DEPARTMENT OF INFORMATION SCIENCE AND ENGINEERING

HANDBOOK

M.Sc in Computer Science (Data Science)

JSS TECHNICAL INSTITUTIONS CAMPUS MYSORE – 570 006

2023 - 2024

About JSS Science and Technology University

JSS Science and Technology University was started under the Private Management of J.S.S. Mahavidyapeetha, Mysuru, during the year 2016. The Government of Karnataka has accorded approval to establish and commence a Private University in the name and style "J.S.S Science and Technology University" at Sri Jayachamarajendra Engineering College campus, Mysuru (Notification No. ED 84 URC 2014).

JSS Science and Technology University is one of the recent additions to the institutions administered by JSS Mahavidyapeetha, and is the second University being established besides a Medical University at Mysuru. India's higher education system is on the verge of major reforms and JSS Science and Technology University has been established to create a bright future and a desired learner centric eco-system and transform into a futuristic global University. The Availability of skilled human resources and trained technical manpower in engineering and technology is a major reason for growing investments in the state. In this context the higher education system has a key role and more particularly JSS S&T U with an objective of transforming the students at all levels of higher education including research and innovation with measures to improve the quality of workforce.

Vision of JSS Science and Technology University

- Advancing JSS S&T University as a leader in education, research and technology on the international arena.
- To provide the students a universal platform to launch their careers, vesting the industry and research community with skilled and professional workforce.
- Accomplishing JSS S&T University as an epicenter for innovation, center of excellence for research with state of the art lab facilities.
- Fostering an erudite, professional forum for researchers and industrialists to coexist and to work cohesively for the growth and development of science and technology for betterment of society.

Mission of JSS Science and Technology University

- Education, research and social outreach are the core doctrines of JSS S&T University that are responsible for the accomplishment of in-depth knowledge base, professional skill and innovative technologies required to improve the socio economic conditions of the country.
- Our mission is to develop JSS S&T University as a global destination for cohesive learning of engineering, science and management which are strongly supported with interdisciplinary research and academia.
- JSS S&T University is committed to provide world class amenities, infrastructural and technical support to the students, staff, researchers and industrial partners to promote and protect innovations and technologies through patents and to enrich entrepreneurial endeavors.
- JSS S&T University's core mission is to create a knowledge led economy through appropriate technologies, and to resolve societal problems by educational empowerment and ethics for better living.

Vision of Sri Jayachamarajendra College of Engineering

- “Be an international leader in engineering education, research and application of knowledge to benefit society globally”.

Mission of Sri Jayachamarajendra College of Engineering

- “To synergistically develop high-quality manpower and continue to stay competitive in tomorrow’s world”.
- “To foster and maintain mutually beneficial partnerships with our alumni, industry, state and central governments through public services assistance and collaborative research”.
- “To create empowered individuals with a sense of identity”.

Vision of Department of Information Science and Engineering

- “To be an outstanding education center in Information Science and Engineering through excellence in teaching and research.”

Mission of Department of Information Science and Engineering

- To empower the graduates with domain-specific knowledge, skill and creative thinking.
- To create wide-angle exposure to the stakeholder on thrust areas.
- To prepare graduates with research and entrepreneurship attitude having high moral and ethical values.

ABOUT THE DEPARTMENT OF INFORMATION SCIENCE & ENGINEERING

- The Department of Information Science & Engineering was established in the year 2000.
- The department offers two undergraduate program B.E in Information Science and Engineering started in the year 2000, B.E in Computer Science & Business Systems (CSBS) started in the year 2019 and two postgraduate programs M.Tech in Software Engineering started in the year 1995 and M.Tech in Data Sciences started in the year 2017.
- The students of the department have a good placement record of more than 90%.
- The department has highly qualified faculty members who have rich experience in the areas of Machine Learning, Deep Learning, Artificial Intelligence, Pattern Recognition, Natural language processing, Medical Image Analysis, Computational Linguistics, Biomedical Informatics, Computer Networks, Wireless Networks, IoT, Speech Signal Processing.
- Faculty have international collaboration with various reputed International Universities like Harvard University, USA, Nanyang Technological University, Singapore, Saint Petersburg State Electro Technical University "LETI" (ETU), Russia, University of Mannheim, Germany, University of Genova, Italy, and many more.
- Faculty publish their research findings in the reputed Journals and Conference proceedings with good citation index.
- The department regularly conducts workshops, seminars, symposiums, and faculty development programmes to keep updated with emerging technologies.
- The department is housed with high end computing facilities like GPU machines such as ParamShavak, High End Internet Facilities, wifi facilities, access to reputed journals like IEEE, Springer, Elsevier and many more.
- Alumni of the department pursue their higher studies within the country as well as abroad and some of the alumni are successful entrepreneurs.

Programmes offered (UG & PG)

Department offers two Undergraduate programs

- B.E in Information Science and Engineering (ISE) with an intake of 90
- B.E in Computer Science and Business Systems (CSBS) with an intake of 60

Department offers two Postgraduate programs

- M.Tech in Software Engineering (SE) with an intake of 18
- M.Tech in Data Sciences (DS) with an intake of 20
- M.Sc in Computer Science (Data Science) with an intake of 30

Department Faculty Details

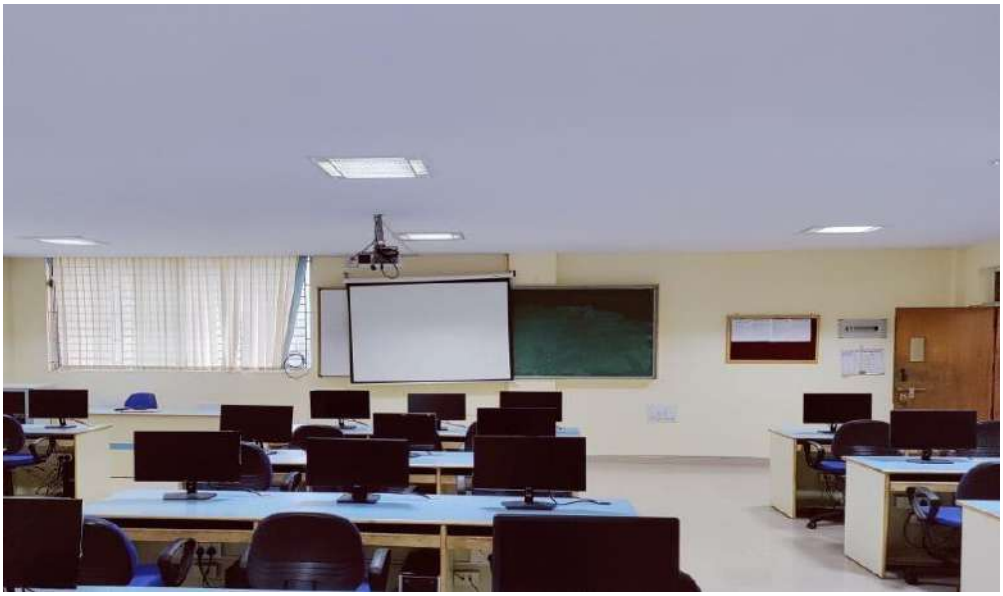
Sl. No.	Name	Designation	Qualification
1	Dr. B S Harish	Professor	B.E., M.Tech., Ph.D
2	Dr. D S Vinod	Professor	B.E., M.Tech., Ph.D
3	Dr. Mahanand B S	HOD, Professor	B.E., M.Tech., Ph.D
4	Dr. S P Shiva Prakash	Professor	BE, M.Tech, Ph.D.
5	Dr.Umesh K K	Associate Professor	BE, M.Tech, Ph.D.
6	Dr. R J Prathibha	Associate Professor	B.E., M.Tech, Ph.D
7	Dr. Vanishri Arun	Associate Professor	BE, M.Tech, Ph.D.
8	Dr. H Y Vani	Associate Professor	B.E., M.Tech., Ph.D.
9	Dr. Manju N	Associate Professor	BE, M.Tech, Ph.D.
10	Dr. C K Roopa	Associate Professor	BE, M.Tech, Ph.D.
11	Dr. M S Maheshan	Associate Professor	BE, M.Tech, Ph.D.
12	Ms. Shyla Raj	Assistant Professor	BE, M.Tech, (Ph.D.)
13	Mr. Praveen Murthy K S	Assistant Professor	BE, M.Tech, (Ph.D.)
14	Ms. Tejaswini M	Assistant Professor	BE, M.Tech , (Ph.D.)
15	Ms. Sindhu G	Assistant Professor	BE, M.Tech
16	Ms. Malapriya S	Assistant Professor	BE, M.Tech , (Ph.D.)
17	Ms. Sindhu A S	Assistant Professor	BE, M.Tech, (Ph.D.)
18	Ms. Shruthi N	Assistant Professor	BE, M.Tech, (Ph.D.)
19	Ms. T S Kaveri	Assistant Professor	BE, M.Tech
20	Ms. Lavanya M S	Assistant Professor	BE, M.Tech, (Ph.D.)
21	Mr. Nagarjun A	Assistant Professor	BE, M.Tech

Laboratory facilities

Department has well equipped laboratories which help in attaining program outcomes. Students develop a wide range of applications to enhance their learning abilities in the laboratory. Details of laboratory facilities are provided in the table below:

Sl. No.	Name of the Laboratory	Equipment Name	Equipment details
1	Software Laboratory – 1	DELL Quantity 30 Nos.	• i7 8th Generation Processor, • Q 370Processor • 810G Mil Grad Chaises • 256 GB Solid State Drive (this gives high performance) • 22 inch Full High Definition Monitor with IPS panel, • 5 Year K7 Antivirus: top end protection with internet security • 8GB single chip RAM • Multimedia Keyboard, Mouse. • System box with build in Graphics card (Pre-fitted) : UHD 630 • Built in Operating System: Windows 10. • Built in speaker.
		DELL Vostro 3900 Series, Quantity 5 Nos.	• Intel core I5 4460 processor,3.2GHz • windows 8.1Professional OS, • 4GB DDRRAM, • 1TB SATA HDD, • 19.5 Wide TFT LED Wider monitor screen
		HCL Quantity 6 Nos.	• 2 GB RAM DDR2, INTEL Core 2 DUO Processor • DVD writer • 160 GB HARD DISK, • 17” LCD Monitor

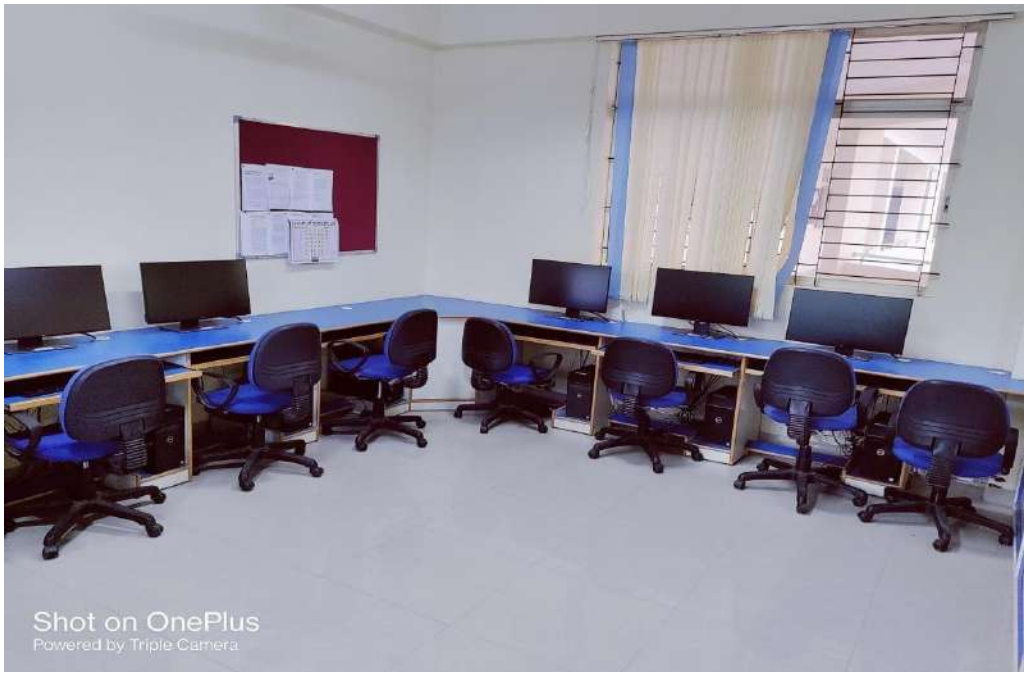
2	Software Laboratory – 2	DELL Quantity 36 Nos.	• i7 8th Generation Processor, • Q 370Processor • 810G Mil Grad Chaises • 256 GB Solid State Drive (this gives high performance) • 22 inch Full High Definition Monitor with IPS panel, • 5 Year K7 Antivirus : top end protection with internet security • 8GB single chip RAM • Multimedia Keyboard, Mouse. • System box with build in Graphics card (Pre-fitted) : UHD630 • Built in Operating System : Windows 10 • Built in speaker
		DELL Vostro 3900 Series, Quantity 5 Nos.	• Intel core I5 4460 processor,3.2GHz, • windows 8.1Professional OS, • 4GB DDR RAM, • 1TB SATA HDD, • 19.5 inch TFT LED monitor
3	PG Lecture hall/ Laboratory	Computing Device Quantity 9 Nos.	• X3100 M4 IBM, Intel Xeon Quad core 500GB HDD, • 4 GB RAM, 2 GB Graphics card, 21.5 inch full HD Monitor • DVD writer, Keyboard & Mouse.
		HCL Quantity 21 Nos.	• 2 GB RAM DDR2, Intel core 2 Duo processor • DVD writer, 160 GB hard disk, • 17 inch LCD Monitor



Software Laboratory-1

Software Laboratory-2

PG Lecture Hall



PG Laboratory

Data Science and Machine Learning Laboratory

Computer Vision and Pattern Recognition Laboratory

Network Operating Center

Research & Consultancy

The department has highly qualified faculty members who have rich experience in the areas of Machine Learning, Deep Learning, Artificial Intelligence, Pattern Recognition, Natural language processing, Medical Image Analysis, Computational Linguistics, Biomedical Informatics, Computer Networks, Wireless Networks, IoT, Speech Signal Processing. Faculty have international collaboration with various reputed International Universities like Harvard University, USA, Nanyang Technological University, Singapore, Saint Petersburg State Electro Technical University "LETI" (ETU), Russia, University of Mannheim, Germany, University of Genova, Italy, and many more. Faculty publish their research findings in the reputed Journals and Conference proceedings with good citation index.

