of variance of linear combination Checking the independence of the probability	asics of Set theory, Mathematical operations (o) understand the concept of random variable (o) study probability distribution (univariate and bivariate) discrete random (xpectation and moments of probability distribution (o) find marginal distribution and conditional distribution of bivariate freque (c) study probability distribution and conditional distribution (o) find conditional mean of bivariate frequency distribution (c) find variance, covariance and correlation of bivariate frequency distribution (c) find variance, covariance and correlation of bivariate frequency distribution (c) find variance, covariance and correlation of bivariate frequency distribution (c) find variance, covariance and correlation, mean, variance, etc. (c) the probabilities of events and its expectation, mean, variance, etc. (c) tinguish between random and non-random experiments (c) and marginal distribution (c) dimean of marginal distribution and conditional mean of bivariate frequency (c) distribution (c) for the nature of distribution and conditional mean of bivariate frequency (c) distribution (c) dimean of bivariate frequency distribution (c) dimean of bivariate frequency distribution (c) dimean of probability for different events based on real life (c) situations. (c) Calculation of mathematical expectation and variance. (c) Obtain marginal and conditional distribution of bivariate probability (c) distribution (c) dimean of bivariate probability (c) distribution of bivariate probability (c) distribution and conditional distribution (c) distrib

- 1. Gupta, S. C. and Kapoor, V. K. (1983). Fundamentals of Mathematical Statistics, Eighth Edition, Sultan Chand and Sons Publishers, New Delhi.
- 2. Sarma, K. V. S. (2001). Statistics Made it Simple: Do it yourself on PC. Prentce Hall of India, New Delhi.
- 3. Hoel, P. G. (1971). Introduction to Mathematical Statistics, John Wiley and Sons, New York.
- 4. Hogg,R.V.and Craig, R.G.(1989).Introduction to Mathematical Statistics,Ed. MacMillan Publishing Co., New York.
- 5. Mayer, P. (1972). Introductory Probability and Statistical Applications, Addison Wesley Publishing Co., London.
- 6. Mood, A. M. and Graybill, F. A. and Boes D.C. (1974). Introduction to the Theory of Statistics, Ed. 3, McGraw Hill Book Company.
- 7. Rao, VLS Prakash (2008). First Course in Probability and Statistics, New Age International Publishers, New Delhi.
- 8. Ross S. (2002). A First Course in Probability, Sixth Edition, Pearson Education, Inc. & Dorling Kindersley Publishing,Inc.

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-II

DS155T : Graph Theory

No. of C	redits: 2	Teaching Scheme	Examination Scheme			
		Theory: 2 Hrs/Week	Continuous Evaluation:	15 Marks		
D	• - • 4		End Semester :	35 Marks		
Prerequ		thematica Cat Theory				
Objectiv		athematics, Set Theory				
•		tudents about graph, gra	inh models types of gr	anh connectivity		
	oplications of g			apii, connectivity,		
		1 1	rent Fulerian and Hamilton	ian circuit		
 To know how to find shortest path for different Eulerian and Hamiltonian circuit. To introduce students about Trees, applications of trees, binary tree, tree traversal , 						
		udents about frees, applic	ations of trees, binary tre	e, nee naversar,		
-	panning trees.	find minimum anonning to	222			
		find minimum spanning tr				
	o make student	ts familiar with the use of a	In these concepts as tools in	other areas of the		
	Outcomes	a and ant will be able	to .			
	-	course, student will be able				
	-	raph, and graph models, ter				
		ve examples on adjacency a				
	•	r tours and Hamiltonian cyc	-			
	-	the shortest spanning trees				
	udents can solv	e the problems on tournal				
Unit		Name of Unit	Teaching Hours	CO Targeted		
No.				001.005		
1	Graphs and	Graph Models	4	CO1, CO5		
Graph: I	Definition, basic	c terminology of Graph, Gr	aph Models, Social networ	ks,		
Commu	nication networ	ks, Information networks	Software Design Application	ons,		
Transpor	tation network	ks, Biological networks, To	urnaments.			
2	Graph Isomo	orphism	5	CO2		
Handsha	king lemma, S	pecial Types of Graph, Dire	ected graph, Matrix represe	ntation of graph,		
	•	sm,Examples on isomorph	• • •			
3	Connected G		8	CO3		
Walk tr	ail. path_cvcle	connected graph, disconne	cted graph, component Cu	t edge. Cut vertex		
		tivity, edge connectivity, N	011			
		edge connectivity and Mi	• • •			
	-	, Dijkstra's algorithm	active of a graph	,		
4	-	Hamiltonian Graphs .	5	CO3		
The Van		Bridge problem, Euler's pa				
		• •		• •		
argorith	algorithm, Hamilton path, Hamilton Circuit, Hamiltonian graph, Applications of Eulerian and					

Ha	Hamiltonian graph: Traveling Salesman problem, Chinese Postman problem.					
	5	Trees	8	CO4		
De	efinitio	on of tree, basic terminology of tree, properties of trees,	Eccentricity	of a vertex,		
Ce	ntre, d	iameter, radius of a tree, Spanning Tree, Chords and bra	nches of Spa	nning Tree,		
Sh	ortest	spanning tree, Kruskal's algorithm, M-ary tree, binary tr	ee, Tree trave	ersal, Ordered		
roc	oted tro	ee, polish notation, arborescence.				
Re	feren	ee Books				
1.	Ken	neth Rosen, Discrete Mathematics and It's Applications,	Tata McGrav	w Hill, Seventh		
	Edition.					
2.	Nars	ingh Deo, Graph Theory with applications to computer s	science and en	ngineering,		
	Prent	ice Hall.				
3.	Doug	als B. West, Introduction to Graph Theory, Pearson Edu	cation, Secon	nd edition.		

