Post Graduate Programme Syllabus

School of Digital Sciences

Kerala University of Digital Sciences, Innovation and Technology
Thiruvananthapuram

DIGITAL UNIVERSITY KERALA

Curating a responsible digital world

SCHOOL OF DIGITAL SCIENCES

The School of Digital Sciences positioned itself across the broad areas of Computational Science, Data Analytics and Scalable Data Systems across various science and technology domains. The curriculum of SoDS aims at the concept of AI applications in STEM - based on the idea of educating students in four specific disciplines — Science, Technology, Engineering and Mathematics — in an interdisciplinary and applied approach. The School was established as a part of Kerala University of Digital Sciences, Innovation and Technology (KUDSIT) in the year 2020, in the Technocity Campus, Trivandrum. This document is prepared for faculty and staff members of SoDS to provide necessary guidance in academic activities of the school.

VISION & MISSION

The vision of the school is to ensure self-sustainability of our nation. The School aims at

- To cater the demand of trained human resources in the areas of AI applications in STEM
- To foster advanced research, development and innovation in frontier areas of Digital Sciences
- To encourage and motivate student community to take up the future challenges of growing IT industry with specific objective of IR 4.0
- To promote innovations and entrepreneurship ecosystem in social innovations

OBJECTIVES

Industry revolution 4.0 is mainly dependent on the developments in AI and which in turn rely on the knowledge and information we are gathering from the data. As we are living in the emerging data driven world, decision support systems based on the insights derived from data are receiving much acceptance in every branches of science/technology or even in arts. We can consider the data analytics as a trans-disciplinary subject which brings Data, technology, information, statistical/mathematical analysis and domain knowledge under a single umbrella. The success of current era can be defined as the amount of useful data the organization is creating or gathering and processing the same for getting fruitful insights using computational methods applying mathematical/statistical frameworks.

Despite being a leader in the implementation of IR 4.0, India still lacks the necessary human resources to meet the demands of industry, academia, or R&D. Since its founding, DUK has provided courses in cutting-edge machine learning, deep learning, and data analytics

technologies. If we want to sustain our country's development toward being the industry leader in information technology and achieve global leadership in the Industry 4.0 revolution, we must develop talented human resources in this field. The courses offered by the School of Digital Sciences are designed to develop skilled human resources capable of leading our country's digital transformation.

ACADEMICS

School of Digital Sciences offers MSc courses which are (1) M.Sc. in Computer Science with Specialization in data analytics, (2) MSc in data analytics & Computational Science, (3) MSc Data Analytics &BioAI, (4) M.Sc. in Computer Science with specialization in Geospatial Analytics and (5) M.Sc. in Data Analytics &Geoinformatics. All of these courses are created to meet the demands of the industry for middle level managers in the fields of data analytics, machine learning, geospatial analytics, and biosciences-related AI applications. Candidates after completion of the courses are expected to have

- ➢ In depth Knowledge in Data Analytics & Machine Learning
- ➢ Decent Knowledge of Statistics and Mathematics
- ➢ Deep knowledge of Python Programming and Database management systems
- ➢ Apply domain knowledge in analytics

In geospatial analytics/geoinformatics courses, the expected skill set after completion of the courses are

- ➢ Deep knowledge of EO Satellite Images
- ➢ Excellent Geospatial problem solving skills
- ➢ Deep knowledge in Python programming with Geospatial contexts
- ➢ Spatial statistics
- ➢ AI/ML in geospatial contexts

COURSE CATEGORIZATION

The courses offered by

- 100 Level - Undergraduate level introductory course
- 200 Level - Undergraduate level advanced course
- 300 Level- Postgraduate level instruction-based course
- 400 Level - Postgraduate level seminar/ research level course
- 500 Level - Research level course

Credit Requirements for Completing M.Sc.

Level of Course	Minimum Credit	Maximum Credit
100	0	6
200	3	18
300	30	50
400	9	18
500	0	9
Total Credits for Courses	**100**	

Semester 1: 30 Credits
Semester 2: 25 Credits
Semester 3: 25 Credits
Semester 4: 20 Credits
One credit: 15 hours of classroom education

Based on the details as mentioned above we define the
Program Educational Objectives (PEO) as

PEO1: Create globally competent data analytics/machine learning experts with leadership qualities and team spirit.

PEO2: Impart communication skills, and professional ethics to students

PEO3: Develop skills in computational problems solving abilities and R&D

PEO4: Engage in lifelong learning to keep pace with the emerging technology areas.

Program learning outcomes

PO1: Develop solid knowledge in the area of study.

PO2: Identify, formulate, and analyse problems reaching validated conclusions.

PO3: Design techniques to solve real life problems to meet the specified needs

PO4: Develop communication skills to address different levels of audience.

PO5: Practice ethical standards of professional conduct and research.

PO6: Acquire professional skills such as collaborative skills, ability to write grants, entrepreneurial skills, and write articles for scholarly journals if it is taught by faculty in the department.

PASS CRITERIA

The student shall obtain a minimum D grade in all core courses and C grade in the project. Minimum CGPA of **5** is required for the award of the master degree.

All challenge examination courses and MOOC courses will not be counted for CGPA computation. However, passing in such courses will enable them to be counted towards the total credits earned.

Students are required to comply with the following credit limits for successfully completing a master program. The students are allowed to take a maximum of 12 Credits through audit courses. The students are allowed to obtain a maximum of 12 Credits through challenge exams.

EXAMINATIONS

The meaning of examination is considered broad and includes all forms of formative and summative assessments including quizzes, projects, lab work, practical design, the product developed, creative arts, fieldwork, etc.

A student will get a fail grade if she/he fails to complete a summative or formative assessment. If a student getting a fail in a core course needs to repeat the same course as and when it is offered or an alternate course has to be fixed by the school in case the core course is not offered within the next 18 months.

Each course level would have a different type of examination, the responsibility of which is divided between the Controller of Examination, Dean or Course instructor as outlined below:

COURSE OUTLINE

The programme will consist of a set of core courses, electives, mini projects, Internship/Major project, lab courses as well as two university core courses.

First semester there will be four core theory courses, two lab courses and one domain specific core along with university core subjects. Second semester there will be three core theory courses, one lab course, a mini project (extending to summer) and two electives. During the third semester there will be two core courses, three electives, one lab course and a mini project. In fourth semester students are supposed to do an Internship or a major project in a reputed company/institute/research organization and submit a thesis.

Mini Projects

A student must complete one mini project during the second and third semesters, guided by a member of the university faculty, an industry professional, or the faculty or staff of another reputable institution. This facilitates the student to get familiarize with the latest research and development trends in the field. At the end of the semester the student is required to submit a report of the mini project and give an oral presentation of the mini project carried out by him/her. The project report and the oral presentation will be evaluated by a committee of the institute including the project guide. The project report and the oral presentation carry 25 marks each. There will not be any external evaluation for the mini projects.

Core Labs

A student is required to do lab courses as specified in the detailed syllabus.

Project/Internship

A student is required to do a project during Semester 4, independently under the guidance of any faculty member of the institute or as an internship project in an industry or any reputed academic/research institute. If a student is opting for an internship project in an industry or any other reputed academic/research institute, he/she is required to have an internal guide from the institute. The project/internship aims to provide the student an opportunity to participate and work in a major research/development activity. Typically, the industry internship helps the student to learn about work culture, business processes, technologies, marketing strategies, etc. At the end of the semester the student is required to submit a report of the project/internship and give an oral presentation of the project/internship carried out by him/her. The project report and the oral presentation will be evaluated by both an internal committee comprising of the faculty members of the institute including the project guide as well as an external committee constituted by the university. The project/internship carries 18 credits.

Audit courses : For completing the course, students should audit following non-credit courses either in 2nd or 3rd semester.

1. Avoiding Plagiarism
2. Technical Communication

The courses are designed at 100 to 500 levels. Details are given below

Course level	Remarks
100-300 Level	The controller of Examinations (COE) will be in charge of the conduct of the summative examination for 100-300 Level courses. There shall be at least two evaluations of the answer sheets, one of them

	should be a course instructor, and an external examiner from the school or outside, fixed by COE.
400 Level	The instructor and/or graduate studies committee of the school shall be in charge of the conduct of the summative examination for 400 Level courses. The valuation shall be conducted by a committee of two faculty members. The valuation shall be based on an open seminar and term report submitted by the student.
500 Level	The instructor and/or graduate studies committee of the school shall be in charge of the conduct of the formative examination for 500 Level courses. The valuation shall be conducted by a committee of two faculty members and an external examiner. The valuation shall be based on the open seminar and research output submitted by the student. It is expected that research output is having a quality suitable to be published in a journal or leading conference.

GRADE POINT CALCULATION

A letter grade system is used to evaluate individual items of work, according to the requirements of the University's Policies and Procedures. The university follows grade point system with a scale of 10 defined as:

Grade	**Percentage of Marks**	**Grade Points**	**Remarks**
S	95% and above	10	Outstanding
A+	90% to less than 95%	9	Excellent
A	80% to less than 90%	8	Very Good
B+	70% to less than 80%	7	Good
B	60% to less than 70%	6	Above Average
C	50% to less than 60%	5	Average
D	40% to less than 50%	4	Pass
E	30% to less than 40%	2	Low Pass
F	Below 30%	0	Fail

AB will be represented for Absent and its GP is considered as 0

"I" will represent incomplete

School of Digital Science is offering following regular MSc courses

1. **MSc.** in Computer Science with Specialization in Data Analytics
2. **MSc.** in Computer Science with Specialization in Geospatial Analytics
3. **MSc.** in Data Analytics & Computational Science
4. **MSc.** in Data Analytics & Geoinformatics
5. **MSc.** In Data Analytics & BioAI

The detailed semester-wise break of each courses is given below

1. **M.Sc. Computer Science with Specialization in Data Analytics**

Semester-wise Breakup of Courses for 2 years

COURSES FOR SEMESTER I

University Core	Digital Access Community Empowerment	One week	3 credits
	Digital Experience Lab	Full semester (hands-on lab)	4 credits
	Design Thinking and Innovation	Full semester	3 credits
Total Credits			**10 credits**

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical(P)	Credit	Level
1.	M1220121	Introduction to computer science	C	3	1	0	3	100
2.	M2220122	Introduction to Data Science	C	3	1	0	3	200
3.	M2220123	Programming with Python	C	3	1	0	3	200
4.	M2220124	Basic Statistics for data analytics	C	4	2	0	4	200

5.	M3220125	Introduction to Database Technology	C	3	1	0	3	300
6.	M2220126	Programming Lab I	C	0	0	4	2	200
7.	M2220127	DA Lab I	C	0	0	4	2	200
Total Credits							**20**	

COURSES FOR SEMESTER II

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial (T)	Practical (P)	Credit	Level
1.	M3220221	Predictive Analytics	C	4	1	0	4	300
2.	M3220222	Data Structures and Algorithm	C	4	1	0	4	300
3.	M3220223	Web Technologies	C	3	1	2	4	300
4.		Elective I	E	3	1	2	4	300
5.		Elective II	E	3	1	2	4	300
6.	M2220224	DA Lab II	C	0	0	4	2	200
7.	M3220225	Mini Project I	C	0	0	6	3	300
Total Credits							**25**	