The department has well equipped research laboratories to develop research capabilities of the students. The students are allowed to access the devices through centralized computing facilities all through the day. Wi-Fi facility is provided to all the students and laboratories have access to scientific journals like IEEE, Science direct, etc.

Employment Opportunities

Placement office encourages students to gain a great deal of knowledge. In order to offer Placement, the placement officer and the companies involve themselves in a lot of industry institute activities which are as follows:

- Regular Students development programs are offered by domain specific core companies, in means of Technical workshops, seminars and quiz programs.
- Regular Industry visits will be organized.
- Special scholarships will be given out to students who are achievers.
- Encouraging students to participate in Hackathons and Coding contests.
- Coordinate with companies in organizing workshops on latest trends in the industries specific to core sectors.
- Involving companies in syllabus formation and delivery of new courses to students.

The Placement and Training department takes initiatives to provide adequate training for students to enable them to have better employability skills compared to other colleges. During the final year of their program, students work in and for companies as interns. In this way they gain valuable practical experience, while bringing their own added value of knowledge and expertise to the companies they are working for. Majority of these students will be converted to full time employees based on their internship perform

Industry-Institute-Interaction

Interaction between technical institutions and industry is the need of the hour. Industry Institute Interaction will have great bearing on the engineering curriculum, exposure of engineering students to industrial atmosphere. There is a need to create avenues for a close academia and industry interaction through all the phases of technology development, starting from conceptualizing to commercialization. The Industry Institute Interaction Cell is established at JSS Science and Technology University with the following objectives:

- To cultivate the strong links with industry.
- To promote various industrial activities by the faculty members and students
- To have a closer linkage and promote research suited to industry needs, and consultancy
- To provide continuing education to people working in industries so that they can upgrade their technical knowledge, and / or obtain higher degrees
- To catalyze the further growth and development of interaction between the Institute and Industry
- To bring about Memoranda of Understanding and Agreements with various industrial and research organizations

Board of Studies

Sl. No.	Category	Designation	Name of the Person	
1	The Dean(s) of the Faculties	Ex-Officio Member	Dr. B Manoj Kumar	
	Dean (Science)		Dr P Mallu	
2	Head of the Department	Chairperson		Dr. Mahanand B S
3	All Professors of the Department	Members		Dr. B S Harish
4	Two Senior Associate Professors of the concerned Department by rotation	Members	1	Dr. D S Vinod
			2	Dr. Umesh K. K.
5	One Senior Assistant Professor of the concerned Department by rotation	Member	1	Dr. R J Prathiba
6	One External Subject Expert from any reputed Academic /Research Institution/ Other Universities nominated by the Academic Council	Member	1	Dr.Uttam Kumar Assistant Professor, Infosys Foundation Career Development Chair Professor International Institute of Information Technology Bangalore
7	One External subject expert from any reputed Academic / Research Institutions/other Universities nominated by the Vice Chancellor upon recommendation by the Dean of respective faculty.	Member	1	Dr.Suresha, PhD (IISC) Professor Department of Studies in Computer Science University of Mysore
8	Two external members from concerned industry/Government Departments/Public Sector undertakings/ allied area relating to placement, nominated by the Academic Council upon recommendation by the Dean of respective faculty.	Members	1 2	Mahesh S Associate Group manager SLK Software Bangalore Jyothi Balraj Wipro technologies Electronic city Phase 1 Bangalore 560100
9	One postgraduate meritorious alumnus, to be nominated by the Head of the Department.	Member	1	Rakshith U J Principal Product Manager AI/ML Platforms and Services Walmart labs, Bangalore

10	The Chairperson, Board of Studies, may with the approval of the Vice Chancellor, co-opt as Members: a) One external subject expert from reputed Academic/Research Institution/Other Universities/Industry/Government departments/public sector undertakings, whenever special courses of studies are to be formulated.	Members		Sharath Chandra N Solution Architect – Applications Tata Consultancy Services, Bengaluru
	b) Two other members of faculty of the concerned Department.		1	Dr. S P Shiva Prakash
			2	Dr. Pradeep M

Programme Overview

M.Sc. in Computer Science (Data Science) is a two-year post-graduate programme dedicated to enlighten students with the designing, implementing, testing, and modifying of the software to make it viable, maintainable andaffordable. The programme offers students with a strong base on principles of data science and application domain.

Programme Educational Objectives

#	**Program Educational Objectives:-The Graduates will be able to:**
PEO – 1	Critically think and apply the principles of data science to solve real world problems.
PEO – 2	Contribute to research and development in cutting edge technology.

Programme Outcomes

#	Program Outcomes: -The Graduates will be able to:
PO-1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO-2	An ability to write and present a substantial technical report/document
PO-3	Students should be able to demonstrate a degree of mastery over the area as per the M.Sc. in Computer Science (Data Science) program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO-4	Ability to develop and apply data science principles to solve real world problems.
PO-5	Analyze and apply emerging IT tools to model complex work activities.
PO-6	To excel in IT profession, entrepreneurship and research activities with ethical standards.

Quality Policy

- To deliver excellent academic programs and develop innovative strategies to educate Undergraduate, Postgraduate and Research students.
- To instill quality education to students in terms of academics, research and societal needs.
- To improve the quality of the undergraduate, postgraduate and research programs.
- Improve infrastructure for student laboratories and classes.
- To encourage undergraduate and postgraduate students to begin startups.
- To introduce modern computing and managerial skills in the curriculum.

JSS MAHAVIDYAPEETHA

JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING, MYSURU

Scheme of Teaching and Examination 2023-24

Choice Based Credit System (CBCS)

M.Sc in Computer Science (Data Science)

Program Structure 2023-24

Scheme of Teaching and Examination for I to IV semester

Semester	Credits
I	24
II	24
III	16
IV	16
TOTAL	**80**

Credit Pattern

Semester	Type of Course	Number	Credits
I	Professional Core Professional Elective – I Professional Core Laboratory Mini Project with Seminar	04 01 01 01	16 credits 04 credits 02 credits 02 credits **Sub Total = 24 credits**
II	Professional Core Professional Elective - II Open Elective Course Research Methodology and IPR Professional Core Laboratory	03 01 04 01 01	12 credits 04 credits 04 credits 02 credits 02 credits **Sub Total = 24 credits**
III	Professional Elective - III Internship/ Industrial Training Project Work Phase- I	04 01 01	04 credits 06 credits 06 credits **Sub Total = 16 credits**
IV	Professional Elective - IV Project Work- Phase- II	01 01	04 credits 12 credits **s** **Sub Total = 16 credits**
TOTAL			**80 credits**

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JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING, MYSURU

Scheme of Teaching and Examination 2023-24

Choice Based Credit System (CBCS)

M.Sc in Computer Science (Data Science) Program

SEMESTER I

Sl. No.	Code	Course Title	Course	Teaching Hours per Week				Credits	Examination			
				L	T	P/ S/ SDA	Total Contact Hours		CIE	SEE	Total Marks	Duration in Hours
1	23MSDS110	Principles of Data Science	PCC 1	4	-	-	4	4	40	60	100	3
2	23MSDS120	Advanced Algorithms	PCC 2	4	-	-	4	4	40	60	100	3
3	23MSDS130	Advanced Database Management Systems	PCC 3	4	-	-	4	4	40	60	100	3
4	23MSDS140	Data Mining	PCC 4	4	-	-	4	4	40	60	100	3
5	23MSDS15X	Professional Elective I	PEC 1	4	-	-	4	4	40	60	100	3
6	23MSDS160L	Advanced Algorithms Laboratory	PCCL	-	-	4	4	2	50	-	50	-
7	23MSDS170M	Mini Project with Seminar	MPS	-	-	4	4	2	50	-	50	-
TOTAL								**24**			**600**	

Note: L: Lecture/ Theory; T: Tutorial; P: Integrated Practical/ Practice; S: Seminar; SDA: Skill Development Activities
PCC: Professional Core Course; PEC: Professional Elective Course; PCCL: Professional Core Course Laboratory; MPS: Mini Project with Seminar

Professional Elective I	
Course Code	**Course Title**
23MSDS151	Linear Algebra
23MSDS152	Neural Networks
23MSDS153	Cloud Computing and Virtualization

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SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING, MYSURU

Scheme of Teaching and Examination 2023-24

Choice Based Credit System (CBCS)

M.Sc in Computer Science (Data Science) Program

SEMESTER II

Sl. No.	Code	Course Title	Course	Teaching Hours per Week				Credits	Examination			
				L	T	P/ S/ SDA	Total Contact Hours		CIE	SEE	Total Marks	Duration in hours
1	23MSDS210	Machine Learning	PCC 5	4	-	-	4	4	40	60	100	3
2	23MSDS220	Digital Image Processing	PCC 6	4	-	-	4	4	40	60	100	3
3	23MSDS230	Natural Language Processing	PCC 7	4	-	-	4	4	40	60	100	3
4	23MSDS24X	Professional Elective II	PEC 2	4	-	-	4	4	40	60	100	3
5	23MSDS25XE	Open Elective Course	OEC	4	-	-	4	4	40	60	100	3
6	23MSDS260R	Research Methodology and IPR	MC	2	-	-	2	2	50	-	50	-
7	23MSDS270L	Natural Language Processing Laboratory	PCCL	-	-	4	4	2	50	-	50	-
TOTAL								**24**			**600**	

Note: L: Lecture/ Theory; T: Tutorial; P: Integrated Practical/ Practice; S: Seminar; SDA: Skill Development Activities
PCC: Professional Core Course; PEC: Professional Elective Course; OEC: Open Elective Course; MC: Mandatory Course; PCCL: Professional Core Course Laboratory

Professional Elective II	
Course Code	**Course Title**
23MSDS241	Information Retrieval
23MSDS242	Big Data Analytics
23MSDS243	Statistical Methods in Information Processing

Open Elective Course	
Course Code	**Course Title**
23MSDS251E	Introduction to Data Structures & Algorithms
23MSDS252E	Introduction to Database Management Systems
23MSDS253E	Introduction to Machine learning

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JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING, MYSURU

Scheme of Teaching and Examination 2023-24

Choice Based Credit System (CBCS)

M.Sc in Computer Science (Data Science) Program

SEMESTER III

Sl. No.	Code	Course Title	Course	Teaching Hours				Credits	Examination			
				L	T	P/ S/ SDA	Total Contact Hours		CIE	SEE	Total Marks	Duration in hours
1	23MSDS31X	Professional Elective III	PEC 3	4	-	-	4	4	40	60	100	3
2	23MSDS320T	Industrial Training/Internship	INT	Minimum 08 weeks commencing from intervening vacation of II and III semesters				6	50	-	50	-
3	23MSDS330P	Project Work Phase-I	PROJ	-	-	12	12	6	50	-	50	-
TOTAL								**16**			**200**	

Note: L: Lecture/ Theory; T: Tutorial; P: Integrated Practical/ Practice; S: Seminar; SDA: Skill Development Activities
INT: Internship/ Industrial Training; PROJ: Project Work

Professional Elective III	
Course Code	**Course Title**
23MSDS311	Deep Learning
23MSDS312	Multimedia Computing
23MSDS313	Internet of Things

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SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING, MYSURU

Scheme of Teaching and Examination 2023-24

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

M.Sc in Computer Science (Data Science) Program

SEMESTER IV

Sl. No.	Code	Course Title	Course	Teaching Hours				Credits	Examination			
				L	T	P/ S/ SDA	Total Contact Hours		CIE	SEE	Total Marks	Duration in hours
1	23MSDS41X	Professional Elective IV	PEC4	4	-	-	4	4	40	60	100	3
2	23MSDS420P	Project Work Phase-II	PROJ	-	-	24	24	**12**	100	200	300	3
TOTAL								**16**			**400**	

Note: L: Lecture/ Theory; T: Tutorial; P: Integrated Practical/ Practice; S: Seminar; SDA: Skill Development Activities
INT: Internship/ Industrial Training; PROJ: Project Work

Note: For passing the student has to score a minimum of 45 marks (CIE + SEE: 20 + 25 OR 21 + 24)

Professional Elective IV	
Course Code	**Course Title**
23MSDS411	Social & Information Network Analysis
23MSDS412	Blockchain Technology
23MSDS413	Conversational Systems

SEMESTER I

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS110***	***Total Credits***	***4***	***Course Type***	***Professional Core Course***		
Course Title	***PRINCIPLES OF DATA SCIENCE***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Fundamentals of Mathematics

COURSE OBJECTIVES: To enable discovery of information and knowledge to guide effective decision making and to gaininsights from various data sets.