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-II DS156P : Lab Course on DS155T (Graph Theory)

	Teaching	Examination Scheme	
Credits:	2 Scheme	Continuous Evaluation: 15 Marks	
	Practical: 4	4 End Semester : 35 Marks	
	Hours/Wee	ek	
Prerequi	isites		
• B	asics of mathemati	ics, Set Theory	
Objectiv	es		
1. To in	troduce students ab	bout graph, graph models, types of graph, connectivity, app	lications of
graph	theory.		
2. To k	now how to find sh	nortest path for different Eulerian and Hamiltonian circuit.	
3. To in	ntroduce students al	bout Trees, applications of trees, binary tree, tree traversal	, spanning
trees			
4. To k	now how to find m	ninimum spanning trees.	
5. To n	nake students famili	liar with the use of all these concepts as tools in other areas	of the
cour	se curriculum.		
6. To k	now how to use Ma	axima software.	
Course (Dutcomes		
-		se, student will be able to :	
		n, and graph models, terminology of graph.	
CO2: Stu	idents can solve exa	amples on adjacency and incidence matrix.	
	entify the Euler tour	irs and Hamiltonian cycle and find shortest path.	
CO4: At	entify the Euler tour ole to Compute the	rs and Hamiltonian cycle and find shortest path. shortest spanning trees.	
CO4: At CO5: Stu	entify the Euler tour ole to Compute the s adents can solve the	rs and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow.	
CO4: At CO5: Stu	entify the Euler tour ole to Compute the s adents can solve the	rs and Hamiltonian cycle and find shortest path. shortest spanning trees.	
CO4: At CO5: Stu CO6: Stu	entify the Euler tour ole to Compute the s adents can solve the	ars and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow. e problems on theory using Maxima Software.	Hours
CO4: At CO5: Stu	entify the Euler tour ole to Compute the s idents can solve the idents can solve the	Irs and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow. e problems on theory using Maxima Software. List of Practical Assignments	Hours 4
CO4: At CO5: Stu CO6: Stu Sr.No. 1	entify the Euler tour ole to Compute the adents can solve the adents can solve the Problem Solving	urs and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow. e problems on theory using Maxima Software. List of Practical Assignments g on Unit 1: Graphs and Graph Models (Written)	4
CO4: Ab CO5: Stu CO6: Stu Sr.No. 1 2	entify the Euler tour ole to Compute the adents can solve the adents can solve the Problem Solving Problem Solving	It is and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow. e problems on theory using Maxima Software. List of Practical Assignments on Unit 1: Graphs and Graph Models (Written) on Unit 2: Graph Isomorphism (Written)	4
CO4: Ab CO5: Str CO6: Str Sr.No. 1 2 3	entify the Euler tour ole to Compute the adents can solve the adents can solve the Problem Solving Problem Solving Problem Solving	In and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow. e problems on theory using Maxima Software. List of Practical Assignments g on Unit 1: Graphs and Graph Models (Written) g on Unit 2: Graph Isomorphism (Written) g on Unit 3: Connected Graph (Written)	4 4 4
CO4: At CO5: Stu CO6: Stu Sr.No. 1 2 3 4	entify the Euler tour ole to Compute the adents can solve the adents can solve the Problem Solving Problem Solving Problem Solving Problem Solving	In the second	4 4 4 4 4
CO4: At CO5: Str CO6: Str Sr.No. 1 2 3 4 5	entify the Euler tour ole to Compute the idents can solve the idents can solve the Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving	In the second	4 4 4 4 4 4
CO4: At CO5: Stu CO6: Stu Sr.No. 1 2 3 4	entify the Euler tour ole to Compute the adents can solve the adents can solve the dents can solve the Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving	In the second	4 4 4 4
CO4: Ab CO5: Str CO6: Str <u>Sr.No.</u> 1 2 3 4 5 6	entify the Euler tour ole to Compute the adents can solve the adents can solve the dents can solve the Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving Software)	In the second	4 4 4 4 4 4 8
CO4: Ab CO5: Str CO6: Str Sr.No. 1 2 3 4 5 6 7	entify the Euler tour ole to Compute the adents can solve the adents can solve the dents can solve the Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving	 and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow. e problems on theory using Maxima Software. List of Practical Assignments f on Unit 1: Graphs and Graph Models (Written) f on Unit 2: Graph Isomorphism (Written) f on Unit 3: Connected Graph (Written) f on Unit 4: Eulerian and Hamiltonian Graphs (Written) f on Unit 5: Trees (Written) f on Unit 1: Graphs and Graph Models (Using Maxima 	4 4 4 4 4 4 8 0 8
CO4: Ab CO5: Stu CO6: Stu 1 2 3 4 5 6 7 8	entify the Euler tour ole to Compute the adents can solve the adents can solve the adents can solve the Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving Software) Problem Solving	 and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow. e problems on theory using Maxima Software. List of Practical Assignments on Unit 1: Graphs and Graph Models (Written) on Unit 2: Graph Isomorphism (Written) on Unit 3: Connected Graph (Written) on Unit 5: Trees (Written) on Unit 1: Graphs and Graph Models (Using Maxima 	4 4 4 4 4 4 8 0 8 8
CO4: Ab CO5: Str CO6: Str 3 4 5 6 7	entify the Euler tour ole to Compute the adents can solve the adents can solve the adents can solve the Problem Solving Problem Solving Problem Solving Problem Solving Problem Solving Software) Problem Solving	 and Hamiltonian cycle and find shortest path. shortest spanning trees. e problems on tournaments and traffic flow. e problems on theory using Maxima Software. List of Practical Assignments on Unit 1: Graphs and Graph Models (Written) on Unit 2: Graph Isomorphism (Written) on Unit 3: Connected Graph (Written) on Unit 5: Trees (Written) on Unit 5: Trees (Written) on Unit 1: Graphs and Graph Models (Using Maxima 	4 4 4 4 4 8 0 8