Electives for Semester II:

M3221227Time series analysis and Sem Modeling

M3221228 Natural Language Processing and Information Retrieval

M3221229 Social Networks and Semantic Web

M3221230 Advanced Machine Learning

M3221231 Anomaly detection & Fraud Analytics

COURSES FOR SEMESTER III

Sl .No	Course ID	Course	Core / Elective	Lecture (L)	Tutorial (T)	Practical (P)	Credit	Level
1.	M3220321	Deep Learning &MLOps	C	2	1	4	4	300
2.	M3220322	Big Data Technologies & Cloud computing	C	2	1	4	4	300
3.	M3220323	Object Oriented Programming – Python	C	3	1	2	4	300
4.	M2220324	DA Lab III	C	0	0	4	2	200
5.	M3220325	Mini Project II	C	0	0	6	3	300
6.		Elective III	E	3	1	2	4	300
7.		Elective IV	E	3	1	2	4	300
Total Credits						25		

Electives for Semester III:

M3221326 Blockchain Technology
M3221327 Spatial Data Analytics
M3221328 Anomaly detection & Fraud Analytics
M3221329 Advanced Machine Learning

COURSES FOR SEMESTER IV

Sl. No	Course ID	Course	Core/ Elective	Credit	Marks
1.	M4220421	Project & Viva Voce	C	20	400

I. M.Sc. Computer Science with Specialization in Geospatial Analytics

Semester-wise Breakup of Courses for 2 years

COURSES FOR SEMESTER I

University Core	Digital Access Community Empowerment	One week	3 credits
	Digital Experience Lab	Full semester (hands-on lab)	4 credits
	Design Thinking and Innovation	Full semester	3 credits
Total Credits			**10 credits**

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical (P)	Credit	Level
1.	M1220121	Introduction to Computer Science	C	3	1	0	3	100
2.	M2220128	Geographic Information System	C	3	1	0	3	200
3.	M2220123	Programming with Python	C	3	1	0	3	200
4.	M2220124	Basic Statistics for data analytics	C	4	2	0	4	200
5.	M3220129	Remote Sensing for Earth Observation	C	3	1	0	3	300
6.	M2220126	Programming Lab I	C	0	0	4	2	200
7.	M2220130	GIS Lab I	C	0	0	4	2	200
	Total Credits					20		

COURSES FOR SEMESTER II

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial (T)	Practical (P)	Credit	Level
1.	M3220221	Predictive Analytics	C	4	1	0	4	300
2.	M3220232	Geospatial Modeling and Analysis	C	3	1	2	4	300
3.	M3220223	WebTechnologies	C	3	1	2	4	300
4.	M3220233	Advanced Image Analytics	C	3	1	2	4	300
5		Elective I	E	3	1	2	4	300
6	M2220234	GA Lab II	C	0	0	4	2	200
7	M3220225	Mini Project I	C	0	0	6	3	300
	Total Credits						25	

Electives for Semester II:

M3221235 Thermal and Hyperspectral remote sensing
M3221236 Microwave Remote Sensing
M3221237 Python for Geospatial Applications

COURSES FOR SEMESTER III

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial (T)	Practical (P)	Credit	Level
1.	M3220321	Deep Learning &MLOps	C	2	1	4	4	300
2.	M3220322	Big Data Technologies & Cloud computing	C	2	1	4	4	300
3.	M3220330	Spatial Big Data Analytics	C	3	1	2	4	300
4.	M2220331	GA Lab III **(SDA)**	C	0	0	4	2	200
5.	M3220325	Mini Project II	C	0	0	6	3	300
6.		Elective II	E	3	1	2	4	300
7.		Elective III	E	3	1	2	4	300
	Total						25	

Electives for Semester III:

M3221326 Blockchain Technology

M3221332 Web and Mobile GIS

M3221333 Topographic Data Analysis Techniques and Applications

M3221334 Geospatial Applications in Urban and Regional Planning

M3221335 Geospatial Applications in Agriculture

COURSES FOR SEMESTER IV

Sl.No	Course ID	Course	Core/ Elective	Credit	Level
1.	M4220421	Project & Viva Voce	C	20	400

III. M.Sc. Data Analytics and Computational Science

Semester-wise Breakup of Courses for 2 years

COURSES FOR SEMESTER I

University Core	Digital Access Community Empowerment	One week	3 credits
	Computer Systems	Full semester	4 credits
	Design Thinking and Innovation	Full semester	3 credits
Total Credits			**10 credits**

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical (P)	Credit	Level
1.	M3220131	Scientific Computing I	C	2	1	4	4	300
2.	M2220122	Introduction to Data Science	C	3	1	0	3	200
3.	M2220123	Programming with Python	C	3	1	0	3	200
4.	M2220124	Basic Statistics for data analytics	C	4	2	0	4	200
5.	M3220125	Introduction to Database Technologies	C	3	1	0	3	300
/6.	M2220126	Programming Lab I	C	0	0	4	2	200
7.	M2220127	DA Lab I	C	0	0	4	2	200
	Total Credits						20	

COURSES FOR SEMESTER II

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical (P)	Credit	Level
1.	M3220221	Predictive Analytics	C	4	1	0	4	300
2.	M3220222	Data Structure and Algorithm	C	4	1	0	4	300
3.	M3220238	Scientific Computing II	C	3	1	2	4	300
4.		Elective I	E	3	1	2	4	300
5.		Elective II	E	3	1	2	4	300
6.	M2220224	DA Lab II	C	0	0	4	2	200
7.	M32202225	Mini Project I	C	0	0	6	3	300
	Total Credits						25	

Electives for Semester II:

M3221229 Social Networks and Semantic Web
M3221226 Stochastic Modeling
M3221227 Time series analysis and Sem Modeling
M3221228 Natural Language Processing and Information Retrieval
M3221239 Computational Chemistry
M3220223 Web Technologies

COURSES FOR SEMESTER III

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical(P)	Credit	Level
1.	M3220321	Deep Learning &MLOps	C	2	1	4	4	300
2.	M3220322	Big Data Technologies & Cloud computing	C	2	1	4	4	300
3.	M3220323	Object Oriented Programming – Python	C	3	1	2	4	300
4.	M2220324	DA Lab III	C	0	0	4	2	200
5.	M3220325	Mini Project II	C	0	0	6	3	300
6.		Elective III	E	3	1	2	4	300
7.		Elective IV	E	3	1	2	4	300
	Total						25	

Electives for Semester III:

M3221327 Spatial Data Analytics
M3221328 Anomaly detection & Fraud Analytics
M3221336 Parallel and GPU computing
M3221329 Advanced Machine Learning

M3221337 Computer Aided Drug Design
M3221338 Computational Neuroscience

COURSES FOR SEMESTER IV

Sl. No	Course ID	Course	Core/ Elective	Credit	Marks
1.	M420421	Project & Viva Voce	C	20	400

IV. M.Sc. Data Analytics and BioAI

Semester-wise Breakup of Courses for 2 years

COURSES FOR SEMESTER I

University Core	Digital Access Community Empowerment	One week	3 credits
	Computer Systems	Full semester	4 credits
	Design Thinking and Innovation	Full semester	3 credits
Total Credits			**10 credits**

Sl. No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical (P)	Credit	Level
1.	M3220132	Molecular Biology	C	3	1	0	3	300
2.	M2220122	Introduction to Data Science	C	3	1	0	3	200
3.	M2220123	Programming with Python	C	3	1	0	3	200
4.	M2220124	Basic Statistics for data analytics	C	4	2	0	4	200
5.	M3220125	Introduction to Database Technology	C	3	1	0	3	300
6.	M2220126	Programming Lab I	C	0	0	4	2	200
7.	M2220127	DA Lab I	C	0	0	4	2	200
	Total Credits						20	

COURSES FOR SEMESTER II

Sl. No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical (P)	Credit	Level
1.	M3220221	Predictive Analytics	C	4	1	0	4	300
2.	M3220222	Data Structure and Algorithm	C	4	1	0	4	300
3	M3220240	Bioinformatics	E	3	1	2	4	300
4		Elective I	E	3	1	2	4	300
5		Elective II	E	3	1	2	4	300
6	M2220224	DA Lab II	C	0	0	4	2	200
7	M3220225	Mini Project I	C	0	0	6	3	300
	Total Credits						25	

Electives for Semester II:

M3221241 Healthcare Analytics – I
M3221227 Time series analysis and Sem Modeling
M3221239 Computational Chemistry
M3221228 Natural Language Processing and Information Retrieval
M3220223 Web Technologies

COURSES FOR SEMESTER III

Sl. No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical(P)	Credit	Level
1.	M3220321	Deep Learning &MLOps	C	2	1	4	4	300
2.	M3220322	Big Data Technologies & Cloud computing	C	2	1	4	4	300
3.	M3220323	Object Oriented Programming – Python	C	3	1	2	4	300
4.	M2220324	DA Lab III	C	0	0	4	2	200
5.	M3220325	Mini Project II	C	0	0	6	3	300
6.		Elective III	E	3	1	2	4	300
7.		Elective IV	E	3	1	2	4	300
		Total					25	

Electives for Semester III:
M3221339 Healthcare Analytics II
M3221328 Anomaly detection & Fraud Analytics
M3221337 Computer Aided Drug Design
M3221338 Computational Neuroscience

COURSES FOR SEMESTER IV

Sl. No	Course ID	Course	Core/ Elective	Credit	Marks
1.	M4220421	Project & Viva Voce	C	20	400

V. **M.Sc. Data analytics with Geoinformatics**

Semester-wise Breakup of Courses for 2 years

COURSES FOR SEMESTER I

University Core	Digital Access Community Empowerment	One week	3 credits
	Computer Systems	Full semester	4 credits
	Design Thinking and Innovation	Full semester	3 credits
Total Credits			**10 credits**

No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical (P)	Credit	Level
1.	M3220125	Introduction to database technologies	C	3	1	0	3	300
2.	M2220128	Geographic Information Systems	C	3	1	0	3	200
3.	M2220123	Programming with Python	C	3	1	0	3	200
4.	M2220124	Basic Statistics for data analytics	C	4	2	0	4	200
5.	M3220129	Remote Sensing for Earth Observation	C	3	1	0	3	300
7.	M2220126	Programming Lab I	C	0	0	4	2	200
8.	M2220130	GIS Lab I	C	0	0	4	2	200
	Total Credits						20	

COURSES FOR SEMESTER II

Sl. No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial(T)	Practical (P)	Credit	Level
1.	M3220221	Predictive Analytics	C	4	1	0	4	300
2.	M3220240	Spatial Statistics	C	4	1	0	4	300
3.	M3220232	Geospatial Modeling and Analysis	C	3	1	2	4	300
4.	M3220233	Advanced Image Analytics	C	3	1	2	4	300
5		Elective I	E	3	1	2	4	300
6	M2220234	GA Lab II (Image Analytics)	C	0	0	4	2	200
7	M3220225	Mini Project I	C	0	0	6	3	300
	Total						25	

Electives for Semester II:

M3221236 Microwave Remote Sensing
M3221237 Python for Geospatial Applications
M3221235 Thermal and Hyperspectral Remote Sensing