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Explain a flow process to solve data science problems.	L2
CO2	Apply mathematical concepts to classify data science problems into standard topology.	L3
CO3	Incorporate the concepts of probability theory and its applications on real world problems	L3
CO4	Analyze and illustrate statistical techniques.	L3
CO5	Assess the solution approach through visualization and presentation.	L5

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction** What is Data Science?, Basic Terminology, Why Data Science?, Example – Sigma Technologies, The data science Venn diagram, The math: Example – Spawner-Recruit Models, Computer programming (Preferably Python/R/Matlab/PERL), Some more terminology, Some Data science case studies, Data Models and its types. Types of Data, Flavors of data, Structured versus unstructured data, Quantitative versus qualitative data, The four levels of data, The Five Steps of Data Science.	12
2	**Basic Mathematics – Vectors and Matrices** Vectors and Linear Combinations, Lengths and Dot Products, Matrices, Solving Linear Equations: Vectors and Linear Equations, The Idea of Elimination, Elimination Using Matrices, Rules for Matrix Operations, Inverse Matrices, Elimination = Factorization: A = LU, Transposes and Permutations, Vector Spaces and Subspaces: Spaces of Vectors, The Nullspace of A: Solving Ax = 0 and Rx = 0, The Complete Solution to Ax = b, Independence, Basis and Dimension, Dimensions of the Four Subspaces	12
3	**Probability** Basic definitions, Probability, Bayesian versus Frequentist, Frequentist approach, Compound events, Conditional probability, The rules of probability, Collectively exhaustive events, Bayesian ideas revisited, Bayes theorem, Random variables.	12
4	**Statistics** Basic Statistics, What are statistics ?, How do we obtain and sample data?, Obtaining data, Sampling data, How do we measure statistics?, Point estimates, Sampling distributions, Confidence intervals, Hypothesis tests, Conducting a hypothesis test, Type I and type II errors, Hypothesis test for categorical variables.	12
5	**Visualization** Basic principles, ideas and tools for data visualization, why does communication matter?, Identifying effective and ineffective visualizations, Scatter plots, Line graphs, Bar charts, Histograms, Box plots, When graphs and statistics lie, Correlation versus causation, Simpson's paradox, If correlation doesn't imply causation, then what does?, Verbal communication, The why/how/what strategy of presenting, Data Science ethical issues.	12

Text Books:

1. Sinan Ozdemir, Principles of Data Science, PACKT Publisher, First Edition, 2016.

Reference Books:

1. Gilbert Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press, Fifth Edition, 2016.
2. Cathy O'Neil, Rachel Schutt, Doing Data Science: Straight Talk from the Frontline, O'Reilly Media, 2013.
3. Jure Leskovec, Anand Rajaraman, Jeff Ullman, Mining of Massive Datasets, Cambridge University Press Publisher,Second Edition, 2015.

Journals/Magazines:

1. Yu, "Three principles of data science: predictability, computability, and stability (PCS)," 2018 IEEE InternationalConference on Big Data (Big Data), 2018, pp. 4-4, doi: 10.1109/BigData.2018.8622080.
2. https://link.springer.com/book/10.1007/978-3-030-43981-1

SWAYAM/NPTEL:

1. Swayam : https://swayam.gov.in/nd1_noc19_cs60/preview
2. NPTEL : https://nptel.ac.in/courses/106106179/

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS120***	***Total Credits***	***4***	***Course Type***	***Professional Core Course***		
Course Title	***ADVANCED ALGORITHMS***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PRE REQUISITES: Data structures

COURSE OBJECTIVES: To provide the theoretical backbone of computer science to analyze time and space complexity theory thereby able to write efficient program. To provide knowledge of various algorithm designstrategies.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Analyze the efficiency of algorithms using time and space complexity theory	L2
CO2	Solve problems using algorithm design methods such as the brute force, greedy method, and dynamic programming	L3
CO3	Solve problems using algorithm design methods such as the backtracking and branch and bound.	L3
CO4	Solve graph and tree problems by applying appropriate algorithmic technique.	L3
CO5	Analyze the computability of certain problem.	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	**Introduction:** Characteristics of Algorithm. Analysis of Algorithm: Asymptotic analysis of Complexity Bounds – Best, Average and Worst-Case behavior; Performance Measurements of Algorithm, Time and Space Trade-Offs, Analysis of Recursive Algorithms through Recurrence Relations: Substitution Method, Recursion Tree Method and Masters' Theorem. Mathematical analysis of Non- Recursive and recursive Algorithms with Examples Important Problem Types: Sorting and Searching	**12**
UNIT 2	**Fundamental Algorithmic Strategies:** Brute-Force, Heuristics, Greedy, Dynamic Programming. Knapsack, Coin change, Huffman code.	**12**
UNIT 3	**Branch and Bound and Backtracking methodologies:** Illustrations of these techniques for Problem-Solving, Travelling Salesman Problem, N-Queens, Graph Coloring, knapsack.	**12**

UNIT 4	**Graph and Tree Algorithms:** Traversal algorithms: Depth First Search (DFS) and BreadthFirst Search (BFS); Shortest path algorithms, Transitive closure, Minimum Spanning Tree, Topological sorting, Network Flow Algorithm.	**12**
UNIT 5	**Computability of Algorithms**: Computability classes – P, NP, NP-complete and NP-hard. Cook's theorem, Standard NP-complete problems and Reduction techniques.	**12**

Text Books:

1. Introduction to the Design and Analysis of Algorithms, AnanyLevitin:, 2rd Edition, 2009, Pearson.
2. Computer Algorithms/C++, Ellis Horowitz, SatrajSahni and Rajasekaran, 2nd Edition, 2014, Universities Press.

Reference Books:

1. Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronal L. Rivest, Clifford Stein, 3rd Edition, PHI, 2009
2. Design and Analysis of Algorithms, S. Sridhar, Oxford (University Press), 2014

Web/Digital resources:

1. https://nptel.ac.in/courses/106/106/106106131/
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-046j-design-and-analysis-of-algorithms- spring-2015/
3. https://nptel.ac.in/courses/106105157

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS130***	***Total Credits***	***4***	***Course Type***	***Professional Core Course***		
Course Title	***ADVANCED DATABASE MANAGEMENT SYSTEMS***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Discrete Mathematical Structures

COURSE OBJECTIVES: To introduce database management systems, and emphasis on how to organize, maintain, and retrieve information from database.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Describe different data models in database management systems	L2
CO2	Demonstrate to create a database and formulation of queries using Structured Query Language (SQL)	L3
CO3	Illustrate query optimization and indexing in relational database.	L3
CO4	Discuss the concepts of transactions and concurrency control.	L2
CO5	Explain advanced database systems and database security.	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 -Create

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	**Introduction:** Introduction to Database. Hierarchical, Network and Relational Models. **Database system architecture**: Data Abstraction, Data Independence, Data Definition Language (DDL), Data Manipulation Language (DML). **Data models**: Entity-relationship model, network model, relational and object-oriented data models, integrity constraints, data manipulation operations.	**12**
UNIT 2	**Relational query languages**: Relational algebra, Tuple and domain relational calculus, SQL3, DDL and DML constructs, Open source and Commercial DBMS - MYSQL, ORACLE, DB2, SQL server. **Relational database design**: Domain and data dependency, Armstrong's axioms, Functional Dependencies, Normal forms, Dependency preservation, Lossless design.	**12**

UNIT 3	**Query processing and optimization**: Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms. **Storage strategies**: Indices, B-trees, Hashing.	**12**
UNIT 4	**Transaction processing**: Concurrency control, ACID property, Serializability of scheduling, Locking and timestamp-based schedulers, Multi-version and optimistic Concurrency Control schemes, Database recovery.	**12**
UNIT 5	**Database Security**: Authentication, Authorization and access control, DAC, MAC and RBAC models, Intrusion detection, SQL injection. **Advanced topics**: Object oriented and object relational databases, Logical databases, Web databases, Distributed databases, Data warehousing and data mining.	**12**

Text Books:

1. Database System Concepts. Abraham Silberschatz, Henry F. Korth and S. Sudarshan,7th edition 2021.

Reference Books:

1. Principles of Database and Knowledge – Base Systems, Vol 1 by J. D. Ullman, Computer Science Press 1988.
2. Fundamentals of Database Systems. R. Elmasri and S. Navathe, 7th edition Pearsm 2008
3. Foundations of Databases. Serge Abiteboul, Richard Hull, Victor Vianu.

Web/Digital resources:

1. https://nptel.ac.in/courses/106/105/106105175/

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS140***	***Total Credits***	***4***	***Course Type***	***Professional Core Course***		
Course Title	***DATA MINING***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Data Structure.

COURSE OBJECTIVES: To build data mining applications using statistical analysis techniques.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Perceive the basic concepts, principles and techniques of data mining	L2
CO2	Analyze association rule mining in various dimensional databases.	L4
CO3	Apply various Classification techniques and different types of classifiers	L3
CO4	Analyze and adapt existing clustering techniques in various applications.	L4
CO5	Illustrate the recent trends and applications of data mining techniques.	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction to Data Mining:** What is Data Mining, Definition, KDD, Challenges, Data Mining Tasks. Data Preprocessing: An Overview, Data Cleaning, Data Integration, Data Reduction, Data Transformation, and Data Discretization and Binarization, Data Transformation; Measures of Similarity and Dissimilarity- Basics..	**12**
2	**Association Rules:** Problem Definition, Frequent Item Set Generation, The APRIORI Principle, Support and Confidence Measures. Association Rule Generation: APRIOIRI Algorithm, The Partition Algorithms, FP-Growth Algorithms, Compact Representation of Frequent Item Sets- Maximal Frequent Item Set, Closed Frequent Item Set. Evaluation of association patterns, Effect of skewed support distribution.	**12**
3	**Classification:** Introduction, Classification techniques: Decision Trees Induction : Construction, Methods for Expressing attribute test conditions, Measures for Selecting the Best Split, Algorithm for Decision tree Induction; KNN Classifier, Bayesian Classifiers, Bayesian Belief Networks - Algorithm and Characteristics.	**12**

4	**Clustering:** Problem Definition, Clustering Overview, K-means Algorithm, K-means: Additional issues. Hierarchical clustering – Agglomerative and divisive methods, specific techniques, key issues in Hierarchical Clustering, Strengths, and Weakness; DBSCAN- Algorithm, strength, and Weaknesses; Cluster Evaluation.	**12**
5	**Advanced Applications:** Mining data streams–Mining Time–series data–Mining sequence patterns in Transactional databases– Mining Object– Spatial– Multimedia–Text and Web data – Spatial Data mining– Multimedia Data mining–Text Mining– Mining the World Wide Web.	**12**

Text Books:

1. Introduction to Data Mining – Pang-Ning Tan, Michael Steinbach & Vipin Kumar, 4th Impression, 2009 by Pearson.
2. Data Mining Introductory and Advanced topics – Margaret H Dunham, PEA.

Reference Books:

1. Data Mining – Concepts and Techniques – Jiawei Han & Micheline Kamber, 3rd Edition Elsevier.

Web/Digital resources:

1. https://onlinecourses.nptel.ac.in/noc22_cs11/preview

PROFESSIONAL ELECTIVE – I

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS151***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - I***		
Course Title	***LINEAR ALGEBRA***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Fundamentals of Mathematics

COURSE OBJECTIVE: To understand the basic concepts of Linear Algebra

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Solve linear equations through matrix representation	L3
CO2	Identify the vector space and subspace	L4
CO3	Test for orthogonality and apply Eigen vectors to solve differential equations.	L3
CO4	Apply Linearly transformation and represent the same in matrix form	L3
CO5	Justify linear inequalities in the vector subspace.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction** Introduction, The Geometry of Linear Equations, An Example of Gaussian Elimination, Matrix Notation and Matrix Multiplication, Triangular Factors and Row Exchanges, Inverses and Transposes, Special Matrices and Applications.	12
2	**Vector Space** Vector Spaces and Subspaces, Solving $Ax = 0$ and $Ax = b$, Linear Independence, Basis, and Dimension, The Four Fundamental Subspaces, Graphs and Networks, Linear Transformations, Review Exercises.	12
3	**Orthogonality** Orthogonal Vectors and Subspaces, Cosines and Projections onto Lines, Projections and Least Squares, Orthogonal Bases and Gram-Schmidt, The Fast Fourier Transform.	12
4	**Linear Transformations** Linear transformations, algebra of linear transformations, isomorphism, representation of transformations by matrices, linearfunctional , inverse of a linear transformation.	12
5	**Computations with Matrices** Eigen values ,Eigen Vectors , Applications to differential Equations, Introduction, Matrix Norm and Condition Number, Computation of Iterative Methods for $Ax = b$.	12

Text Books:

1. Linear Algebra and Its Applications by Gilbert Strang, 2016 Edition,Wellesley-Cambridge Press and SIAM,ISBN:978-09802327-7-6.