- 1. Kenneth Rosen, Discrete Mathematics and It's Applications, Tata McGraw Hill, Seventh Edition.
- 2. Narsingh Deo, Graph Theory with applications to computer science and engineering, Prentice Hall.
- 3. Dougals B. West, Introduction to Graph Theory, Pearson Education, Second edition.

Savitribai Phule Pune University B.Sc. Data Science (Pattern 2024) Semester-II

SEC151DS : Lab Course on Excel and Advanced Excel

No. of C	redits:	Teaching Scheme	Exa	mination Sch	ieme
02		Practical: 4 Hrs/Week	Con	tinuous Evalu	uation:15 Marks
			End	Semester :	35 Marks
Prerequi	isites				
٠	Basic Compu	ter Skills and Mathematics Skil	1.		
Objectiv	res				
•	To familiarize	e the student in introducing and	explorin	g MS excel.	
•	To provide di	fferent ways of representation a	and explo	oratory data an	nalysis in excel.
•	To prepare the	e students to use excel in their p	oroject w	orks	
•	Analyze data	like a professional.			
Course (Outcomes				
On Com	pletion of this co	ourse, student will be able to -			
CO1: To	Implement fund	lamental concept of Microsoft	Excel		
CO2: Per	rform calculation	ns in excel and apply excel fund	ctions.		
CO3: Re	present data usir	ng charts and diagrams			
	• •	raphic presentations on stored			
CO5: Per	rform various ad	vanced data tools and data anal	ytics.		
Unit		Name of Unit		Teaching	CO Targeted
No.				Hours	
1		o Microsoft Excel		7	CO1
	-	ook &Work sheets			
	ous Data Types				
-		res with data, Cell and Texts			
	•	& Resizing of Columns & Row	'S		
• Work	ting with Data a	nd Ranges			
• Enter	ring data into wo	orksheet			
• Savir	ng & quitting wo	orksheet			
• Open	ing and moving	around in an existing workshee	et		
• Tooll	pars and menu, k	keyboard shortcuts			
• Work	ting with single	e and multiple workbook- co	pying, r	enaming, mo	ving, adding an
delet	ing, copy in gent	tries and moving between work	books		
• Diffe	rent Views of W	Vork sheets			
• Colu	mn Freezing, La	bels, Hiding, Splitting etc.			
• Using	g different featur	res with Data and Text; Advan	ced paste	special techr	niques
2	Formulas ,Fu	nctions and charts in Excel		7	CO1,CO2,CO3
• Use (of Formulas				<u> </u>
0.50 (P.Sc. Data Science Sullabus from			

Calculations and Functions				
Chart Tools				
Different types of charts and their use				
Logical Functions				
Text Functions				
Date and Time Functions				
Lookups.				
3 Advance Data Tools	4	CO5		
What-if-Analysis- Goal Seek, Data Table				
Scenario Manager				
Formatting Charts, 3D Graphs				
4 Advanced Graphing and Charting	5	CO3,CO4		
• Formatting and customizing Pivot tables				
• Using advanced options of Pivot tables, Pivot charts				
• Line, Bar and Pie charts				
• Scatter plots				
• Histograms.				
5 Analytics using Excel	7	CO5		
Data analysis using normal chart				
Regression in Excel				
Correlation, stddev, average, ANOVA				
Reference Books				
1. Mastering MS Excel: Functions and Formulas, Webtech (Kh	anna Public	cations)		
2. Microsoft Excel 2019 Data Analysis and Business Modeling	, Wayne Wi	inston, 2019		
3. Advance Excel 2016, training Guide, By Ritu Arora				