COURSES FOR SEMESTER III

Sl. No	Course ID	Course	Core/ Elective	Lecture (L)	Tutorial (T)	Practical (P)	Credit	Level
1.	M3220340	Geospatial Applications for Environment and Climate Change	C	3	1	2	4	300
2.	M3220341	Geospatial Applications for Hydrological Modeling	C	3	1	2	4	300
5.	M3220330	Spatial Big Data Analytics	C	3	1	2	4	300
3.	M2220331	GA Lab III (Spatial Data Analytics)	C	0	0	4	2	200
4.	M3220325	Mini Project II	C	0	0	6	3	300
6.		Elective III	E	3	1	2	4	300
7.		Elective IV	E	3	1	2	4	300
	Total						25	

Electives for Semester III:

M3221333 Topographic Data Analysis Techniques and Applications
M3221332 Web and Mobile GIS
M3221334 Geospatial Applications in Urban and Regional Planning
M3221335Geospatial Applications in Agriculture

COURSES FOR SEMESTER IV

Sl. No	Course ID	Course	Core/ Elective	Credits	Level
1.	M4220421	Project & Viva Voce	C	20	400

***Apart from the courses listed above students may attend courses from other departments of the university/MOOC/online courses based on university norms**

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SYLLABUS

Semester I

Course Code	Course Name	L-T-P Credits	Level
M1220121	Introduction to Computer Science	3-1-0-**3**	100

Course Outcomes	
CO1	Examine the concepts of designing Arithmetic Logic Unit, control unit and the Booth's algorithm for multiplication, Restoring and non-restoring division Algorithms
CO2	Analyze the input-Output Organization of a computer, Modes of data transfer and Pipelining
CO3	Explain the concepts of Advanced Computer Architecture, Embedded OS and Distributed OS
CO4	Introduction to computer networks

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	1	2
CO2	2	1	1	2	1	2
CO3	2	1	1	2	1	2
CO4	2	1	1	2	1	2

Module	Content
1	Basic Structure of Computers: Computer Types, Functional UNIT, Basic Operational Concepts, Bus, Structures, Software, Performance, Multiprocessors and Multi Computers, Data Representation, Fixed Point Representation, Floating - Point Representation. Register Transfer Language and Micro Operations: Register Transfer Language, Register Transfer Bus and Memory Transfers, Arithmetic Micro Operations, Logic Micro Operations, Shift Micro Operations, Arithmetic Logic Shift Unit, Instruction Codes, Computer Registers Computer Instructions - Instruction Cycle. Memory - Reference Instructions, Input - Output and Interrupt, Instruction Formats, Addressing Modes, DATA Transfer and Manipulation, Program Control, Reduced Instruction Set Computer.
2	Micro Programmed Control: Control Memory, Address Sequencing, Micro program Examples, Design of Control Unit, Hard Wired Control, Micro programmed Control. The Memory System, Read-Only Memories, Cache Memories Performance Considerations, Virtual Memories secondary Storage, Introduction to RAID. Input-Output Organization: Peripheral Devices, I/O Interfaces, Asynchronous Data Transfer Modes, Priority Interrupt, Direct Memory Access, Input-Output Processor (IOP), Serial Communication, Interconnect (PCI) Bus, Introduction to Standard Serial Communication Protocols like RS232, USB, IEEE1394. Pipelining: Pipeline concept, Throughput, data hazard, Instruction hazard
3	Operating Systems Overview: Operating Systems Functions, Distributed Systems, Operating Systems Structures Operating System Services and Systems Calls, System Programs, Memory Management: Swapping, Contiguous Memory Allocation, Paging, Structure of the Page Table, Segmentation, Virtual Memory, Demand Paging, Page-Replacement Algorithms, Allocation of Frames, Thrashing Case Studies - UNIX,

	Linux, Windows Principles of Deadlock, Detection and Avoidance, Recovery from Deadlock. File system interface
4	Computer networks and Internet: The network edge: Client and server programmes, Access networks, Physical Media. The network core, network access, delay and loss, protocol layers and services, Application layer protocols, socket programming, content distribution

Text Books:

1. John L. Hennessy, David A. Patterson, Computer Architecture: A Quantitative Approach. Fifth Edition
2. John L. Hennessy, David A. Patterson Computer Organization and Design: The Hardware / Software Interface (Fifth Edition), Morgan Kaufmann
3. William Stallings, Operating System: Internals and Design Principles, Prentice Hall, 8th Edition
4. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, Operating System Concepts, John Wiley & Sons, Inc., 9th Edition
5. Trent Jaeger," Operating System Security", Morgan and Claypool, 2008

Course Code	Course Name	L-T-P credits	Level
M2220122	Introduction to Data Science	3-1-0-**3**	200

Course Outcomes	
CO1	Introducing data science
CO2	Data cleaning methods
CO3	Data Transformation and Discretization
CO4	Data Warehousing and Online Analytical Process

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	2	1	2
CO2	2	1	2	2	1	1
CO3	3	2	1	1	1	2
CO4	3	2	1	3		2

Module	Content
1	Unit 1: Introduction to Data Science, Data Science and It's applications, Building models, Data Science Project Life Cycle Bigdata: Introduction to bigdata, Hadoop, Hadoop architecture, Drawbacks of Hadoop, Apache Spark and it's applications

	Data Preparation: Data Exploration, Data Quality, Data types and conversion Problems with data and data cleaning methods, Data Integration: Entity identification Problem, Redundancy and correlation analysis
2	Data Quality: Data cleaning work flow, Outlier detection, Data Deduplication Major tasks in data cleaning, How to handle missing values, Noisy data etc., Rule based cleaning Data Integration: Entity identification Problem, Redundancy and correlation analysis, Data Reduction: Different types of reduction methods, Wavelet transform, PCA, Attribute subset selection, Parametric data reduction, Sampling techniques in data reduction, Data cube aggregation Data Transformation and Discretization: Data Normalization Techniques such as min-max normalization, log normalization etc. Data Transformation, Discretization by binning, histogram analysis, correlation analysis etc. Syntactic and Semantic Data Transformation
3	Data Visualization :Univariate visualizations: Histogram, Quartiles etc. Multivariate visualizations : Scatterplot, Bubble chart, Visualizing high dimensional data, Exploratory data Analytics Feature selection Feature selection and evaluation methods Feature selection framework, Stable feature selection, Sparsity based selection, multi-source feature selection, distributed, multi- view and multi-label feature selection, Pattern based feature generation
4	Data Warehousing and Online Analytical Process Data Warehouse and OLAP Technology : Data Warehouse, Multidimensional Data Model, Data Warehouse Architecture & Implementation, Usage of Data Warehousing Online Analytical Processing Data Cube Computation: Efficient Methods for Data Cube Computation, Discovery Driven exploration of data cubes, Attribute

	Oriented Induction for data characterization and its implementation Data Marts and Data Lakes

Text Books:

1. Data Mining: Concepts and Techniques, Third Edition, Micheline Kamber, Jian Pei , Morgan Kaufmann; 3rd edition (July 6, 2011)
2. Introduction to Data Mining – Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Pearson education. 2019
3. Feature Engineering and Selection, A Practical Approach for Predictive Models, Max Kuhn, KjellJohnso
4. Data Science Concepts and Practice, Second Edition, Vijay Kotu, Bala Deshpande
5. Morgan Kaufmann is an imprint of Elsevier
6. Data Mining: Concepts and Techniques, Third Edition, Micheline Kamber, Jian Pei , Morgan Kaufmann; 3rd edition (July 6, 2011)
7. Introduction to Data Mining – Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Pearson education. 2019

Course Code	Course Name	L-T-P - Credits	Level of course
M2220123	Programming with Python	3-1-0-**3**	200

Course Outcomes	
CO1	Introduce Binary Number system and Computational Problem solving methods
CO2	Introduction to Python
CO3	Writing functions in Python
CO4	Iterations, classes etc in Python

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	1	2
CO2	3	2	2	1	1	1
CO3	2	2	2	1	1	2
CO4	3	2	2	1	1	1

Course content	
Module	Content
1	Basics: The binary number system, Data encoding. Computational problem solving: Problem analysis, Program design, Program implementation, Program testing. Algorithms and flowcharts, Overview of programming languages. Python: Introduction, Installing and running Python programs. Data and expressions: Comment statements, Literals, Variables and identifiers, Keywords, Operators, Expressions and Data Types, Operator precedence and

	associativity, Type conversion.
2	Environment variables, Formatting numbers and strings, the format method. Control structures: Boolean expressions, One and multi-way selection, Iterative control, Nested loops, Indentation, break and continue statements. Collections: Range function, Lists, Tuple, Sets and Dictionaries – Creating, Accessing, Basic operations and Methods, Sorting and Copying. String operations.
3	Functions & modules: Defining and calling functions, Scope and lifetime, Local functions, Returning single and multiple values, Parameter passing, Namespaces, Keyword & default arguments, Optional parameters, Variable number of arguments, Passing collections to a function, Mapping functions in a dictionary, Closures, Lambda functions, Function redefinition. Object-oriented programming basics: Objects, abstraction, encapsulation, classes, the __init__() method. Modules, Packages, Standard Library modules. Graphics: Turtle Module, Drawing with colors, Drawing basic shapes using iterations, Creating bar charts.
4	Files: Types of files, Opening, Closing, Reading and Writing files. Exceptions: Catching and handling exceptions, multiple exceptions. Iterators, Text, Binary Handling: iteration protocol, iterable objects, Generators and Generator expressions, Data processing pipelines. Python & CGI; Python Interacting with databases, Database access, Multithreading.

Text Books:

1.. Jake Vander Plas ,Python Data Science Handbook – Essential Tools for Working with Data, O'Reilly Media,Inc, 2016

2. Zhang.Y. , An Introduction to Python and Computer Programming, Springer Publications, 2016

3. Wes McKinney, (2017) Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, 2nd Edition, O'Reilly Media.

4. Haslwanter, T.(2015) An Introduction to Statistics with Python, Springer

Course Code	Course Name	L-T-P - Credits	Level
M2220124	Basic Statistics for data analytics	4-2-0-**4**	200

Course Outcomes	
CO1	Relate various measures used in summary statistics
CO2	Apply the basic concepts of probability and statistical inference in given conditions.
CO3	Compare central value of two populations based on statistical test.
CO4	Compare variances among populations.