Reference Books:

1. Numerical Linear Algebra, William Layton and Myron Sussman, University of Pittsburgh Pittsburgh, Pennsylvania, ISBN 978-1-312-32985-0

Journals/Magazines:

1. Vittoria Bonanzinga some applications of linear algebra and geometry in real lifearXiv:2202.10833, February 2022,

Web/Digital resources:

1. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/video_galleries/video-lectures/

SWAYAM/NPTEL:

1. https://nptel.ac.in/courses/111106051- Linear Algebra, IIT Madras Dr. K.C. Sivakumar

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS152***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - I***		
Course Title	***NEURAL NETWORKS***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PRE REQUISITES: Mathematical Concepts like Statistics and Calculus.

COURSE OBJECTIVES:

1. To understand the biological neural network and to model equivalent neuron models.
2. To understand the architecture, learning algorithms and issues of various feed forward andfeedback neural networks.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Examine different Neural Network Architectures and Learning Rules.	L2
CO2	Analyze and differentiate Single Layer Perceptron and Multi-layered Perceptron based ontheir capabilities.	L4
CO3	Apply Back Propagation and solve different Neural Network Problems.	L3
CO4	Apply Self Organizing Maps in solving different pattern classification tasks.	L3
CO5	Differentiate Neural Networks and Deep Learning Algorithms.	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	**Introduction:** A Neural Network, Human Brain, Models of a Neuron,Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks	**12**
UNIT 2	**Single Layer Perceptron:** Unconstrained optimization, LMS algorithm, learning curves, perceptrons, convergence theorem, limitations of single-layer perceptron **Multilayer Perceptron:** Back-propagation algorithm, XOR problem, feature detection, accelerated convergence of back-propagation algorithm, limitations	**12**
UNIT 3	**Back Propagation:** Back Propagation and Differentiation, Hessian Matrix, Generalization, Cross Validation, Network Pruning Techniques, Virtues, and Limitations of Back Propagation Learning, Accelerated Convergence, Supervised Learning.	**12**

UNIT 4	**Self-Organizing Maps (SOM):** Two Basic Feature Mapping Models, Self-Organization Map, SOM Algorithm, Properties of Feature Map, Learning Vector Quantization, Adaptive Pattern Classification.	**12**
UNIT 5	**Applications of Neural Networks:** Recent trends in Neural Networks,Applications of NeuralNetworks,What is Deep Learning,Difference between Neural Networks and Deep Learning. Case Study:Using Feed forward Neural Networks for Handwritten Digit Recognition.	**12**

Text Books:

1. Neural Networks a Comprehensive Foundations, Simon Haykin, PHI edition.

Reference Books:

1. Artificial Neural Networks - B. Yegnanarayana Prentice Hall of India P Ltd 2005.
2. Neural Networks in Computer Intelligence, Li Min Fu TMH 2003.
3. Neural Networks -James A Freeman David M S Kapura Pearson Education 2004.
4. Introduction to Artificial Neural Systems Jacek M. Zurada, JAICO Publishing House Ed.2006.

Web/Digital resources:

1. http://cognet.mit.edu/book/introduction-to-neural-networks
2. https://www.udemy.com/course/deep-learning-convolutional-neural-networks-theano-tensorflow
3. https://www.coursera.org/learn/neural-networks-deep-learning

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS153***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - I***		
Course Title	***CLOUD COMPUTING AND VIRTUALIZATION***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	***4***			***CIE***	**SEE**	**Total**
	Tutorial	***-***		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	***-***		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	***4***	***4***	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Database management system.

COURSE OBJECTIVES: To provide a wide Knowledge & deep understanding of configuring & managing cloudinfrastructure for an organization

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Levelof Cognitive Domain
CO1	Describe the essentials, benefits and the reasons for cloud adoption.	L2
CO2	Apply the various cloud services offered in application implementation.	L3
CO3	Gathering the working knowledge of Cloud Micro Services.	L2
CO4	Describe the concept of layering and virtualization in the cloud computing.	L3
CO5	Illustrate various security issues in cloud computing.	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	Introduction, Essentials, Benefits, Why Cloud? Business and IT perspective, Cloud and Virtualization, Cloud Service Requirements, Dynamic Cloud Infrastructure, Cloud Computing Characteristics, Cloud Adoption and Cloud Rudiments.	**12**
2	Network-Centric Computing and Network-Centric Content, Cloud Computing, Cloud Delivery Models and Services, Ethical Issues, Cloud Vulnerabilities. Cloud Computing at Amazon, Google and Microsoft, Windows Azure Open-Source Platforms for Private Clouds. Cloud Computing Interoperability – The Inter-cloud, Service Level Agreement.	**12**
3	Application Architectures, Monolithic and Distributed – Micro Service fundamentals –Design Approach – Cloud Native Application	**12**
4	Virtualization, Cloud Resource Virtualization. Virtualization, Layering and virtualization, Virtual machine monitors, Virtual Machines, Performance and Security Isolation, Full virtualization and para virtualization, Hardware support for virtualization.	**12**

5	Security: Cloud Security, Cloud Application Development. Cloud security risks, Security: The top concern for cloud users, Privacy and privacy impact assessment, Trust, operatingsystem security, Virtual machine Security, Security of virtualization, Security risks posed by shared images, Security risks posed by a management OS, A trusted virtual machine monitor.	**12**

Text Books:

1. Kumar Saurabh, Cloud Computing,Wiley India,2011
2. Dan C Marinescu: Cloud Computing Theory and Practice. Second Edition, Elsevier(MK) 2017
3. RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Cloud Computing Principles and Paradigms, 1 st Edition, Wiley,2013.

Reference Books:

1. Toby Velte, Anthony Velte, Robert Elsenpeter, Cloud Computing, A Practical Approach, McGraw Hill, 2010.
2. Judith Hurwitz, Robin Bloor, Marcia Kaufman, Fern Helper, Cloud Computing For Dummies, Wiley, 2010
3. Ronald Krutz and Russell Dean Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Wiley,2010.

Web/Digital resources:

1. http://onlinecourses.nptel.ac.in
2. www.aws.amazon.com

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS160L***	***Total Credits***	***2***	***Course Type***	***Professional Core Course Laboratory***		
Course Title	***ADVANCED ALGORITMS LABORATORY***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	***-***			**CIE**	**SEE**	**Total**
	Tutorial	***-***		***Weightage***	***100%***	***-***	***100 %***
	Practical	***4***		***Maximum Marks***	***50 Marks***	***-***	***50 Marks***
	Total	***4***	***2***	***Minimum Marks***	***25 marks***	***-***	***25 Marks***

COURSE PREREQUISITE: Analysis and Design of Algorithms

COURSE OBJECTIVES: This course provides an understanding of advanced algorithms, algorithmic paradigms,and data structures used to solve the problems.

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	To implement the graph search algorithms.	L4
CO2	To implement the string matching algorithms	L3
CO3	To implement the modular linear equation algorithms	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

Week	List of Experiments/ Programs	No. of Hours
1	Sort a given set of elements using the Quicksort method and determine the time required to sort the elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.	2
2	Implement a parallelized Merge Sort algorithm to sort a given setof elements and determine the time required to sort the elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.	2
3	Implement 0/1 Knapsack problem using Dynamic Programming.	2
4	Find a subset of a given set S = {sl, s2,. ,sn} of n positive integerswhose sum is equal to a given positive integer d. For example, if S= {1, 2, 5, 6, 8} andd = 9 there are two solutions {1,2,6}and{1,8}.A suitable message is to be displayed if the given problem instance doesn'thave a solution.	2
5	Implement N Queen's problem using Back Tracking	2
6	Implement any scheme to find the optimal solution for the Traveling Salesperson problem and then solve the same probleminstance using any approximation algorithm	2

	and determine the error in the approximation.	
7	a. Print all the nodes reachable from a given starting node in adigraph using BFS method. Check whether a given graph is connected or not using DFSmethod.	2
8	From a given vertex in a weighted connected graph, find shortestpaths to other vertices using Dijkstra's algorithm.	2
9	Implement All-Pairs Shortest Paths Problem using Floyd'salgorithm.	2
10	a. Obtain the Topological ordering of vertices in a given digraph. Compute the transitive closure of a given directed graph usingWarshall's algorithm	2
11	Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal's algorithm.	2
12	Find Minimum Cost Spanning Tree of a given undirected graphusing Prim's algorithm	2
13	Internal Test	2

Text Books:

1. Basse, S., & Gleder, A. V. (1999). Computer Algorithm – Introduction to Design and Analysis. 3rd edition. Pearson Education.
2. Dasgupta, S., Papadimitriou,C., & Vazirani, U. (2017). Algorithms. 1st edition. TataMcGraw Hill.
3. Skiena, S. S. (2008). The Algorithm Design Manual. 2nd edition. Springer-Verlag London

Reference Books:

1. Cormen, T.H., Leiserson,C.E., Rivest, R.L., & Stein,C.(2010). Introduction to Algorithms. 3rd edition. Prentice-Hall of India Learning Pvt. Ltd.
2. Kleinberg, J., & Tardos, E. (2013). Algorithm Design. 1st edition. Pearson Education India.Algorithms, 2 nd edition, University Press, 2007.

Journals/Magazines:

1. https://www.mdpi.com/journal/algorithms

Web/Digital resources:

1. https://ocw.mit.edu/courses/6-854j-advanced-algorithms-fall-2005/
2. https://cp-algorithms.com/

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS170M***	***Total Credits***	***2***	***Course Type***	***MINIPROJECT WITH SEMINAR***		
Course Title	***Mini Project with Seminar***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**-**	**-**		**CIE**	**SEE**	**Total**
	Tutorial	**-**	**-**	***Weightage***	***100 %***	-	***100 %***
	Practical	**4**	**-**	***Maximum Marks***	***50 Marks***	-	***50 Marks***
	Total	**4**	**2**	***Minimum Marks***	***25 Marks***	-	***25 Marks***

COURSE PREREQUISITE: Programming Skills

COURSE OBJECTIVES: To develop practical ability & knowledge about practical tools, techniques in order to solvereal life problems

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Identify and analyze a problem to be solved computationally.	L4
CO2	Design and develop solutions to the problem and analyze results.	L3
CO3	Prepare project reports and presentations.	L6

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

This course is introduced to help the students to get a practical exposure of the subjects studied during this semester. It is expected that the work should be focused in a particular area for concept, design, implementation and analysis. Topicsselection covering recent and relevant topics related to the emerging areas. Ideally, recent reputed journal papers abstraction and implementation shall be encouraged. At the end of the semester, a student has to submit a detailed report incorporating literature survey, problem formulation, clear problem statement, research methods, result analysis,conclusion, etc.

SEMESTER II

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS210***	***Total Credits***	***4***	***Course Type***	***Professional Core Course***		
Course Title	***MACHINE LEARNING***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Datamining.

COURSE OBJECTIVE: To be able to formulate machine learning problems corresponding to different applications.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Understand different types of machine learning techniques and Apply various mathematical models for supervised machine learning models.	L2
CO2	Recognize the characteristics of machine learning, binary classification and Bayesian learning	L2
CO3	Apply and evaluate the unsupervised machine learning models through various clustering algorithms.	L3
CO4	Solve classification problems using concept learning and decision trees	L3
CO5	Analyze Multilayer Perceptron and Neural network algorithms	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction:** What Is Machine Learning, Examples of Machine Learning Applications, History of Machine Learning, Related Topics. **Supervised Learning:** Learning a Class from Examples, Vapnik-Chervonenkis Dimension, Probably Approximately Correct Learning, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization, Dimensions of a Supervised Machine Learning Algorithm.	**12**
2	**Bayesian Decision Theory:** Introduction, Classification, Losses and Risks, Discriminant Functions, Association Rules. **Parametric Methods:** Introduction, Maximum Likelihood Estimation, Evaluating an Estimator: Bias and Variance, The Bayes' Estimator, Parametric Classification, Regression, Tuning Model Complexity Bias/Variance Dilemma, Model Selection Procedures.	**12**

3	**Clustering:** Introduction, Mixture Densities, k-Means Clustering, Expectation-Maximization Algorithm, Mixtures of Latent Variable Models, Supervised Learning after Clustering, Spectral Clustering, Hierarchical Clustering, Choosing the Number of Clusters. **Nonparametric Methods:** Nonparametric Density Estimation, Generalization to Multivariate Data, Nonparametric Classification, Condensed Nearest Neighbor, Distance-Based Classification, Outlier Detection, Nonparametric Regression Smoothing Models.	**12**
4	**Decision Trees:** Introduction, Univariate Trees, Pruning, Rule Extraction from Trees, Learning Rules from Data, Multivariate Trees. **Linear Discrimination:** Introduction, Generalizing the Linear Model, Pairwise Separation, Parametric Discrimination Revisited, Gradient Descent, Logistic Discrimination, Learning to Rank.	**12**
5	**Multilayer Perceptron:** Introduction, The Perceptron, Training a Perceptron, Learning Boolean Functions, Multilayer Perceptrons, MLP as a Universal Approximator, Backpropagation Algorithm, The Perceptron, Training a Perceptron, Learning Boolean Functions, Multilayer Perceptrons, MLP as a Universal Approximator, Backpropagation Algorithm.	**12**

Text Books:

1. Ethem Alpaydin, Introduction to Machine Learning, 4/e MIT Press, 2020.

Reference Books:

1. Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, 2nd Edition, Wiley, 2001.
2. C.Bishop, Pattern Recognition and Machine Learning, Springer 2007.

Web/Digital resources:

1. https://nptel.ac.in/courses/106106139 Introduction to Machine Learning.

DEPARTMENT	*INFORMATION SCIENCE & ENGINEERING*						
Course Code	**23MSDS220**	*Total Credits*	**4**	*Course Type*	*Professional Core Course*		
Course Title	**DIGITAL IMAGE PROCESSING**						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	*4*			**CIE**	**SEE**	**Total**
	Tutorial	*-*		*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	*-*		*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	*4*	*4*	*Minimum Marks*	*20 marks*	*25 Marks*	*45 Marks*

COURSE PREREQUISITE: Statistics, Calculus and Linear Algebra.

COURSE OBJECTIVES: To be able to find solutions to different Engineering problems using Image Processing algorithms.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Explain the basic concepts in image processing.	L2
CO2	Develop image enhancement methods based on intensity transformation and spatial filtering.	L3
CO3	Model and apply different segmentation and edge detection techniques	L3
CO4	Develop algorithms for feature extraction to detect objects in image.	L3
CO5	Apply the image processing concepts to analyze colour images	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
UNIT 1	**Introduction:** Image processing systems and its applications. Basic image file formats. Image formation: Geometric and photometric models; Digitization - sampling, quantization; Image definition and its representation, neighborhood metrics.	**12**
UNIT 2	**Intensity transformations and spatial filtering:** Enhancement, contrast stretching, histogram specification, local contrast enhancement; Smoothing, linear and order statistic filtering, sharpening, spatial convolution, Gaussian smoothing, DoG, LoG.	**12**

UNIT 3	**Segmentation:** Pixel classification; Grey level thresholding, global/local thresholding; Optimum thresholding - Bayes analysis, Otsu method; Derivative based edge detection operators, edge detection/linking, Canny edge detector; Region growing, split/merge techniques, line detection,Hough transform.	**12**
UNIT 4	**Image/Object features extraction:** Textural features - gray level co-occurrence matrix; Moments; Connected component analysis; Convex hull; Distance transform, medial axis transform, skeletonization/thinning, shape properties. **Registration:** Mono-modal/multimodal image registration; Global/local registration; Transformand similarity measures for registration; Intensity/pixel interpolation.	**12**
UNIT 5	**Colour image processing:** Fundamentals of different colour models - RGB, CMY, HSI, YCbCr, Lab; False Colour; Pseudo Colour; Enhancement; Segmentation. **Morphological Filtering Basics:** Dilation and Erosion Operators, Top Hat Filters	**12**

Text Books:

1. Digital Image Processing. R. C. Gonzalez and R. E. Woods, 4th edition, Prentice Hall, 2018.

Reference Books:

1. Image Processing: The Fundamentals. Maria Petrou and PanagiotaBosdogianni, John Wiley & Sons, Ltd.
2. Digital Image Processing. K. R. Castleman:, Prentice Hall, Englewood Cliffs.
3. Visual Reconstruction. A. Blake and A. Zisserman, MIT Press, Cambridge.
4. Digital Pictures. A. N. Netravali and B. G. Haskell, Plenum Press.
5. Digital Images and Human Vision. A. B. Watson:, MIT Press, Cambridge.

Web/Digital resources:

1. https://nptel.ac.in/courses/117105079

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS230***	***Total Credits***	***4***	***Course Type***	***Professional Core Course***		
Course Title	***NATURAL LANGUAGE PROCESSING***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	***4***			**CIE**	**SEE**	**Total**
	Tutorial	***-***		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	***-***		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	***4***	***4***	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Datamining, System Software

COURSE OBJECTIVES: To learn the basic concepts in building NLP applications using linguistic knowledge and machinelearning approaches.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Finite state transducers for Language Processing.	L3
CO2	Illustrate the various aspects of natural language processing using phonetics.	L2
CO3	Develop of Parts of Speech taggers using linguistic knowledge.	L3
CO4	Design of natural language processing tools using machine learning algorithms.	L3
CO5	Illustrate the various aspects of discourse analysis, dialogues and natural language generation.	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction** Introduction to NLP: Definition, Knowledge in speech and speech language processing, Word Classes: Review of Regular Expressions, Morphology: Inflectional, derivational, parsing and parsing with FST, Combining FST lexicon and rules, human morphological processing.	**12**
2	**Phonology** Speech sounds, phonetic transcription, phoneme and phonological rules, optimality theory, machine learning of phonological rules, phonological aspects of prosody and speech synthesis. Pronunciation, Spelling and N-grams: Spelling errors, detection and elimination using probabilistic models, pronunciation variation (lexical, allophonic, dialect), decision tree model, counting words in Corpora, simple N-grams, smoothing (Add One, Written-Bell, Good-Turing), N-grams for spelling and pronunciation.	**12**

3	**POS Tagging** Tag sets, concept of HMM tagger, rule based and stochastic POST, algorithm for HMM tagging, transformation-based tagging, Sentence level construction & unification: Noun phrase, co-ordination, sub-categorization, concept of feature structure and unification.	**12**
4	**Lexical Semantics and Word Sense Disambiguation:** Semantics: Representing Meaning: Unambiguous representation, canonical form, expressiveness, meaning structure of language, basics of FOPC, semantics of FIPC. Semantic Analysis**:** Syntax driven, attachment & integration, robustness. Lexemes (homonymy, polysemy, synonymy, hyponymy), WordNet, internal structure of words, creativity and the lexicon: metaphor and metonymy and their computational approaches. Word Sense Disambiguation: Selection restriction-based, machine learning based and dictionary based approaches.	**12**
5	**Pragmatics** Discourse: Reference resolution and phenomena, syntactic and semantic constraints on Co reference, pronoun resolution algorithm, text coherence, discourse structure. Dialogues: Turns and utterances, grounding, dialogue acts and structures. Natural Language Generation: Introduction to language generation, architecture, discourse planning, text schemata, rhetorical relations.	**12**

Text Books:

1. D. Jurafsky& J. H. Martin – "Speech and Language Processing – An introduction to Language processing, Computational Linguistics, and Speech Recognition", Pearson Education

Reference Books:

1. Allen, James. 1995. – Natural Language Understanding.Benjamin/Cummings, 2ed.Bharathi, A Vineet Chaitanya
   and Rajeev Sangal. 1995.
2. Natural Language Processing-A PananianPerspective.PrenticeHllIndia, Eastern Economy Edition. Eugene Cherniak:
3. Chris Manning and HinrichSchütze, Foundations of Statistical Natural Language Processing, MIT Press. Cambridge, MA: May 1999.

Web/Digital resources:

1. http://www.cse.iitb.ac.in/~cs626-449
2. http://cse24-iiith.virtual-labs.ac.in/#

PROFESSIONAL ELECTIVE – II

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS241***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - II***		
Course Title	***INFORMATION RETRIEVAL***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: DBMS

COURSE OBJECTIVE: The main objective of this course is to present the basic concepts in information retrieval andmore advanced techniques of multimodal based information systems.

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Describe set theoretic and algebraic Information Retrieval models	L2
CO2	Describe Information Retrieval Boolean Model to retrieve relevant documents	L2
CO3	Describe inverted index implementation on parallel and distributed architecture	L2
CO4	Analyze Vector Space Model using different representations to evaluate the results	L4
CO5	Analyze the results of Retrieval models using various techniques	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction:** Motivation, Basic concepts, Past, present, and future, The retrieval process. **Modeling:** Introduction, A taxonomy of information retrieval models, Retrieval: Adhoc and filtering, A formal characterization of IR models, Classic information retrieval, Alternative set theoretic models, Alternative algebraic models, Alternative probabilistic models, Structured text retrieval models, Models for browsing.	12
2	**IR Using Boolean Model:** Information retrieval using the Boolean model, An example information retrieval problem, A first take at building an inverted index, Processing Boolean queries, The dictionary and postings lists, Determining dictionary terms, Postings lists, revisited, Tolerant retrieval, Wildcard queries, Spelling correction, Phonetic correction.	12
3	**Indexing** Introduction; Inverted Files; Other indices for text; Boolean queries; Sequential searching; Pattern matching; Structural queries; Compression. Index construction, Construction of large indexes, Distributed indexing, Dynamic indexing, Other types of indexes Parallel and Distributed IR: Introduction, Parallel IR, Distributed IR.	12
4	**Vector space retrieval** Scoring and term weighting, Parametric and zone indexes, Weighted zone scoring, Term frequency and weighting, Inverse document frequency, tf-idf weighting, Variants in weighting functions, Documents as vectors, Inner products ,Queries as vectors, Heuristics for efficient scoring and ranking, Inexact top K document retrieval, Interaction between vector space and other retrieval methods , Query parsing and composite scoring, Text Operations: Introduction, Document preprocessing, Document classification and clustering.	12
5	**Retrieval Evaluation** Introduction, Retrieval performance evaluation, Reference collections. Query Languages: Introduction, keyword-based querying, Pattern matching, Structural queries, Query protocols. Query Operations: Introduction, User relevance feedback, Automatic local analysis, Automatic global analysis. Searching the Web: Introduction, Challenges, Characterizing the web, Search engines	12

Text Books:

1. Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval,Cambridge University Press, 2012

Reference Books:

1. Ricardo Baeza-Yates, Berthier Ribeiro-Neto: Modern Information Retrieval, Pearson, 2003.
2. David A. Grossman, Ophir Frieder: Information Retrieval Algorithms and Heuristics, 2nd Edition, Springer,2004.

Web/Digital resources:

1. https://nlp.stanford.edu/IR-book/information-retrieval.html

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS242***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - II***		
Course Title	***BIG DATA ANALYTICS***						
TeachingLearning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	***4***			***CIE***	**SEE**	**Total**
	Tutorial	***-***		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	***-***		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	***4***	***4***	***Minimum Marks***	***20 Marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Database Management Systems.

COURSE OBJECTIVES: The main objectives of this subject are to introduce basic concepts related to Big Data which includes the Big Data Ecosystem and technologies and to apply machine learning algorithms to complex data.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Explain fundamentals of big data analytics and its applications	L2
CO2	Apply big data technologies and tools to analyze the data	L3
CO3	Apply data mining methods to solve complex big data problems.	L3
CO4	Identify frequent items in big data problems	L3
CO5	Explain recommendation system and its applications	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction** Overview of Big Data, History, Structuring Big Data, Types of Data, Elements of Big Data, Data analytics project life cycle, Problems & challenges in understanding Data Analytics, Web page categorization, computing the frequency of stock market change. Use of Big Data in Social Networking, Use of Big Data in preventing Fraudulent activities, Use of Big Data in Retail Industry.	**12**

2	**Big Data Technology** Exploring Big Data Stack, Virtualization, Virtualization Approaches, Distributed and parallel computing for Big Data, The cloud and Big Data, Cloud Deployment Models, Cloud Delivery Models, Cloud providers in Big Data Market. Introducing Hadoop, Hadoop Ecosystem, Hadoop Distributed File Systems(HDFS), Features of HDFS : Hadoop YARN, MAP Reduce, Features of Map Reduce, Working of Map Reduce, Techniques to Optimize Map Reduce Jobs, Uses of Map Reduce, HBase, Features of HBase, Role of HBase in Big Data processing, Other tools of Hadoop (Hive, Pig and Pig Latin, Sqoop, ZooKeeper, Flume, OOZie),	**12**
3	**Mining Data Streams** The Stream Data Model, A Data-Stream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing, Sampling Data in a Stream, Filtering Streams, Estimating Moments, Dealing With Infinite Streams, Counting Ones in a Window.	**12**
4	**Frequent Itemset** The Market Basket Analysis, A Priori Algorithm, Handling Larger Datasets in Main Memory, Limited-Pass Algorithms, Counting Frequent Items in a Stream.	**12**
5	**Recommendation Systems** A Model, Content Based Recommendations, Collaborative Filtering, Dimensionality Reduction Problem, The NetFlix Problem.	**12**

Text Books:

1. Big Data: Black Book, DT Editorial Services, Dream Tech Press Publishers, 2015.
2. Mining of Massive Datasets, Jure Leskovec, Anand Rajaraman, Jeff Ullman, Second Edition, Cambridge University Press Publisher, 2015.

Reference Books:

1. Big Data Analytics with R and Hadoop, Vignesh Prajapati, Packt Publishing, 2013
2. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, 2015.

Web/Digital Resources:

1.https://nptel.ac.on/courses/106104189
2.https://statanalytica.com/blog/data-analytics-tools/

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS243***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - II***		
Course Title	***STATISTICAL METHODS IN INFORMATION PROCESSING***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	***4***			***CIE***	**SEE**	**Total**
	Tutorial	***-***		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	***-***		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	***4***	***4***	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Mathematics.