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	1	2
CO2	3	2	1	1	1	1
CO3	2	3	2	1	1	2
CO4	2	3	2	2		2

Course content	
Module	Content
1	Introduction to summary statistics- Central tendency, Percentiles and box plots, variance and standard deviations, Covariance and Pearson correlation coefficients, scatter plots
2	Probabilistic and statistical inferences, Different types - Classical, Frequency, Axiomatic, Conditional probability, Independence, Bayes' Theorem. Random variables, Probability Distributions, The binomial distributions, Poisson distributions, Probability distribution functions, The normal PDF, Parameter estimation and optimizations,
3	Inferences about population central value, level of significance of statistical test, Comparing two population central values, Independent samples and non- parametric samples
4	Inference about population variances, estimation test for comparing two population variances, comparing more than two populations: ANOVA, Non- parametric alternatives

Text Books:

1 Kenneth Rosen, Discrete Mathematics and its Applications, 6th edition, Tata McGraw Hill, New Delhi, 2007.

2. Lyman Ott, R. Lyman Ott, MichealLongnecker, An introduction to statistical methods and data analysis, 6thEdn, Cengage Learning, 2008

References:

1. G. W. Snedecor, and W.G.Cochran, *Statistical Methods*. Iowa State University Press, 1989.
2. D. J. Saville, and G. R. Wood, *Statistical Methods: The Geometric Approach*, Springer, New York, 1997.
3. Rudolf Jakob Freund, William J. Wilson, Statistical methods, Academic Press, 1997

Course Code	Course Name	L-T-P - Credits	Level
M3220125	Introduction to database technology	3-1-0-**3**	300

Course Outcomes	
CO1	Summarize the basic concepts and applications of Database Management System.
CO2	Design Entity – Relationship diagram and convert into corresponding logical schema.
CO3	Write SQL queries based on the given requirements
CO4	Overview of NoSQL, Distributed databases, NoSQL Data Models

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	1	1
CO2	2	2	3	1	1	2
CO3	2	3	2	1	1	1
CO4	2	3	2	1	1	2

Course content	
Module	Content
1	Introduction to Database Management Systems: Data, Information, Database, Transaction and its desired properties, File Server Model, Client Server Model DBMS Features, Components of DBMS
2	Data Modeling: Logical and Physical Data Models, E-R Modeling A detailed study, Record Based Models, Relational Model An overview, Relational Concepts, Tables, Keys, Constraints, Data Integrity and Constraints, Integrity Rules, Database Objects Schema and Non-schema, Normalization, Codds Rules.
3	Introduction to SQL: Introduction to SQL, SQL Features, SQL Operators, SQL Datatypes, SQL Parsing, Types of SQL Commands, Advanced Study of Structured Query Language, Querying Data from the database, Correlated Sub-queries, Joins, Hierarchical Queries, Bind Variables, Cursors, Functions, Stored Procedures.
4	Overview of NoSQL, Architectures for parallel databases, Parallelizing individual operations Distributed databases, NoSQL Data Models, Key-Value and Document Data Models, Column-Family Stores, Graph databases, Challenges in NoSQL approach, ElasticSearch database and Data Analytics with Kibana

Text Books:

1. Database Management System, MonelliAyyavaraiah, ArepalliGopi, Horizon Books,2017
2. SQL & NoSQL Databases: Models, Languages, Consistency Options and Architectures for Big Data Management, Andreas Meier, Michael Kaufmann, Springer, 2019
3. Abraham Silberschatz; Henry F Korth, Database System Concepts, McGraw Hill Publication, 2002
4. Hellerstein, Joseph, and Michael Stonebraker. Readings in

Database Systems (The Red Book). 4th ed. MIT Press, 2005.
5. Raghu, and Johannes Gehrke. Database Management Systems. 3rd ed. McGraw- Hill, 2002.

References:

1. Stefano Ceri; Giuseppe Pelagatti, Distributed Databases: Principles and Systems, Universities Press, 2000
2. Jan L Harrington, Object Oriented Database Design Clearly Explained, Harcourt, 2000
3. Elmasri,Ramez; Navathe, Shamkant B, Fundamentals of Database Systems, Pearson, 2000

Course Code	Course Name	L-T-P - Credits	Level
M2220126	Programming Lab I	0 – 0 -4-2	200

Course Outcomes	
CO1	Deploying Python for data analysis
CO2	Apply basic programming skills on Data acquisition and transformation
CO3	Implement functions
CO4	Apply programming skills in doing graphics & Develop the ability of effective communication, practical skill and document design.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	2	2
CO2	1	2	3	3	1	
CO3	2	3	2	1		
CO4	2	1	3	2		

List of exercises/Lab programs:

- Overview of Python
- Installing and maintaining Python
- Programming Language Basics
- Managing files and workspace – Python
- Controlling functions (procedures or commands) using arguments (options or Parameters) or an object's class; how to change class
- Data Acquisition – reading comma- and tab-delimited files in Python
- Data Transformations – modifying existing variables and creating new ones
- Selecting variables and observations – Python

- Writing functions (macros)
- Graphics
- Traditional graphics : including bar, scatter, strop, box plots, histograms, plotting groups, adding embellishments and regression fits.

Text Books:

1. Lyman Ott, R. Lyman Ott, MichealLongnecker, An introduction to statistical methods and data analysis, 6th Edn, Cengage Learning, 2008

References :

1. G. W. Snedecor, and W.G.Cochran, Statistical Methods. Iowa State University Press, 1989

Course Code	Course Name	L-T-P - Credits	Level
M2220127	Data Analytics Lab I	0-0-4-**2**	200

Course Outcomes	
CO1	Deploying Python for data analysis
CO2	Apply basic programming skills on Data acquisition and transformation
CO3	Data Summarization
CO4	Develop the ability of effective communication, practical skill and document design.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2			1	3
CO2	2	2		2	1	
CO3	2	2		3	1	
CO4	2	3		1	2	

List of exercises/Lab programs:

1. EDA with Python
2. Central tendency and Computation of Z & t score with python
3. Gaussian Distributions
4. PDF functions using python
5. Summarization using Pivot tables
6. Hypothesis testing using python
7. Visualization using Python – Basic charts

Text Books:

1. Charles Dierbach, “Introduction to Computer Science Using Python: A Computational Problem-Solving Focus”, Wiley, 2017.

2. Ashok NamdevKamthane, Amit Ashok Kamthane, “Programming and Problem Solving with Python”, McGraw Hill Education, 2018

References :

1. ReemaThareja, “Python Programming using Problem Solving Approach”, Oxford Higher Education, 2017.
2. Bradley N. Miller, David L. Ranum Problem Solving with Algorithms and Data Structures Using Python, Franklin, Beedle& Associates, 2011.

Course code	Course name	L-T-P-C	Level
M2220128	Geographical Information System	3-1-0-3	200

Course outcomes	
CO1	Understanding the relevance of spatial cognition/information and spatial processes
CO2	Understanding the fundamentals of Geographic Information System
CO3	Introducing spatial data editing and data management techniques
CO4	Integrating and applying the concepts of various spatial modelling techniques

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	2	1	1
CO 2	3	3	3	2	2	2
CO 3	2	3	3	2	2	1
CO 4	3	3	3	2	2	2

Module	Content
1	Introduction to GIS: nature and scope of GIS, components of GIS, proprietary and open-source software, spatial data sources, spatial data types and formats. Applications of GIS.

2	Modelling real world: Geodesy - shape and size of the earth, ellipsoid, geoid, datum, projections, coordinate reference systems. Spatial data models - vector and raster data models, Spatial and attribute data modelling, projections and transformation.
3	Data creation and management: Input, editing and management of spatial data, encoding methods, conventional data storage methods, concepts of databases - Geo-database, RDBMS, comparison of various storage methods. Spatial and tabular query.
4	Introduction to geoprocessing: Overlay analysis, proximity analysis, neighbourhood analysis. Terrain analysis, spatial interpolation, surface analysis. Spatial data visualization.

Textbooks:

1. Kang-tsung Chang, Introduction to Geographic Information Systems 9th Edition, ISBN10: 1259929647, 2019.
2. Burrough P A, McDonnell Principles of Geographical Information systems, 3rd edit London: Oxford University Press, 2016.

Course Code	Course Name	L-T-P Credits	Level
M3220129	Remote Sensing for Earth Observation	3-1-0-3	300

Course Outcomes	
CO1	Understand Various techniques and types of Remote sensing for earth observation
CO2	Gain knowledge of various Remote sensing techniques
CO3	Apply knowledge acquired in real world contexts
CO4	Discuss the modern relevance of UAV Remote sensing

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	1	1
CO2	2	1	1	1	1	1
CO3	3	2	2	2	1	1
CO4	3	1	1	1	2	1

Module	Content
1	Introduction to Remote Sensing – Remote sensing process – Physics of Remote Sensing: Electro Magnetic Radiation, EMR Theory – Energy sources and Radiation principles – Energy interaction in the atmosphere: Scattering, Absorption – Atmospheric windows – Energy interaction with earth surface features: Spectral reflectance of earth surface feature types – Spectral reflectance patterns for different regions of EMR - Spectral response patterns – Atmospheric and Geometric influence on spectral response pattern
2	Earth observation systems – Platforms – Orbits – Sensors – Concept of Resolution: Spatial, Spectral, Radiometric and Temporal – Multispectral Scanning – Characteristic of Earth Observation satellites: IRS, Landsat, Sentinel – Elements of Visual Image Interpretation – Visual Data interpretation keys
3	Types of Remote Sensing System: Based on Energy sources and Range of EMS – Characteristics of Optical, Thermal and Microwave and Hyperspectral Remote Sensing
4	Introduction to UAV: UAV Remote Sensing – Payload and Onboard Sensors - Mission Planning – UAV Image Processing - Orthophoto, DSM/ DEM and 3D Point Cloud Generation - UAV Applications; Introduction to GEE: Platform – Code editor – Datasets and case studies

Text Books:

1. Lillesand, T., Kiefer, R. W., &Chipman, J. (2015). Remote sensing and image interpretation. John Wiley & Sons.
2. Campbell, J. B., & Wynne, R. H. (2011). Introduction to remote sensing. Guilford Press.
3. Thenkabail, P. S. (2016). Remote Sensing Handbook; Volume 1: Remotely Sensed Data Characterization, Classification, and Accuracies. Taylor & Francis. Girard, C. (2018). Processing of remote sensing data. Routledge.

References:

1. Borengasser, M., Hungate, W. S., & Watkins, R. (2007). Hyperspectral remote sensing: principles and applications. CRC press.
2. Chang, C. I. (Ed.). (2007). Hyperspectral data exploitation: theory and applications. John Wiley & Sons.
3. Kuenzer, C., &Dech, S. (2013). Thermal infrared remote sensing. Remote Sensing and Digital Image Processing. doi, 10(1007), 978-94.

Woodhouse, I. H. (2017). Introduction to microwave remote sensing. CRC press.