COURSE OBJECTIVES: To define the type and size of data to be collected. To organize and summarize the data. To analyze the data and draw inferences using different statistical methods.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Explain the different statistical measures and analysis types available.	L2
CO2	Apply correlation to identify relationships between variables and regression analysis to predict outcomes	L4
CO3	Forecast the trend pattern exhibited by the given data using Time series Analysis	L4
CO4	Carry out one way and two way Analysis of Variance	L4
CO5	Calculate and Interpret statistical quality control using Charts	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction to Statistics :** Introduction to uni-variate data, Measures of central tendency, Arithmetic mean, Median, Mode, Geometric Mean and Harmonic Mean, Measures of dispersion, Range, Quartile deviation, Mean deviation, Standard deviation and Co-efficient of variation, Skewness, Kurtosis and Moments, Problems.	**12**
2	**Correlation and regression analysis:** Introduction to Correlation analysis, Types of correlation, Methods of studying correlation – Karl. Pearson's coefficient of correlation Rank correlation method, Partial and Multiple Correlation, Introduction to Regression analysis – Regression lines, Properties of Regression coefficients, Angle between two regression lines, Problems.	**12**

3	**Analysis of Time Series:** Components of time series – Problems of classifications – Methods of measuring trends, Freehand graphing method, semi average method, moving average method, method of least squares, Introduction to Measurement of seasonal variation, Method of simple averages (weekly, monthly and quarterly), Ratio to trend method, Problems.	**12**
4	**Analysis of variance:** Introduction to Small sample tests based on t and F distribution, Test for single mean, difference between means, Paired t-test, Test for equality of variances, ANOVA- one - way classification, Two-way classification., Non-Parametric Test: The Mann Whitney test, The Kruskal-Wallis single-factor analysis of variance by ranks, Procedure, Problems.	**12**
5	**Statistical Quality Control:** Introduction - Process control, control charts for variables - Mean and Range chart (X Bar and R), control charts for variables - Mean and Standard deviation chart (X Bar and s), Introduction to Attributes Control charts, Control chart for the number of defectives (np-chart), Control chart for the fraction of defectives (p-chart), Control chart for the number of defects (c-chart).	**12**

Text Books:

1. Fundamentals of mathematical statistics, S.C.Gupta and V.K.Kapoor,12th edition,Sultan chand & sons,2020.
2. Statistics for Technology- A course in Applied Statistics, C.Chatfield, 3rd edition, 1999.

Reference Books:

1. Statistical methods, S.R.Guptha, Sultan Chand & Sons,2012.
2. Fundamentals of Applied Statistics, S.C.Gupta and V.K.Kapoor , Sultan chand & sons,2020
3.Statistics – Theory and Practice, R.S.N.Pillai, &V.Bagavathi, Sultan chand & sons,2008.
4.Statistic – Problems and Solutions, V.K.Kapoor, Sultan chand & sons,2006.

Web/Digital resources:

1. home.iitk.ac.in/~shalab/spesda.htm
2. onlinecourses.nptel.ac.in/noc20_ma19

DEPARTMENT	***INFORMATION SCIENCE AND ENGINEERING***						
Course Code	***23MSDS260R***	***Total Credits***	***2***	***Course Type***	***Mandatory Core Course***		
Course Title	***RESEARCH METHODOLOGY AND IPR***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	***2***			***CIE***	***SEE***	***Total***
	Tutorial	***-***		***Weightage***	***100 %***	***-***	***100 %***
	Practical	***-***		***Maximum Marks***	***50 Marks***	***-***	***50 Marks***
	Total	***2***	***2***	***Minimum Marks***	***25 marks***	***-***	***25 Marks***

COURSE PREREQUISITE: NIL

COURSE OBJECTIVES: To understand the fundamental concepts of research Methodologies and intellectual property rights.

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Explain and illustrate the basic principles of research and defining the Research Problem.	L2
CO2	Explain the need of Literature Review and Research Design	L2
CO3	Design of various Sample Surveys, explain data collection methods and IPR	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
		Lecture
1.	**Introduction to Research Methodology**: Meaning, Objectives, Characteristics, Approaches of Research - Significance of Research - Research Methods Vs. Methodology - Types of Research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research Process.	**10**
2.	**Reviewing of The Literature:** Introduction, Importance of Literature Review in Defining a Problem, Survey of Literature- Primary and Secondary Sources - Reviews, Treatise, Monographs Patents. Research Design: Introduction – Meaning of Research Design - Need of Research Design -Features of Good Design.	**10**
3.	**Design of Sample Surveys:** Introduction, Sample Design, Sampling and Non - Sampling Errors, Steps in Sampling. Data Collection: Methods of Data Collection - Collection of Primary Data and Secondary Data. **Intellectual Property Rights** -Invention and Creativity, Intellectual Property, Importance and Protection of Intellectual Property Rights (IPRs) A Brief Summary of: Patents, Copyrights, Trademarks, Industrial Designs.	**10**

Text Book:

1. Kothari, C.R, Research Methodology: Methods and Techniques, New Age International, 2010
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K, An introduction to Research Methodology, RBSA Publishers, 2002.

Reference Books:

1. Anderson, T. W, An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
2. Fink, A, Conducting Research Literature Reviews: From the Internet to Paper, Sage Publications, 2009.
3. Keith Eugene Maskus, Intellectual Property Rights in the Global Economy, Institute for International Economics,Washington, DC, 2000

Web Resources:

1. https://nptel.ac.in/courses/121106007
2. https://onlinecourses.swayam2.ac.in/cec20_hs17/

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS270L***	***Total Credits***	***2***	***Course Type***	***Professional Core Course Laboratory***		
Course Title	***NATURAL LANGUAGE PROCESSING LABORATORY***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	***-***			**CIE**	**SEE**	**Total**
	Tutorial	***-***		***Weightage***	***100%***	***-***	***100 %***
	Practical	***4***		***Maximum Marks***	***50 Marks***	***-***	***50 Marks***
	Total	***4***	***2***	***Minimum Marks***	***25 marks***	***-***	***25 Marks***

COURSE PREREQUISITE: Machine Learning, Datamining.

COURSE OBJECTIVE: To learn the basic concepts in building NLP applications using linguistic knowledge and machinelearning approaches.

COURSE OUTCOMES (COs): After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Illustrate Preprocessing of Text(Word and Sentence tokenization)	L3
CO2	Implementation of computational linguistic tool using Rule Based Approach	L2
CO3	Development of Natural Language Processing applications using Machine Learning Algorithms	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content

Week	List of Experiments/ Programs	No. of Hours
1.	Implementation of Pre - Processing text	2
2.	Implementation of Morphological Analysis of words	2
3.	Development of Morphological Generation of words	2
4.	Implementation of Stemming And Lemmatization	2
5.	Development of POS Taggers	2
6.	implementation of Chunkers	2
7.	Building Parser	2
8.	Implementation of NER	2
9.	Design of N–Gram Language Model	2
10.	Implementation of Word Sense Disambiguation Tool	2
11.	Study Wordnet–Lesk Algorithm	2
12.	CASE STUDY : Application of NLP- Sentiment Analysis of tweets in Twitter platform	2
13.	Laboratory Test	2

Text Books:

1. Natural Language Processing with Python Written by Steven Bird, Ewan Klein and Edward Loper.
2. Foundations of Statistical Natural Language Processing. Written by Christopher Manning and Hinrich Schutze.

Reference Books:

1. Text Mining in R - Julia Silge and David Robinson
2. Sentiment Analysis and Opinion Mining - Bing Liu
3. Natural Language Processing with Java - Richard M Resse and Ashish Singh Bhatia

Journals/Magazines:

1. https://www.avenga.com/magazine/nlp-finance-applications/

Web/Digital resources:

1. Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit
2. Natural Language Processing with Python
3. Book GitHub Repository
4. Deep Learning for Natural Language Processing

SEMESTER III

PROFESSIONAL ELECTIVE – III

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS311***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - III***		
Course Title	***Deep Learning***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	***4***			**CIE**	**SEE**	**Total**
	Tutorial	***-***		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	***-***		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	***4***	***4***	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Machine Learning, Linear Algebra

COURSE OBJECTIVES: To understand the theoretical basis underlying neural networks and deep learning. To implementdeep learning components on real-world data sets.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Differentiate between machine learning and deep learning.	L2
CO2	Focus on artificial neural network and their uses in deep learning.	L2
CO3	Analyze different deep learning models and parameters.	L4
CO4	Train a deep learning model.	L3
CO5	Implement a deep learning application to solve real-world problem.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	Introduction to Machine learning, Supervised and Unsupervised ML, Reinforcement learning , Linear regression ,Cost functions ,Overfitting Under-fitting, Hyper-parameter, Deep Learning vs Traditional Machine Learning**.**	**12**
2	Artificial Neural Network Feed-forward neural network, Back propagation, optimization problem, Activation & Synaptic Dynamics, stability and convergence.	**12**
3	Introduction to deep learning, What is Deep Learning Algorithm, What is Deep Learning Algorithm, Convolutional Neural Networks (CNNs), Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Generative Adversarial Networks (GANs).	**12**
4	Radial Basis Function Networks (RBFNs), Self-Organizing Maps (SOMs), Restricted Boltzmann Machines (RBMs), Deep Belief Networks (DBN), Gradient Descent Optimization Technique, Dropout, Transfer learning.	**12**
5	Deep learning library, Keras backend, Tensorflow, Theano, Keras models and layers, Keras modelclass, Case studies on vision based object detection and human action detection using deep learning models.	**12**

Text Books:

1. T1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.
2. T2. Bishop, C. M., Pattern Recognition and Machine Learning, Springer, 2006.

Reference Books:

1. R1. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
2. R2. Golub, G.,H., and Van Loan,C.,F., Matrix Computations, JHU Press,2013.
3. R3. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.

Web/Digital resources:

1. https://www.tutorialspoint.com/python_deep_learning/index.html
2. https://www.javatpoint.com/deep-learning

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS312***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - III***		
Course Title	***MULTIMEDIA COMPUTING***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Data Communication.

COURSE OBJECTIVES: To introduce basic of audio, speech, image, video representation, Coding, processing andanalysis techniques.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Discuss multimedia tools and basic theory of elements of multimedia processing	L2
CO2	Describe Image data types.	L2
CO3	Paraphrase the process of capturing Video and Audio signals	L2
CO4	Apply Multimedia Algorithms for noise reduction in multimedia elements	L3
CO5	Analyze various standards of multimedia representations	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction and Review of Basic Theory** What is Multimedia?, Multimedia and Hypermedia, World Wide Web, Overview of Multimedia Software and Authoring Tools. Review of Fourier theory, Probability and Statistics, Sampling and Quantization, A/D and D/A Conversion. Human Vision and Perceptual Phenomena, Animations.	**12**

2	**Image Data Types** Binary, Grayscale and Color Images, Image Sampling and Quantization, Algorithms for 24bit – 8bit Color Image Conversion, Popular Image File Formats. Spectral Sensitivity of Vision, Color Matching and CIE XYZ space, x-y Chromaticity Diagram, Monitor Color Specifications and Gamma Correction, CIELa*b* and RGB and CMYK Color Models, Color Models for Video.	**12**
3	**Video and Audio** Fundamental Concepts in Video: Types of video signals, Scanning, Broadcast TV, Analog and Digital video. Sampling and Quantization of Sound, Psychoacoustics, Perceptual Coding of Audio, Differential Coding of Audio: Lossless Predictive Coding and DPCM, MIDI:Musical Instrument Digital Interface	**12**
4	**Data Compression** Entropy and Lossless Coding Bounds, Variable Length Coding, Run Length Coding, Huffman coding, LZW coding, Arithmetic coding, Lossless Image Compression. Rate-distortion curve and bounds, DCT-based lossy coding of grayscale and color images, Haar transform-based coding. Introduction to Video Compression, Block Motion Estimation, Motion Compensated Video Coding.	**12**
5	**Standards and Multimedia Communication** JPEG, H.261, MPEG, MPEG Audio. Quality of Multimedia Data Transmission, Multimedia over IP	**12**

Text Books:

1. Ze-Nian Li & Mark S. Drew, “Fundamentals of Multimedia”, Second Edition, Prentice-Hall India, 2014.

Reference Books:

1. Rafael C. Gonzales & Richard E. Woods, “Digital Image Processing”, 4th Edition, Pearson, 2018.

Web/Digital resources:

1. https://nptel.ac.in/courses/117/105/117105083

DEPARTMENT	*INFORMATION SCIENCE & ENGINEERING*						
Course Code	*23MSDS313*	*Total Credits*	*4*	*Course Type*	*Professional Elective Course - III*		
Course Title	*INTERNET OF THINGS*						
Teaching Learning Process		*Contact Hours*	*Credits*	*Assessment in Weightage and marks*			
	Lecture	4			CIE	SEE	Total
	Tutorial	-		*Weightage*	*40 %*	*60 %*	*100 %*
	Practical	-		*Maximum Marks*	*40 Marks*	*60 Marks*	*100 Marks*
	Total	4	4	*Minimum Marks*	*20 marks*	*25 marks*	*45 Marks*

COURSE PREREQUISITE: Operating System.

COURSE OBJECTIVES: Students will be explored the interconnection and integration of the physical world and cyberspace. They are also able to design and develop IoT applications.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Identify and design IoT protocol layers and design IoT levels.	L1
CO2	Describe IoT system management and link layer protocols.	L2
CO3	Interface sensors for industrial applications.	L3
CO4	Develop and demonstrate IoT solutions for data processing and analysis	L4
CO5	Apply IoT design and deployment methodologies to various applications	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction** Introduction to Internet of Things: Introduction: Definition and Characteristics of IoT, Physical Design of IoT: Things in IoT, IoT Protocols, Logical Design of IoT: IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies: Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication protocols, Communication Protocols, Embedded Systems, IoT Levels and Deployment Templates. Internet of Things Applications: Home Automation, Smart Metering/Advanced Metering Infrastructure-Health/Body Area Networks, City Automation, Smart Cards, Tracking, Surveillance system, Environment, Energy, Retail, Logistics, Agriculture, Industry and Health care and Lifestyle	**12**
2	**M2M and Layer Connectivity** M2M**,** Difference between IOT and M2M, SDN and NEV for IOT, IOT System management with NETCONF_YANG, Need for IOT System Management, Simple Network Management Protocol(SNMP), Layer Connectivity: Wireless Technologies for the IoT-WPAN Technologies for IoT/M2M, Cellular and Mobile Network Technologies for IoT/M2M.	**12**

3	**Sensors and Industrial Systems:** Introduction to sensors and transducers, integrating sensors to sensor processing boards, introduction to industrial data acquisition systems, industrial control systems and their functions.	**12**
4	**IoT Data Processing and Storage:** Time Series Data and their characteristics, time series databases, basic time series analytics, data summarization and sketching, dealing with noisy and missing data, anomaly and outlier detection.	**12**
5	**Application of IoT** Case Studies illustrating IoT Design-Introduction, Home Automation, Cities, Environment, Agriculture, Productivity Applications using different IoT devices, platform and software.	**12**

Text Books:

1. Daniel Minoli," Building the Internet of Things with IPv6 and MIPv6: The Evolving world of M2M Communications", Wiley, 2013.
2. Arshdeep Bahga, Vijay Madisetti," Internet of Things: A Hands-on Approach" Universities Press., 2015.

Reference Books:

1. Michael Miller, The Internet of Things", First Edition, Pearson, 2015.
2. Claire Rowland ,Elizabeth Goodman et.al.," Designing Connected Products", First Edition,O'Reilly, 2015

Web/Digital resources:

1. https://www.coursera.org/specializations/iot

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS320T***	***Total Credits***	***6***	***Course Type***	***INTERNSHIP/INDUSTRIAL TRAINING***		
Course Title	***INDUSTRIAL TRAINING/INTERNSHIP***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture				**CIE**	**SEE**	**Total**
	Tutorial			***Weightage***	***100 %***	***-***	***100 %***
	Practical	**12**		***Maximum Marks***	***100 Marks***	***-***	***100 Marks***
	Total	**12**	**6**	***Minimum Marks***	***50 Marks***	***-***	***50 Marks***

COURSE PREREQUISITE:

COURSE OBJECTIVES: Provide to students the feel of the actual working environment and to gain practical knowledge and skills, which in turn will motivate, develop and build their confidence.

COURSE OUTCOMES (COs)

CO#	**Course Outcomes**	**Highest Level of Cognitive Domain**
CO1	Describe use of advanced tools and techniques encountered during industrial training and visit.	L2
CO2	Develop awareness about general workplace behavior and build interpersonal and team skills.	L3
CO3	Develop solutions and prepare professional work reports and presentations	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

This course is designed to help the student obtain skills to use of advanced tools and techniques used in the industry during industrial training and visit. And also students get an opportunity to interact with industrial personnel and follow engineering practices and discipline prescribed in industry. It is also designed to develop awareness about general workplace behavior and build interpersonal and team skills

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS330P***	***Total Credits***	***6***	***Course Type***	***Project Work Course***		
Course Title	***PROJECT WORK PHASE-I***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture				**CIE**	**SEE**	**Total**
	Tutorial			***Weightage***	***100 %***	**---**	***100 %***
	Practical	**12**		***Maximum Marks***	***100 Marks***	**---**	***100 Marks***
	Total	**12**	**6**	***Minimum Marks***	***50 Marks***	**---**	***50 Marks***

COURSE PREREQUISITE: Regular Subjects Mentioned In the Scheme

COURSE OBJECTIVES: To understand formation of the problem as part of software life cycle

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Conduct literature review in the area relevant to the computer science.	L2
CO2	Formulate a problem.	L3
CO3	Prepare a consolidated report of the literature survey and problem formulation.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 – Create

The students are required to take up an in-house or industrial project work relevant to the course. In this course preliminary work involving literature review and problem formulation will be taken up. The candidate conducts the project under the supervision of project guide.

SEMESTER – IV

PROFESSIONAL ELECTIVE – IV

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS411***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course- IV***		
Course Title	***SOCIAL AND INFORMATION NETWORK ANALYSIS***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Advanced Algorithms.

COURSE OBJECTIVE: This course introduces the concepts of representing Social Network and Information Network and analysis of Information flow in Social and Information Network.

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Illustrate Social Network as a connected graph.	L2
CO2	Demonstrate the social network as a small world	L3
CO3	Apply methods to evaluate the behavior of cascading networks and the diffusion over social and information networks.	L3
CO4	Develop graph models to describe the structure of the web and Information Network.	L3
CO5	Apply page rank algorithm to web pages in the Information Network	L3

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction:**Aspects of Networks, Central Themes and Topics. Graphs**:** BasicDefinitions, Paths and Connectivity, Distance and Breadth-First Search, Network Datasets: An Overview	12
2	**The Small-World Phenomenon** Six Degrees of Separation, Structure and Randomness, Decentralized Search, Empirical Analysis and Generalized Models, Core-Periphery Structures and Difficulties in Decentralized Search, Advanced Material: Analysis of Decentralized Search. **Positive and Negative Relationships:** Structural Balance , Characterizing the Structure of Balanced Networks, Applications of Structural Balance , A Weaker Form of Structural Balance , Advanced Material: Generalizing the Definition of Structural Balance.	12
3	**Cascading Behaviour in Networks** Diffusion in Networks, Modeling Diffusion through a Network, Cascades and Clusters, Diffusion, Thresholds, and the Role of Weak Ties, Extensions of the Basic Cascade Model, Knowledge, Thresholds, and Collective Action, Advanced Material: The Cascade Capacity. **Epidemics :** Diseases and the Networks that Transmit Them , Branching Processes, The SIR Epidemic Model , The SIS Epidemic Model , Synchronization , Transient Contacts and the Dangers of Concurrency , Genealogy, Genetic Inheritance, and Mitochondrial Eve, Advanced Material: Analysis of Branching and Coalescent Processes	12
4	**Power Laws and Rich-Get-Richer Phenomena** Popularity as a Network Phenomenon, Power Laws, Rich-Get-Richer Models, The Unpredictability of Rich-Get-Richer Effects, The Long Tail, The Effect of Search Tools and Recommendation Systems Advanced Material: Analysis of Rich-Get-Richer Processes. **The structure of the Web :** The World Wide Web, Information Networks, Hypertext, and Associative Memory The Web as a Directed Graph, The Bow-Tie Structure of the Web, The Emergence of Web 2.0	12
5	**Link Analysis and Web Search** **Searching the Web**: The Problem of Ranking , Link Analysis using Hubs and Authorities, PageRank, Applying Link Analysis in Modern Web Search, Applications beyond the Web, Advanced Material: Spectral Analysis, Random Walks, and Web Search **Strong and Weak Ties:** Triadic Closure , The Strength of Weak Ties, Tie Strength and Network Structure in Large-Scale Data , Tie Strength, Social Media, and Passive Engagement Closure, Structural Holes, and Social Capital, Advanced Material: Betweenness Measures and Graph Partitioning	12

Text Books:

1. “Networks, Crowds, and Markets Reasoning about a Highly Connected World”, David Easley, Cornell University, New York, Jon Kleinberg, Cornell University, New York, 2010

Reference Books:

1. "Networks: An Introduction By M. E. J. Newman, A College-Level Textbook About The Science Of Networks.", M.E. J. Newman Hardback, Oxford University Press, 2010

Journals/Magazines:

1. Shi, C., Li, Y., Zhang, J., Sun, Y., & Philip, S. Y.2. A survey of heterogeneous information network analysis. IEEETransactions on Knowledge and Data Engineering, 29(1), 17-37, 2016.
2. Shi, C., Hu, B., Zhao, W. X., & Philip, S. Y.. Heterogeneous information network embedding for recommendation.IEEE Transactions on Knowledge and Data Engineering, 31(2), 357-370, 2018.

Web/Digital resources:

1. https://ocw.mit.edu/courses/1-022-introduction-to-network-models-fall-2018/

SWAYAM/NPTEL:

1. https://onlinecourses.nptel.ac.in/noc22_cs117/preview

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS412***	***Total Credits***	***4***	***Course Type***	***Professional Elective Course - IV***		
Course Title	***BLOCKCHAIN TECHNOLOGY***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Advanced Database Management Systems, Information Retrieval.

COURSE OBJECTIVES: To design and secure applications using Blockchain for various real time applications.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Analyze how the traditional databases can be replaced with blockchain for the real time applications.	L4
CO2	Integrate various cryptographic algorithms in to blockchain	L2
CO3	Apply various consensus mechanisms to the real world blockchain applications.	L3
CO4	Identify where a blockchain based structure may be applied, its potential and its limitation	L3
CO5	Identify the threats of blockchain and deploy security mechanisms.	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction**: Basic concepts of Block chain, Nodes, Crypto currency, tokens, Public Ledger, Peer to peer Network, Types of block chain, Permissioned block chain model, Permission-less block chain model, Block chain Construction.	**12**
2	**Cryptography**: Machines that encrypted data in the past, Modern encryption, Private and public keys, Hash functions, From blocks to hashes, Hash Pointer, Markle tree, Ledgers, Transactions and trade, The public witness, Computers that witness, Distributed Consensus, Smart contract design, Bitcoin Block chain Network.	**12**
3	**The structure of the network:** consensus algorithm Proof of Work, Proof of Stake, Delegated Proof of Stake, Proof of Authority, Proof of Elapsed Time, Proof of Capacity, Proof of Space, Proof of Burn, RAFT, PAXOS, Byzantine Fault Tolerance System, PBFT.	**12**

4	**Second generation applications of Block chain technology Smart contracts:** origins and how they function, Creating and deploying smart contracts, Tokens, Token standards, Second generation tokens Decentralized applications, How are DApps constructed?, Decentralized Autonomous Organizations (DAOs).	**12**
5	**Blockchain Security:** Blockchain vulnerabilities, Smart contract vulnerabilities, Blockchain on CIA security triad, Blockchain based DNS security platform, deploying blockchain based DDOS protection.	**12**

Text Books:

1. "Introduction to Blockchain Technology", Tiana Laurence, 1st edition, Van Haren Publishing, 2019.
2. Blockchain: The Blockchain For Beginners Guide To Blockchain Technology And Leveraging BlockchainProgramming", Kindle Edition, Josh Thompsons, 18 may 2017.

Reference Books:

1. "Hands-On Cybersecurity with Blockchain: Implement DDoS protection, PKI-based identity, 2FA, and DNSsecurity using Blockchain", Rajneesh Gupta, 1st edition, 2018.
2. "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", Narayanan, Bonneau, Felten, Millerand Goldfeder, Princeton University Press (19 July 2016)

Web/Digital resources:

1. https://nptel.ac.in/courses/106104220
2. https://nptel.ac.in/courses/106105184

DEPARTMENT	INFORMATION SCIENCE & ENGINEERING						
Course Code	23MSDS413	Total Credits	4	Course Type	Professional Elective Course - IV		
Course Title	CONVERSATIONAL SYSTEMS						
Teaching Learning Process		Contact Hours	Credits	Assessment in Weightage and marks			
	Lecture	4			CIE	SEE	Total
	Tutorial	-		Weightage	40 %	60 %	100 %
	Practical	-		Maximum Marks	40 Marks	60 Marks	100 Marks
	Total	4	4	Minimum Marks	20 marks	25 marks	45 Marks

COURSE PREREQUISITE: Artificial Intelligence

COURSE OBJECTIVES: To build conversational systems using ML and AI technologies.