Course Code	Course Name	L-T-P -Credits	Level
M2220120	GIS Lab I	0-0-4-2	200

Course Outcomes	
CO1	Spatial Data creation and Management
CO2	Spatial querying
CO3	Integration of spatial data
CO4	Spatial analysis & Visualization

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	2	1	1
CO2	2	2	2	2	1	1

CO3	2	2	2	2	1	1
CO4	1	2	1	2	1	1

List of Exercises

1. Creating, Editing and Managing layers : Point, Polyline and Polygon
2. Managing Projections and Datums
3. Symbolizing Layers
4. Managing Attribute Table, Calculating Geometry and Field Calculations
5. Spatial and Tabular Query
6. Join/Relate layers with external Database
7. Converting XY table data to GIS layer format
8. Overlay and Proximity Analysis
9. Neighborhood Analysis
10. Map Algebra
11. Surface Analysis
12. Cartographic Visualization

Text Books:

1. Heywood.L, Comelius.S and S. Carver An Introduction to Geographical Information Systems(4th edition), Prentice Hall, 2012
2. Burrough P A, McDonnell Principles of Geographical Information systems, London: Oxford University Press, 1998

References :

1. Lo.C.P., Yeung. K.W. Albert, Concepts And Techniques of Geographic Information Systems, Prentice- Hall of India Pvt ltd, New Delhi, 2002.
2. Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. Geographic Information Systems and Science. Wiley. 3rd edition, 2010

Course Code	Course Name	L-T-P - Credits	Level
M3220131	Scientific Computing I	2-1-4-**4**	300

Course Outcomes	
CO1	Introduction to scientific computing, Error in computing, Scientific models
CO2	Solutions of equations with one variable, Systems of equations
CO3	Eigen value problems
CO4	Curve fitting and approximations

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	1	1
CO2	2	2	3	1	1	2
CO3	2	3	2	1	1	1
CO4	2	3	2	1	1	2

Course content	
Module	Content
1	Introduction to scientific computing, it's applications. Number System and Errors Representation on integers and floating point numbers, Errors in computation, loss of significance. Scientific models for computation, Developing insights, Computational complexity

2	Solutions of Equations in one variable: Bisection Method, Newton Raphson Method, Fixed Point iteration, Error Analysis, Accelerating Convergence, Polynomial Evaluation – Horner's rule, Zeros of polynomials and Muller's Method, Systems of Linear Equations: Gaussian Elimination, Triangular decomposition, Pivoting strategies, Error analysis and Operations count, Ill-conditioning and condition number of system, Evaluation of determinants
3	Eigenvalue Computations : Diagonalization of system of ODE, Power Method, Gershgorin theorem, Jacobi's Method, Given's and Householder's methods for Tridiagonalization, Method of sturm sequences for tridiagonal matrix, Lanczos Method, QR Factorization
4	Curve fitting and Approximation : Lagrange's interpolation, Polynomial wiggle problem, Spline interpolation, Least Square Method – line and other curves, Orthogonal Polynomials, Tchebyshev interpolation, Fourier approximation and Fast Fourier, Transforms (FFT) algorithm.

Course Code	Course Name	L-T-P - Credits	Level
M3220132	Molecular Biology	3-1-0-**3**	300

Course Outcomes	
CO1	Introducing Molecular Biology, Structure of aminoacids and protiens
CO2	Different levels of structural organization of protiens, Enzyme structure and functions
CO3	Nucleic acids and it's role in life
CO4	RNA and it's functions

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	1	1
CO2	2	2	3	1	1	2
CO3	2	3	2	1	1	1
CO4	2	3	2	1	1	2

Course content	
Module	Content
1	Importance of Molecular Biology, Central Dogma of Molecular Biology, Model organisms for studying Molecular Biology.

	Amino acids: structure of twenty amino acids, classification, concept of zwitterionic structure, physical and chemical properties. Proteins: classification of proteins on the basis of composition, conformation and function
2	Different level of structural organization of proteins(primary, secondary, tertiary & quaternary), forces stabilizing protein structure and shape, physical and chemical properties, Role of weak forces in biology Enzymes: classification and nomenclature, Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, activation energy, and transition state, enzyme, activity, enzyme units specific activity, concept of active sites, Kinetics of enzyme catalysed reactions - Michaelis-Menten Equation.
3	Nucleic acid as the genetic material, Structure and functions of Nucleic acids: Nucleosides & Nucleotides, purines and pyrimidines. Biologically important nucleotides, Watson and Crick model of DNA structure, Genome and its organization, DNA Replication
4	RNA structure and tye of RNA, Transcription and Translation, Genetic code Gene regulation, Types of DNA damage, mechanism of DNA repair, Molecular basis of DNA mutation.

Text books:

1. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular

Biology of the Gene, 6th edition, Cold Spring Harbour Laboratory Press, Pearson Publication

2. U. Satyanarayana and U. Chakrapani, Biochemistry, Elsevier
3. Sharma, D.K. (2013) Biochemistry. Narosa Publishing House
4. Nelson D. L. and Cox M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company

Semester II

Course Code	Course Name	L-T-P - Credits	Level
M3220221	Predictive Analytics	4-1-0-4	300

Course Outcomes	
CO1	Analyze the relationship between variables using linear and multiple regression techniques.
CO2	Demonstrate various supervised learning approaches used for classification.
CO3	Compare different clustering algorithms used in data analytics.
CO4	Summarize ensemble methods used in predictive analysis.
Mapping of course outcomes with program outcomes	

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3		2	1	2
CO2	3	2		1	1	
CO3	3	2		2	1	
CO4	3	2		1	2	

Module	Content
1	Linear regression, the least square estimates, Multiple Regression, regression with categorical predictors, Bias – Variance Trade off Classification, KNN algorithm, Decision trees, Classification and regression trees, Decision rules, SVM, Neural network, Activation functions, Logistic regression, Naive Bayes Algorithm, Model evaluation techniques, Ensemble methods
2	Clustering, Hierarchical clustering, k-means clustering, Birch clustering, Measuring cluster goodness, Association rules, Affinity and Market Basket analysis
3	Reinforcement Learning: Introduction, Sequential Decision-Making, Markov Decision process, Value functions & Bellman Equation, Dynamic programming
4	Recommender Systems: Introduction to recommender systems, Collaborative filtering, Content based recommendation systems, Knowledge based RS, Hybrid approaches, Evaluation of RS

Text Books:

1. Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow: Concepts By AurélienGéron, "O'Reilly Media, Inc.", 2019
2. P.-N. Tang, M. Steinbach, and V. Kumar: Introduction to Data Mining, Addison Wesley, 2006
3. Jiawei Han and MichelineKamber, Data Mining: Concepts and Techniques, Morgan Kaufman Publishers, Third Edition, 2011.

References:

1.A Practical Approach for Machine Learning and Deep Learning Algorithms by Abhishek Kumar Pandey, Pramod Singh Rathore, S Balamurugan, BPB Publications, 2019

Course Code	Course Name	L-T-P credits	Level
M3220222	Data Structures And Algorithms	4-1-0-4	300

Course Outcomes	
CO1	Analyze a given algorithm and express its time and space complexities in asymptotic notations.
CO2	Summarize the operations and applications of abstract and concrete data structures.
CO3	Apply the concept of recursion and heap in problem solving.
CO4	Show data representation and manipulation using nonlinear data structures like trees and graphs.

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	1	1	2
CO2	2	2	2	1	1	1
CO3	3	3	2	1	1	2
CO4	2	3	1	1	2	1

Course content	
Module	Content

1	Introduction to ADT and Algorithms: Principles of DSA, data types, data structures, abstract data types, algorithm notion, time complexity, space complexity, asymptotic notations, analysis of algorithms, design of algorithms, data, procedural abstraction, worst case complexity, Big-Oh notation, incremental design, analysis of Python list and dictionary operations.
2	Stack and Queues: Introduction to stack, the stack abstract data type, basic operations, implementing a stack in Python, algorithm analysis of Python implementations of stack, computational problems relating to stack, parenthesis matching, base conversion, expression representation using Polish and reverse Polish notations, Evaluation of expression using stack, introduction to queues, the queue ADT, basic operations, Python implementation, computational problems related to queue.
3	Lists and Linked List: The unordered list ADT, linked list, linked list operations, doubly linked list, Python implementation, applications. Recursion: Closed form, recursive form, format of a recursive function, recursion vs. Iteration, problem solving, Fibonacci series, Towers of Hanoi, celebrity problem (with and without recursion), Efficiency of Recursion Algorithm. Searching: Sequential and binary search, hashing. Sorting: Selection, bubble, insertion and quick sorts.
4	Trees: Definitions, tree operations, binary tree, Python implementations, balanced binary tree, complete binary tree, traversal in a tree, balanced binary search tree, binary search tree, extended binary tree, height balanced trees, AVL trees, B-tree. Heap: Introduction to binary heap, max heap, min heap, min heap operations, representation, complexity. Graphs: Weighted graph, spanning tree, greedy method, Kruskal's algorithm, Prim's algorithm, traversal, DFS and BFS, shortest path, Dijkstra's algorithm.

Text Books:

1. Bradley N. Miller, David L. Ranum Problem Solving with Algorithms and Data Structures Using Python, Franklin, Beedle& Associates, 2011.

2. T.H. Cormen Introduction to algorithms, MIT Press. 2009

References:

1. A.D Aho, J. E. Hopcroft and J. D. Ullman, Data Structures and Algorithms, Pearson education Asia, 1983.
2. Y. Langsam, M. J. Augenstein and A. M. Tenenbaum, Data Structures using C, Pearson Education Asia, 2004
3. Adam Drozdek, Data Structures and Algorithms in Java, Published by Brooks/Cole, 2nd edition 2002

Course Code	Course Name	L-T-P - Credits	Level
M3220223	WEB TECHNOLOGIES	3-1-2-4	300

Course Outcomes	
CO1	Summarize transmission protocols and web server architecture
CO2	Utilize CSS to display HTML elements in Webpage
CO3	Develop web pages using java script
CO4	Summarize various design patterns used in software development

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	1	3
CO2	2	1	3	2	1	2
CO3	2	1	3	3	1	2
CO4	1	1	2	3	2	3

Module	Content
1	Characteristics of Modern Web Applications, HTML Responsive Web Design, HTML5 Elements, Attributes and elements, Type of Style sheets: Internal Style Sheet, Inline Style sheet, External Style Sheet, CSS3 Elements and features, CSS frameworks, Content delivery network, Selectors, XML Schema, Presenting XML Using XML Processors: DOM and SAX.

2	Introduction to Java Script, Object in JavaScript, Dynamic HTML with Java Script, JavaScript Object Notation, Data types, Arrays, Decisions and Loops, Functions and scope, JavaScript libraries, JavaScript Frameworks, ECMAScript, TypeScript, Single page applications (SPA), Basics of React Web Framework
3	Creational Design Patterns, Factory Pattern, Abstract Factory Pattern, Prototype pattern, Singleton Pattern, Builder Pattern, Dependency Injection pattern, The Web Services based on technologies such as SOAP, REST, WSDL, Django Framework: Architecture, MTV Architecture Pattern in Django Structure
4	Data Access with Django and Python, CRUD Operations with DJango, Models, Templates, Controllers, Sample Django MTV Web Application, REST API with Django - Advanced, Cache and Sessions with Django, Data Visualization Techniques for small and large data, Fundamentals of web application architecture (1Tier, 2-Tier,3-Tier, N Tier and MVC) and components, User interface app components, Structural components, Microservices, Monolithic vs. Microservices.

Text Books:

1. Jeffrey C. Jackson, Web Technologies - A Computer Science Perspective, Pearson Education - 2009.
2. Joseph B. Mille, Internet Technologies and Information Services, ABC-CLIO - 2014.
3. William S Vincent, Django for Professionals: Production websites with Python & Django Paperback, Import - 2019.

References:

1. Leon Shklar, Richard Rosen , Web Application Architecture - Principles, Protocols and Practices, Wiley - 2009
2. Laura Lemay, Rafe Colburn, Jennifer Kyrnin, Mastering HTML, CSS &Javascript Web Publishing Paperback 2016

Course Code	Course Name	L-T-P credits	Level
M3220238	Scientific computing II	3-1-2-4	300

Course Outcomes	
CO1	Optimization
CO2	Numerical solutions to differential equations
CO3	Stochastic methods and simulations
CO4	Modeling with ODE

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	1	1	2
CO2	2	2	2	1	1	1
CO3	3	3	2	1	1	2
CO4	2	3	1	1	2	1

Course Contents	
Module	Content
1	Optimization: Unconstrained optimization, The search direction, The line search, example algorithm, Constrained optimization, Global optimizations and heuristics: Simulated annealing, Genetic algorithm Numerical Optimization: Linear optimization - Simplex metod, Transportation problem Non-linear optimization: Golden ratio method, Conjugate method
2	Numerical solution to ordinary differential equations: Euler method, Ranga-Kutta methods, Quantifying error, Stiff Ordinary differential equations, Numerical Solutions to PDE, Parabolic equation, Hyperbolic equations
3	Stochastic method and simulation: Simulation, Numerical Integration, Simpson's rule, Monte Carlo Integration, Bootstrapping, Deterministic or stochastic approximation, Random models, Modelling with matrices, Signal processing and discreet Fourier transform, Computation of Aeronautic flow
4	Modelling with Ordinary differential equations: Couette flows, Pharmacokinetics, Modeling with delay differential equations and partial differential equations, Modelling with optimization and simulation: Stock pricing and portfolio selection, magnetic phase transitions, Regression modelling
	Text Books 1. Numerical Methods for Mathematics Science & Engineering. (Second Edition) John H. Mathews Prentice Hall of India. 2. Numerical Analysis (Seventh Edition) Burden and Faires Thomson Asia PTE. LTD 3. Numerical Analysis- A practical Approach Maron Mc Millan,1982

Course Code	Course Name	L-T-P - Credits	Level
M3221336	Parallel and GPU Computing	3-1-2-4	300

Course Outcomes	
CO1	HPC introduction
CO2	Open MPI
CO3	GPU architecture
CO4	Parallel programm execution

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	1	1	2
CO2	2	2	2	1	1	1
CO3	3	3	2	1	1	2
CO4	2	3	1	1	2	1

Course Contents	
Modules	Contents
1	HPC Introduction, Architecture of a supercomputer and the performance comparisons. Flynn's taxonomy, vector and pipelining, Single instruction, Multiple data array, Multiprocessors: Shared – Memory processors, Massively parallel processors, Heterogeneous computer Structures. Importance of HPC Benchmark, Resource management in HPC, Amdahl's law, Processor Core Architecture, Memory hierarchy
2	OpenMP programming model: Thread parallelism, Thread variables, Synchronization, Reduction, Message-Passing Interface (MPI) MPI standards, Communicators, Point-to Point messages, Synchronization collectives, Parallel Algorithms: Fork-Join, Divide-Conquer, Manager-Worker, Embarrassingly parallel Importance of Checkpointing in HPC
3	GPU Architecture, CPU / GPU comparisons, CUDA Standard, Kernels and host-device communication, shared and constant memory, CUDA OpenCL / OpenACC, Kernels Launch parameters, GPU coding restrictions
4	Program Execution Time: Flow of time, process scheduling, measuring time by interval counting operation, reading the processor timers, accuracy of processor timers, program execution time with cycle counter. Concurrent programming with processes, Concurrent program with Threads
Text Books High Performance Computing: Modern Systems and Practices Thomas Sterling, MaciejBrodowicz, Matthew Anderson · 2017 Michael J Quinn, "Parallel programming in C with MPI and OpenMP", Tata McGraw Hill, 2003. 2. Kaihwang and NareshJotwani, "Advanced Computer Architecture " 2nd edition Tata Mcgraw- Hill	

Course Code	Course Name	L-T-P - Credits	Level
M3220240	Bioinformatics	3-1-2-4	300

Course Outcomes	
CO1	Introduction to Bioinformatics and databases
CO2	Genomics and Protioemics
CO3	Functional Genomics
CO4	Protieomics

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	3	1	3
CO2	2	1	3	2	1	2
CO3	2	1	3	3	1	2
CO4	1	1	2	3	2	3

Module	Content
1	Introduction to Bioinformatics, the cell as basic unit of life-Prokaryotic cell and Eukaryotic cell - Central Dogma: DNA-RNA-Protein, Introduction to DNA and Protein sequencing, Human Genome Project, Applications of Bioinformatics Bioinformatics databases - Nucleotide sequence databases, Primary

	nucleotide sequence databases-EMBL, GeneBank, DDBJ; Secondary nucleotide sequence databases; Protein databases- UniProt, Protein Data Bank
2	Genomics and Proteomics: Genome Mapping, DNA Sequencing method, Open Reading frame, Determining sequence of a clone Sequence Analysis-Basic concepts, Alignment of pairs of sequence:- Homologous, Analogue, Orthologous, paralogous, Xenologous (Need for sequence alignment, Local and Global Aalignment, Scoring matrices- PAM and BLOSUM matrices
3	Functional genomics and concepts Pairwise sequence alignments: BLAST, Multiple sequence alignments (MSA) BLAST:- Nucleotide BLAST, Protein BLAST, PSI-BLAST, Analysis of BLAST results, E Value, sensitivity and specificity of BLAST, FASTA Structure analysis tools and softwares
4	Introduction to proteomics, Proteome and proteomics, Protein isolation methods, Branches of proteomics, protien sequencing methods Phosphoproteomics and Glycoproteomics.

Text Books

1. P. Narayanan, Bioinformatics: A Primer, New Age International Publishers.
2. Harshawardhan P. Bal, Bioinformatics Principles and Applications, Tata McGraw-Hill
Publishing Company Ltd.

Additional References

1. Marketa Zvelebil and Jeremy O. Baum, Understanding Bioinformatics, Garland Science
2. Rastogiet. al., Bioinformatics: Methods and Applications, Prentice Hall of India.
3. Dan E. Krane and Michael L. Raymer, Fundamental Concepts of Bioinformatics, Pearson
Education.
4. Claverie&Notredame, Bioinformatics - A Beginners Guide, Wiley-Dreamtech India Pvt Ltd

Course Code	Course Name	L-T-P -Credits	Level
M3221228	Natural Language Processing & IR	3-1-2-4	300

Course Outcomes	
CO1	Introducing NLP
CO2	Concepts on Language Modeling
CO3	Information retrieval - Introduction
CO4	Retrievall models

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	1	3
CO2	2	2	3	2	1	2
CO3	3	1	3	2	1	2
CO4	2	2	3	2	2	3

	Course contents
Module	Content
1	Introduction to NLP, Knowledge Acquisition, Regular expression (RE) and Text Processing, Word Tokenization, Word Normalization and Word Stemming, Sentence Segmentation, Edit Distance, Word Alignment Problem and Statistical Machine Translation (MT)

2	Text Classification and Sentiment Analysis, Naïve Bayes Classifier, Precision, Recall and the F measure, Text Classification, Evaluation, Sentiment Analysis - Baseline Algorithm Learning Sentiment Lexicons and Discriminative Classifier - Maximum Entropy Classifier, Generative vs. Discriminative Model Making features from text, Feature-based Linear Classifier, Problem of Over counting evidence, Named Entity Recognition (NER) and Maximum Entropy Sequence Model
3	Introduction to Information Retrieval - Relevance of Information retrieval, The nature of the unstructured and semi-structured text, traditional IR mechanisms - Inverted index and Boolean queries, applications of IR, components of an IR System
4	Retrieval Models - Boolean, vector space, TF-IDF, probabilistic, language modeling, matrix decompositions, and latent semantic indexing, vector space scoring, cosine measure, Efficiency considerations, Document length normalization, Relevance feedback, and query expansion. IR performance and evaluation

Text Books:

1. Grady Booch, James Rambaugh, Ivar Jacobson, The United Modeling Language User Guide- Published by Addison-Wesley, 2005
2. James Rambaughet. al., Object Modeling and Design Prentice Hall,1991
3. Meilier Page Jones, Fundamentals of Object Oriented Design in UML, Pearson Education, Asia, 2002

References

1. Ivar Jacobson, The Road to the Unified Software Development Process, Cambridge University Press, 2000

Course Code	Course Name	L-T-P - Credits	Level
M3221229	Social Networks and Semantic Web	3-1-2-4	300

Course Outcome	
CO1	Introduction to semantics web
CO2	Ontology and it’s role in semantic web
CO3	Introduction to social network
CO4	Detecting communities in web

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	1	1	2
CO2	2	2	2	2	1	2
CO3	3	2	2	2	1	2
CO4	2	1	1	2	1	2

Course Contents

Module	Contents
1	Introduction to Semantic Web, Importance of semantic web, Technology adoption Introduction to Social Network, Key concepts, Development of SNA, Global structure of networks, The macro-structure of social networks, Personal Networks
2	Ontology and their role in the Semantic Web: Ontology-based knowledge Representation -Ontology languages for the Semantic Web: Resource Description Framework, Modelling and aggregating social network data: State-of-the-art in network data representation – Ontological

	representation of social individuals – Ontological representation of social relationships – Aggregating and reasoning with social network data – Advanced representations.
3	Modeling and aggregating social network data: Network based data representation, ontological representation of social individuals, aggregating and reasoning with social networks Developing social-semantic applications, Building semantic web applications with social network features
4	Extracting evolution of Web Community from a Series of Web Archive – Detecting communities in social networks – Definition of community – Evaluating communities – Methods for community detection and mining – Applications of community mining algorithms – Tools for detecting communities social network infrastructures and communities – Decentralized online social networks – Multi-Relational characterization of dynamic social network communities.

Text Books

1. Social Network Analysis for Startups, by Maksim Tsvetovat, Alexander Kouznetsov
Released September 2011, Publisher(s): O'Reilly Media, Inc.
2. Understanding Social Networks: Theories, Concepts, and Findings by Charles Kadushin Oxford University Press, USA, published 2011

References

1. Social Network Analysis: A Handbook by John P. Scott, 2000, Sage Publications Ltd

Course Code	Course Name	L-T-P –Credits	Level
M3221226	Stochastic Modelling	3-1-2-4	300

Course Outcome	
CO1:	Introduction to stochastic Modeling
CO2:	Understand the foundations of modern stochastic models theory, problem and state of the art solutions.
CO3:	Analyze and evaluate critically the building and integration of stochastic models algorithms and systems.
CO4:	Design and demonstrate a working stochastic models system through team research project, and project report, presentation.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	2
CO2	3	2	1	1	1	2
CO3	3	2	2	1	1	2
CO4	3	2	1	1	1	2

Module	Contents
1	Introduction to stochastic process: Difference between deterministic & Stochastic process, Different types of stochastic functions, Trajectories and finite-dimensional distributions Renewal process, Convolutions, Laplace transform, Limit theorems for renewal processes

2	Advanced forecasting using Bayesian diffusion modeling: Bayesian belief networks, Representation, Independence and conditional independence, Partial independence and other structure. Exact inference in BBN
3	Approximate inference: Monte Carlo approximations, Loopy belief propagation, Variational methods. Learning of BBNs: learning parameters, learning structure, Bayesian averaging, EM (learning with hidden variables and missing values), structural EM
4	Dynamic belief networks: Particle filtering. Markov random fields (Markov networks):Representation (potentials), Independence and conditional independence, Trees, Boltzman machines, Conditional Markov random fields. Inference in Markov networks. Learning Markov networks: Iterative proportional fitting, Cluster variational methods, Relational graphical models

Text Books:

1. Hsu HP. Theory and problems of probability, random variables, and random processes. New York: McGraw-Hill; May 2014.
2. Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, Third
Edition, Prentice-Hall, 2008.
3. Koller D. and Friedman, N., Probabilistic Graphical Models: Principles and Techniques , The
MIT Press (2009).
4.Barber, D., Bayesian Reasoning and Machine Learning , Cambridge Univ. Press (2012).