COURSE OUTCOMES: After completing this course, students should be able to:

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Explain AI assistant technologies for conversational systems	L2
CO2	Design and develop Rule Based Dialogue systems.	L3
CO3	Develop Data-driven Dialogue Systems using Natural Language Processing techniques.	L3
CO4	Analyze reinforcement learning approach for dialog system	L4
CO5	Analyze and examine Dialogue Systems.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introducing Dialogue Systems:** What is a Dialogue System? A Brief History of Dialogue Systems, Present-Day Dialogue Systems, Modelling Conversation in Dialogue Systems: User- Initiated Dialogues, System-Directed Dialogue, Multi-Turn Open-Domain Dialogue. Designing and Developing Dialogue Systems.	12
2	**Rule-Based Dialogue Systems:** A Typical Dialogue Systems Architecture: Automatic Speech Recognition, Natural Language Understanding (NLU), Dialogue Management, Natural Language Generation (NLG), Text-to-Speech Synthesis (TTS), Designing a Dialogue System, Tools for Developing Dialogue Systems, Rule-Based Techniques in Dialogue Systems: Visual Design Tools, Scripting Tools for Handcrafting Dialogue Systems, Advanced Toolkits and Research-Based Toolkits.	12
3	**Data-Driven Dialogue Systems:** Data-Driven Approach, Dialogue Components in the Data- Driven Approach: Natural Language Understanding, Dialogue Management, Natural Language Generation.	12
4	**Reinforcement Learning (RL):** Representing Dialogue as a Markov Decision Process, From MDPs to POMDPs, Dialogue State Tracking, Dialogue Policy, Problems and Issues with Reinforcement Learning and POMDPs.	12

5	**Evaluating Dialogue Systems:** Conducting Evaluation: Laboratory Studies vs. Evaluations in the Wild, Evaluating Task-Oriented Dialogue Systems, Evaluating Open-Domain Dialogue Systems, Evaluation Frameworks: PARADISE, Quality of Experience, Interaction Quality. BestWay to Evaluate Dialogue Systems.	**12**

Text Books:

1. MichealMcTear, Conversational AI: Dialogue Systems, Conversational Agents and chatbots,2020, 1st Edition, Morganand Claypool.

Reference Books:

1. SriniJanarthanam, Chatbots and Conversational UI Development, 2017, 1stEdition, Packt Publishers.
2. Diana Perez-marin and Ismael Pascual-Nieto, Conversational Agents And Natural Language Interaction, 2011,1st Edition, IGI Global publishers.
3. Luis Fernando D Haro, Zoraida Callejas, Satosh Nakamura, Conversational Dialogue Systems for the Next Decade,2021,1st Edition, Springer.

Web/Digital resources:

1. https://www.ibm.com/cloud/learn/conversational-ai

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS420P***	***Total Credits***	***12***	***Course Type***	***Project Work Course***		
Course Title	***PROJECT WORK PHASE-II***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**-**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60%***	***100 %***
	Practical	**24**		***Maximum Marks***	***40 Marks***	**60 Marks**	***100 Marks***
	Total	**24**	**12**	***Minimum Marks***	***20 Marks***	***25 Marks***	***45 Marks***

COURSE PREREQUISITE: All regular subjects as per the Scheme

COURSE OBJECTIVE: To design, implement and preparing a technical report for the defined problem

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Conduct literature review and formulate a problem in the area relevant to the computer science.	L2
CO2	Conduct experiments/Design and Analysis/solution iterations and document the results.	L3
CO3	Prepare a technical report and presentations.	L4

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

The students are required to take up a project work relevant to the course, which involves literature review, problem formulation, experimentation, analysis of results and discussion. The entire project will be executed under the supervision of project guide.

Guidelines:

1. Student shall be associated with a faculty member serving as internal guide to supervise the project.
2. If the student is conducting the project work in an industry or an organization an external guideis to be chosen from industry or organization (along with internal guide) with the approval of theHead of the Department
3. The student will work with the project guide /supervisor towards the identification of the problem through a systematic literature review and finalize the objectives and scope of work.
4. Student is expected to come out with detail specifications, methodology, resources required, critical issues and any other issues related to design and implementation of the project should beprovided in consultation with Guide.
5. The student should submit the proposal with in ten working days from the commencement of thesemester to the Head of Department after due approval from the guide.
6. The student is expected to exert on design, development and testing of the proposed work as perthe schedule.
7. The student should present an interim progress review as per the department calendar of events.
8. Completed project work phase -1/ project work phase -2 documentation should be in the form ofa report and the report should be submitted to the department at the end of the semester.
9. The report should include: Abstract, Content sheets, Introduction chapter with objectives, literature review chapter, materials and methodology chapter, results and discussion chapter, summary and conclusion followed by reference list and appendix if any.
10. The student should make a final presentation at the end of the semester as per the departmentCalendar of events.

OPEN ELECTIVE COURSE

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS251E***	***Total Credits***	***4***	***Course Type***	***Open Elective Course***		
Course Title	***INTRODUCTION TO DATA STRUCTURES AND ALGORITHMS***						
Teaching Learning Process		***Contact Hours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Fundamentals of Computer Science

COURSE OBJECTIVES: To understand the fundamental concepts and basic principles of Data Structures & Algorithms.

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Explain asymptotic notations and analyze the performance of algorithms.	L2
CO2	Explain the working principle of linear data structure stack, queue, linked list and implement with their real time applications	L3
CO3	Explain the working principle of non-linear data structure trees and graphs and implement with their real time applications	L3
CO4	Apply concepts of linear and nonlinear data structures to solve problems.	L3
CO5	Apply file structures and hashing techniques for efficient searching.	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Basic Terminologies & Introduction to Algorithm and Data Organization:** Algorithm specification, Recursion, Performance analysis, Asymptotic Notation - The Big-O, Omega and Theta notation.	**12**
2	**Linear Data Structure:** Array, Stack, Queue, Linked-list and its types, Various Representations, Operations & Applications of Linear Data Structures.	**12**

3	**Non-linear Data Structure**: Trees (Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree) and Graphs (Directed, Undirected), Various Representations, Operations (search and traversal algorithms) & Applications of Non-Linear Data Structures.	**12**
4	**Searching and Sorting on Various Data Structure:** Sequential Search, Binary Search, Breadth First Search, Depth First Search, Insertion Sort, Selection Sort, Merge Sort,Quick Sort, Heap Sort.	**12**
5	**File Organization**: Sequential, Direct, Indexed Sequential, Hashing and various types of accessing schemes.	**12**

Text Books:

1. Fundamentals of Data Structures, E. Horowitz and S. Sahni, 2nd edition, Universities Press, 2008.
2. Data Structures and Algorithms, Alfred V. Aho, John E. Hopperoft, Jeffrey D.Ullman. Edition 1,Pearson, 1982

Reference Books:

1. The Art of Computer Programming: Volume 1: Fundamental Algorithms, Donald E. Knuth, Edition 1,Addison –Wesley – 2011
2. Introduction to Algorithms, Thomas, H. Cormen, Charles E. Leiserson, Ronald L. Rivest,Clifford Stein, edition 3,MIT Press, 2009
3. Open Data Structures: An Introduction (Open Paths to Enriched Learning), 31st ed. Edition.

Web/Digital resources:

1. https://nptel.ac.in/courses/106/102/106102064/

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS252E***	***Total Credits***	***4***	***Course Type***	***Open Elective Course***		
Course Title	***INTRODUCTION TO DATABASE MANAGEMENT SYSTEMS***						
Teaching Learning Process		***Contac tHours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Introduction to Discrete Mathematical Structures.

COURSE OBJECTIVES: To introduce Database Management Systems and emphasis on how to organize, maintainand retrieve information from a Database.

COURSE OUTCOMES (COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Describe different data models in database management systems	L2
CO2	Demonstrate to create a database and formulation of queries using Structured Query Language (SQL)	L3
CO3	Illustrate query optimization and indexing in relational database.	L3
CO4	Discuss the concepts of transactions and concurrency control.	L2
CO5	Explain advanced database systems and database security.	L2

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction:** Introduction to Database. Hierarchical, Network and Relational Models. **Database system architecture**: Data Abstraction, DataIndependence, Data Definition Language (DDL), Data Manipulation Language (DML). **Data models**: Entity-relationship model, network model, relational and object-oriented data models, integrity constraints, data manipulation operations.	**12**
2	**Relational query languages**: Relational algebra, Tuple and domain relational calculus, SQL3, DDL and DML constructs, Open source and Commercial DBMS - MYSQL, ORACLE, DB2, SQL server. **Relational database design**: Domain and data dependency, Armstrong's axioms, Functional Dependencies, Normal forms, Dependency preservation, Lossless design.	**12**
3	**Query processing and optimization**: Evaluation of relational algebra expressions, Query equivalence, Join strategies, Query optimization algorithms. **Storage strategies**: Indices, B-trees, Hashing.	**12**
4	**Transaction processing**: Concurrency control, ACID property, Serializability of scheduling, Locking and timestamp-based schedulers, Multi-version and optimistic Concurrency Control schemes, Database recovery.	**12**
5	**Database Security**: Authentication, Authorization and access control, DAC, MAC and RBAC models, Intrusion detection, SQL injection. **Advanced topics**: Object oriented and object relational databases, Logical databases, Web databases, Distributed databases, Data warehousing and data mining.	**12**

Text Books:

1. Database System Concepts. Abraham Silberschatz, Henry F. Korth and S. Sudarshan,7th edition 2021.

Reference Books:

1. Principles of Database and Knowledge – Base Systems, Vol 1 by J. D. Ullman, Computer SciencePress 1988.
2. Fundamentals of Database Systems. R. Elmasri and S. Navathe, 7th edition Pearsm 2008
3. Foundations of Databases. Serge Abiteboul, Richard Hull, Victor Vianu.

Web/Digital resources:

1. https://nptel.ac.in/courses/106/105/106105175/

DEPARTMENT	***INFORMATION SCIENCE & ENGINEERING***						
Course Code	***23MSDS253E***	***Total Credits***	***4***	***Course Type***	***Open Elective Course***		
Course Title	***INTRODUCTION TO MACHINE LEARNING***						
Teaching Learning Process		***Contac tHours***	***Credits***	***Assessment in Weightage and marks***			
	Lecture	**4**			**CIE**	**SEE**	**Total**
	Tutorial	**-**		***Weightage***	***40 %***	***60 %***	***100 %***
	Practical	**-**		***Maximum Marks***	***40 Marks***	***60 Marks***	***100 Marks***
	Total	**4**	**4**	***Minimum Marks***	***20 marks***	***25 marks***	***45 Marks***

COURSE PREREQUISITE: Mathematics, Data Structures, Linear Algebra

COURSE OBJECTIVES: To be able to formulate machine learning problems corresponding to different applications.

COURSEOUTCOMES(COs)

CO#	Course Outcomes	Highest Level of Cognitive Domain
CO1	Explain the basic principles of Learning theories	**L2**
CO2	Explain the principles of dimensionality reduction and feature selection techniques	**L2**
CO3	Develop a wide variety of supervised learning algorithms	**L3**
CO4	Analyze various clustering algorithms	**L4**
CO5	Apply machine learning algorithms to Software Engineering	**L3**

L1 – Remember, L2 – Understand, L3 – Apply, L4 – Analyze, L5 – Evaluate, L6 - Create

Course Content / Syllabus:

UNIT No.	Content	Hours
1	**Introduction & Bayesian Decision Theory** What Is Machine Learning?, Challenges, Examples of Machine Learning Applications, Present Research Avenues, Introduction to Bayesian Decision Theory, Classification, Losses and Risks, Discriminant Functions, Utility Theory, Association Rules	**12**
2	**Dimensionality Reduction** Introduction, Feature Generation, Feature Selection, Principal Component Analysis, Factor Analysis, Multidimensional Scaling, Linear Discriminant Analysis, Locality Preserving Projections (LPP) and its variants, Locality Preserving Indexing and its variants.	**12**

3	**Supervised Learning** Learning a Class from Examples, Probably Approximately Correct (PAC) Learning, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization, Dimensions of a Supervised Machine Learning Algorithms, Decision Tree Induction, Nearest Neighbors, Bayesian Classifier, Artificial Neural Networks, Model Over fitting, Performance Evaluation of classifiers.	**12**
4	**Clustering** Basic Concepts, Proximity Measures, Sequential Algorithms, Hierarchical Algorithms, Schemes based on Functional Optimization, Clustering Algorithms based on Graph Theory, Cluster Validity.	**12**
5	**Machine Learning Applications in Software Engineering** The challenges, Related Issues, Learning Approaches, SE tasks for ML Applications, State of the Practice in ML & SE, Present Status, Applying ML algorithms to SE Tasks.	**12**

Text Books:

1. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2004.
2. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.

Reference Books:

1. Richard Dudda, Peter Hart and David Stork, Pattern Classification, 2nd Edn., John Wiley and Sons, 2001.
2. Judith Hurwitz and Daniel Kirsch, Machine Learning, IBM Ltd. Edn., 2018.
3. Trevor Hastie, Robert Tibshirani and Jerome Friedman, The Elements of Statistical Learning, 2nd Edn., Springer,2008.
4. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

Journals/Magazines:

1. Adaption of Machine Learning ML AI in 2020
2. Machine Learning in Industry
3. Machine Learning in Digital Marketing
4. Machine Learning in Military
5. ML after Covid-19

Web/Digital resources:

1. http://www.nptelvideos.in/
2. http://www.eduplus.in/
3. https://www.cse.iitb.ac.in/~pjyothi/cs419_spr18/index.html
4. https://lgatto.github.io/IntroMachineLearningWithR/an-introduction-to-machine-learning-with-r.html
5. https://ocw.mit.edu/courses/sloan-school-of-management/15-097-prediction-machine-learning-and- statistics-spring-2012/lecture-notes/