References:

1. Feller W. An introduction to probability theory and its applications. John Wiley & Sons; 2008.
2. A. Papoulis, Probability, Random Variables, and Stochastic Processes, Mc-Graw Hill, 2005.
3. David J.C. Mackay. Information theory, inference, and learning algorithms. Cambridge, UK:Cambridge University Press.
4. Judea Pearl. Probabilistic Reasoning in Intelligent Systems. Morgan Kaufman.

Course Code	Course Name	L-T-P - Credits	Level
M3221227	Time Series Analysis and SEM Modeling	3-1-2-4	300

Course Outcome	
CO1	Introduction to time series
CO2	ARIMA model discussion
CO3	State-space model
CO4	Structural Equation Models

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	1
CO2	2	3	1	2	1	1
CO3	2	2	1	1	1	1
CO4	3	3	2	2	2	1

Course Contents

Module	Contents
1	Characteristics of Time Series, The Nature of Time Series Data, Time Series Statistical Models, Measures of Dependence: Autocorrelation and Cross-Correlation, Stationary Time Series, Estimation of Correlation
2	ARIMA Models, Introduction, Autoregressive Moving Average Models

	, Autocorrelation and Partial Autocorrelation Functions , Forecasting , Estimation , Building ARIMA Models Multiplicative Seasonal ARIMA Models
3	State-Space Model, Introduction, Filtering, Smoothing, and Forecasting, Maximum Likelihood Estimation, Structural Models: Signal Extraction and Forecasting, ARMAX Models in State-Space Form
4	Structural equation models: The basics, Latent versus observed variables, Exogenous versus endogenous latent variables, The factor analytic model, The general structural equation model, The formulation of covariance and mean structures

Text Books

1. Robert H. Shumway, David S. Stoffer, Time Series Analysis and Its Applications With R Examples, Springer, 2014
2. Subba Rao, CalyampudiRadhakrishna Rao, Time Series Analysis: Methods and Applications, . Elsevier, 2012

References:

1. Brockwell P.J and Davis R.A. (2002) Introduction to Time Series and Forecasting Second edition, Springer-Verlag.
2. Ruey S. Tsay (2005). Analysis of Financial Time Series, Second Ed. Wiley & Sons

Course Code	Course Name	L-T-P - Credits	Level
M3221230 / M3221329	Advanced Machine Learning	3-1-2-4	300

Course Outcome						
CO1	Finding similar text items in big data					
CO2	Link Analysis					
CO3	ML in web advertisement					
CO4	Recommendation systems					
Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	1	2	1
CO2	2	1	1	2	1	1
CO3	2	2	1	2	1	1
CO4	3	3	2	2	2	1
Course Contents						
Module	Contents					
1	Finding similar text items: Shingling of Documents, Similarity preserving summaries of sets - Minhashing and signatures, Locality Sensitive Hashing of Documents, Distance measures, Locality sensitive functions					

2	Link Analysis: Page Rank, Computation of PageRank, Google PageRank Algorithm, Topic Sensitive PageRank, Link Spam, HITS algorithm, Mining of Frequent item sets
3	Advertising on the Web: On-Line algorithm, The matching problem, Adwords and it's implementation, Mining of social network graphs, Social network as graph clustering of social network graphs, Discovery of communities, Partitioning of graphs, SimRank, Neighbourhood properties of graphs
4	Recommender Systems: Introduction to recommender systems, Collaborative filtering, Content based recommendation systems, Knowledge based RS, Hybrid approaches, Evaluation of RS

Text Books:

1. AnandRajaraman, Jeffrey D Ullman. Mining of Massive Datasets, Cambridge University Press 2010.

2. Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press(2011), 1st ed

Course Code	Course Name	L-T-P - Credits	Level
M3221231/ M3221328	Anomaly detection & Fraud Analytics	3-1-2-4	300
Course Outcome			

CO1	Anomaly detection - Introduction and different types
CO2	Rank based anomaly detection
CO3	Fraud analytics - Introduction
CO4	Fraud analytics - ML techniques

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	1
CO2	2	3	1	2	1	1
CO3	2	2	1	1	1	1
CO4	3	3	2	2	2	1

Course Contents

Module	Contents
1	Anomaly Introduction, Anomaly in different domains such as Finance, Healthcare, Defence& Internal security, Manufacturing and Industry, Shape of Anomaly detection Different types of anomalies, Outliers in data Distance based Anomaly detection, Similarity measures, Distance to all

	points, Distance to nearest Neighbour Local Correlation Integral (LOCI) Algorithm, Nearest Neighbor Approach, Density Based Approaches
2	Rank based Detection Algorithms: Anomaly detection algorithms based on clustering and weighted ranks, Model based anomaly detection: Models of relationships between variables, Distribution models, time varying process Ensemble methods: Independent methods, Sequential application of alogirthms, Ensemble anomaly detection with adaptive sampling, Weighted adaptive sampling Anomaly detection in Time series: Abnormal subsequence detection, Outlier detection based on multiple measures, Online anomaly detection for time series
3	Fruad analytics : Introduction & Importance, Statistical fraud assessment, Types of fraud, Fraud data and pre-processing methods
4	Fruad analytics: Visualization, Outlier detection, Clustering, Predictive Fraud Analytics: Classification, Regression; Model Evaluation Case Study and Overview: Fraud analytics applications

Text Books

1. Anomaly Detection Principles and Algorithms Kishan G. Mehrotra, Chilukuri K. Mohan, HuaMing Huang · 2017
2. Practical Machine Learning: A New Look at Anomaly DetectionTed Dunning, Ellen Friedman · 2014
3. Anomaly Detection: Techniques and Applications, SairaBanu · 2021 ond Ed. Wiley & Sons
4. Fraud Analytics Using Descriptive, Predictive, and Social Network Techniques: A Guide to Data Science for Fraud Detection, Bart Baesens, Veronique Van Vlasselaer, WouterVerbeke Wiley, 2015
5. Profit Driven Business Analytics: A Practitioner's Guide to Transforming Big Data into Added Value (Wiley and SAS Business Series) Wouter Verbeke (Author), Bart Baesens (Author), Cristian Bravo (Author)

Course Code	Course Name	L-T-P - Credits	Level
M3221239	Computational Chemistry	3-1-2-4	300

Course Outcome						
CO1	Quantum mechanics basics					
CO2	Computational chemistry introduction					
CO3	Abinitio methods					
CO4	Molecular Mechanics					
Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	1
CO2	2	3	1	2	1	1
CO3	2	2	1	1	1	1
CO4	3	3	2	2	2	1
Course Contents						
Module	Contents					
1	Basic concepts from quantum mechanics: Schrodinger Equation, Quantum mechanics applied to simple problems such as particle in a 1D box, harmonic oscillator, rigid rotor, hydrogen atom solutions, multi-electron systems.					
2	Introduction to computational chemistry: Potential energy surface-stationary point, saddle point or transition state, energy minimization , Basis functions-Slater type orbitals (STO) and Gaussian type orbitals					

	(GTO). Hartree-Fock Theory and Basis Sets, Basis sets: minimal, split valence, polarized and diffuse basis sets, contracted basis sets, Pople's style basis sets and their nomenclature, Effective core potentials (ECP).
3	Ab initio and semi-empirical methods (as AM1, PM3, MNDO etc), Hückel method, SCF theory, Density Functional theory (DFT), Møller-Plesset (MP) methods, hybrid and double hybrid methods.
4	Molecular Mechanics, Force Field, Parameters and other problems with Molecular Mechanics, Molecular Dynamics, Simulated Annealing, Monte Carlo Simulations.

Text Books

1. Frank Jensen, Introduction to Computational Chemistry, Wiley
2. Christopher J. Cramer, Essentials of Computational Chemistry: Theories and Models, wiley

Course Code	Course Name	L-T-P - Credits	Level
M3221241	Healthcare Analytics - I	2-2-4-4	300

Course Outcome						
CO1	Medical data types & cleaning					
CO2	Electronic health records - Description and EDA					
CO3	Medical Imaging data analytics					
CO4	Sensor data analytics					
Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	1	2
CO2	3	2	2	1	1	1
CO3	2	2	2	1	1	2
CO4	3	2	2	1	1	1
Course Contents						
Module	Contents					
1	Medical data formats: Digital Imaging and Communications in Medicine, Analyse, N1fT1, MINC, Medical data formats for signals : European Data Format, BioSemi Data format, General Data Format Data Augmentation, Generation and Labelling, Statistical Data cleaning Approaches, Data Normalization Feature extraction, Texture feature extraction, Shape feature extraction, Feature normalization					
2	Electronic Health records, Different Components of EHR Coding Systems such as International classification of diseases,					

	Systematized Nomenclature of Medicine Clinical Terms,International Classification of Functioning, Disability, and Health, Diagnosis-Related Groups, Unified Medical Language System, Digital Imaging and Communications in Medicine Objectives of secondary analysis of electronic healt record data, EDA, Analytics using Medical Information Mart for Intensive care - Trend Analysis, Mortality prediction in ICU
3	Analytics on Medical Imaging data: Applications in Radiography, Nuclear Medicine,Positron Emission Tomography (PET), Elastography, Photoacoustic Imaging, Tomography. Magnetic Resonance Imaging (MRI), Ultrasound Imaging Techniques Medical Image Enhancement, Basics of Histogram , Medical Image De-noising , Spatial Filtering, Non- data Adaptive Transform, Data-Adaptive Transforms, Segmentation
4	Analytics of Sensor Data in Healthcare: Taxonomy of Sensors Used in Medical Informatics, Sensor Data Mining Applications, Chronic Disease and Wellness Management, Activity monitoring, Behavioural Modification using ML, Biomedical signal analysis, Different types of Biomedical signals, Denoising signals using PCA, Wavelet filtering, Multivariate Biomedical signal analysis, Cross-correlation analysis

Text Books

1. Secondary Analysis of Electronic Health Records, By MIT Critical Data · 2016
2. Healthcare data analytics edited by C K Reddy, CC Aggarwal, CRC Press, 2015
3. Handbook of Biomedical image analysis: Eds**.** Koen Leemput, Dirk Vandermeulen, Frederik Maes, Siddharth Srivastava, Emiliano D'Agostino, Paul Suetens, Springer Nature, 2005

Course Code	Course Name	L-T-P - Credits	Level
M2220224	Data Analytics Lab II	0-0-4-2	200

Course Outcomes	
CO1	Develop skills on Supervised learning
CO2	Hands on training in unsupervised learning
CO3	Develop skills in feature engineering
CO4	Apply theoretical knowledge to data sets

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	2	2	2	3	2
CO3	3	2	1	2	3	2
CO4	3	3	2	2	2	2

List of exercises/Lab programs

1. Density estimation (KNN)
2. Naive Bayes and classification
3. PCA using R
4. Multiple regression analysis
5. SVM
6. t-test, including standard and Bayesian p-values, Wilcoxon Mann-Whitney rank sum test
7. Paired t-test including standard and Bayesian, Wilcoxon signed-rank test

8. Analysis of variance, Kruskal-Wallis & post hoc tests

Text Books:

1. Lyman Ott, R. Lyman Ott, MichealLongnecker, An introduction to statistical methods and data analysis, 6th Edn, Cengage Learning, 2008

References:

1. G. W. Snedecor, and W.G.Cochran, Statistical Methods. Iowa State University Press, 1989

Course Code	Course Name	L-T-P - Credits	Level
M3220225	MINI PROJECT I	0-0-6-3	300

Course Outcomes	
CO1	Develop a project in computer science field or in multidisciplinary domains, preserving ethical values
CO2	Choose modern tools and technologies which are appropriate for the project development.
CO3	Develop the capability to manage projects as an individual or as a member /leader in a team.
CO4	Develop effective presentation and oral communication skills

Course Code	Course Name	L-T-P -Credits	Level
M3220321	Deep Learning & MLOps	2-1-4-4	300

Course Outcomes	
CO1	Introduction to neural networks
CO2	Deep Neural networks
CO3	Sequence Modeling
CO4	Regularization in deep learning

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	2	1
CO2	3	2	1	1	1	2
CO3	3	2	1	1	1	2
CO4	3	3	2	1	2	2

Module	Contents
1	Deep Neural Networks - Convolutional Neural Networks, Recurrent Neural Networks - LSTM, GRU, CRNN
2	Auto Encoders, Restricted Boltzmann Machine, Regularizations in Deep Learning - Dropout, Novel architectures for Sequence Modelling - Attention, Transformer and variants. Generative Adversarial Networks. Deep Kernel Machines - Deep Kernels and Multi Kernel Learning, Transfer Learning
3	Introduction to MLOps, Components of MLOps, Machine Learning life cycle, Major phases of MLOps, Different tools for MLOps, Data version control DVC, Model Development, Productionalization

	and Development, Monitoring – Devops
4	Models and Deployment, CI/CD Pipelines, Building ML artifacts, Deployment strategies, Monitoring and feedback loop, Model governance, Tesor Flow Extend, KubeFlow, MLOps in cloud MLOps : A few real world examples

Text Books

1. Deep Learning with Python, by François Chollet, Manning Publications; 1st edition, 2017

2. Deep Learning by Ian Goodfellow, YoshuaBengio & Aaron Courville, The MIT Press; Illustrated edition, 2016

3. Introducing MLOps, by Mark Treveil, Nicolas Omont, Clément Stenac, Kenji Lefevre, Du Phan, Joachim Zentici, Adrien Lavoillotte, Makoto Miyazaki, Lynn Heidmann, November 2020

References:

1. Neural Networks and Learning Machines, Simon Haykin, Person, 2009.

2.Mastering Machine Learning Algorithms, Giuseppe Bonaccorso, Ingram short title, 2018

Course Code	Course Name	L-T-P - Credits	Level
M3220322	Big Data Technologies & Cloud Computing	2-1-4-4	300

Course Outcomes

CO1	Introducing Apache Spark
CO2	Mining in data stream
CO3	Introduction to cloud
CO4	Big data in cloud environment

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	2	1
CO2	3	2	1	1	1	1
CO3	3	3	1	1	1	2
CO4	3	3	2	1	2	1

Module	Content
1	Introduction to Apache Spark, Spark Cluster, Spark Core, High level architecture, Spark Context, RDD, Lazy Operation, Caching methods, Spark SQL
2	Machine learning with spark, Spark Machine Learning libraries, Spark ML and Applications, Mining of data streams

3	Cloud components, Essential characteristics, Rapid elasticity, Architectural influences. Benefits: scalability, simplicity, vendor, security, Limitations, Layers in cloud architecture, Software as a Service (SaaS), features of SaaS and benefits, Platform as a Service (PaaS)
4	Big Data and Machine Learning on Cloud, Big Data with BigQuery OR databricks cloud, Machine Learning Options on Cloud

Text Books:

1. Data Analytics with Spark Using Python, By Jeffrey Aven, Addison Weley Data & Analytics series, 2018
2. Big Data Analytics with Spark, Mohammed Guller, APress, 2015

References:

1. AnandRajaraman, Jeffrey D Ullman. Mining of Massive Datasets, Cambridge University Press 2010

Course Code	Course Name	L-T-P - Credits	Level
M3220323	Object Oriented Programming - Python	3-1-2-4	300
Course Outcomes			
CO1	Introduction to OOP		
CO2	Attribute Access, Properties, and Descriptors		
CO3	Creating Numbers		
CO4	Object Serialization and Persistence		

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	1	2	1
CO2	2	3	2	1	1	1
CO3	2	2	1	2	1	2
CO4	2	3	2	1	2	1

Module	Contents
1	Overview of OOP: Abstraction, Encapsulation, Inheritance,

	Polymorphism, Classes, subclasses and objects, Accessibility, Passing objects to methods. Object initialization: The object superclass, The __init__() method, Enumerated constants, Stateless objects. Basic special methods: __repr__(), __str__(), __format__(), __hash__(), __bool__(), __bytes__(), __del__(), __new__() methods, comparison operator methods.
2	Attribute Access: Attribute processing, Creating properties, Methods for attribute access, Descriptors. Abstract base classes: Base classes, Polymorphism, Callables, Containers, Collections, Numbers, Iterators, Context managers, Theabc module. Callables and contexts: Callables, memoization, Managing contexts. Containers and collections: Abstract base classes of collections, Special methods, Standard library extensions, Creating new kinds of collections, sequences, mappings and sets.
3	Numbers: Abstract base classes of numbers, The arithmetic operator's special methods, Creating a numeric class, computing numeric hash, Special methods, In-place operators. Decorators and Mixins: Cross-cutting concerns, Built-in decorators, Standard library mixin classes, Creating function and class decorators, Adding methods to a class, Decorators for security. Graphics: Turtle Module, Drawing with colors, Drawing basic shapes, using iterations, Creating bar charts.
4	Object serialization and persistence: Serializing and saving - JASON, CSV & XML, Storing and retrieving objects via Shelve and SQLite, Storing configuration files – INI & PY. Transmitting and sharing objects: Transmitting objects using HTTP and REST, Using a message queue to transmit objects. Modules and package design: Designing modules and packages, Installing python modules`

Textbook

1. Steven F Lott, Mastering Object-Oriented Python, second edition, Packt publishing, 2019.

2. Charles Dierbach, "Introduction to Computer Science Using Python: A Computational Problem-Solving Focus", Wiley, 2017.

References:

1. Ashok NamdevKamthane, Amit Ashok Kamthane, “Programming and Problem Solving with Python”, McGraw Hill Education, 2018.

Course Code	Course Name	L-T-P - Credits	Level
M2220324	Data Analytics Lab III	0-0-4-2	200

Course Outcomes	
CO1	Develop skills on Supervised learning
CO2	Hands on training in unsupervised learning
CO3	Develop skills in feature engineering
CO4	Apply theoretical knowledge to data sets

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	2	2	2	3	2
CO3	3	2	1	2	3	2
CO4	3	3	2	2	2	2

List of exercises/Lab programs:

- Hadoop Hands-on
- Getting Started with MapReduce and Hadoop
- MapReduce Exercises
- HDFS Introduction
- Hbase/Cassandra HandsOn [NoSQL]
- Working with Large data sets
- Working with pySpark
- Machine Learning with pySpark

Text Books:

1. Tom White, Hadoop: The Definitive Guide, 3rd edition, O'Reilly Media , 2012.
2. Toby Segaran, Jeff Hammerbacher, Beautiful Data, O'Reilly Media, 2009.

References:

1. AnandRajaraman, Jeffrey D Ullman. Mining of Massive Datasets, Cambridge University Press 2010.

Course Code	Course Name	L-T-P -Credits	Level
M3221327	Spatial Data Analytics	3-1-2-4	300

Course Outcomes	
CO1	Spatial Data and it's properties
CO2	Geometric distributions
CO3	Spatial autocorrelation
CO4	Machine Learning applications in geospatial science

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	1	2	1
CO2	3	2	2	1	1	1
CO3	3	2	2	2	1	2
CO4	3	3	3	1	2	1

Module	Content
1	Spatial Data, Object and Field View, Coordinate Reference Systems, Spatial Data Models, Spatial Data Acquisition, Sources of Spatial Data, Spatial Data Analysis, Geo-visualization and Information Delivery.

2	Analyzing Geographic Distributions, Point Pattern Analysis, Spatial Process, Complete Spatial Randomness, First- and Second-Order Effects, Point Pattern Analysis Methods,Nearest Neighbor Analysis, Ripley's K Function and the L Function Transformation, Kernel Density Function
3	Spatial Autocorrelation, Global Spatial Autocorrelation, Local Spatial Autocorrelation, Optimized Hot Spot Analysis, Cluster Analysis;HierarchicalClustering,k-Means Algorithm, Density-Based Clustering, Spatial regression
4	Geostatistical (Probabilistic) Estimation- Semi-variogram analysis, isotropic and anisotropic models, Ordinary Kriging, Simple Kriging, Indicator Kriging, Cokriging
5	Machine Learning and their applications in Spatial Data Science, Classification and regression problems, supervised and unsupervised Machine Learning algorithms, segmentation, object-based image analysis (OBIA) and predictive modeling in Spatial Analysis

Text Books:

1. Grekousis, George, Spatial Analysis Methods and Practice; Describe, Explore, Explain through GIS, 2020, Cambridge University Press

2. Peter J.Taylor, Quantitative Methods in Geography: An introduction to Spatial Analaysis, INDIGO BOOKS, ISBN: 9788131609545, 8131609545, Edition: 2018

References:

1. David O'Sullivan, David Unwin, Geographic Information Analysis, 2nd Edition, March 2010, ISBN: 978-0-470-28857-3.
2. Lloyd, Christopher D. Spatial Data Analysis: An Introduction for GIS Users. Oxford: Oxford UP, 2010.

Course Code	Course Name	L-T-P - Credits	Level
M3221339	Healthcare Analytics II	3-1-2-4	300

Course Outcome	
CO1	Genomic data analysis
CO2	Clinical data analytics
CO3	Social data analytics for healthcare
CO4	Clinical data analytics and decision support system

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	1	2
CO2	3	2	2	1	1	1
CO3	2	2	2	1	1	2
CO4	3	2	2	1	1	1

Course Contents

Module	Contents
1	Genomic data analysis and personalized medicine, Genomic data generation, Methods and standards of genomic data, Genetics and Genomics for Personalized Medicine, Pharmacogenetics and Pharmacogenomics, The Potential of Machine-learning in Pharmacogenetics, Pharmacogenomics and Pharmacoepidemiology

2	Mining of digital clinical text using NLP and IR. Infomation extraction, Rule based approaches, Pattern-based algorithms, Machine Learning with clinical text data, Decision support system
3	Social Media analytics and healthcare, Tracking of infectiosdisases, Boutbreak detection using search query and website access logs,Tempral data mining in healthcare, Association analsis, Temporal pattern mining Infectious data analysis using temporal methods Medical data visualization, Standard techniques, Geospatial Analytics, Temporal analysis,
4	Clinical decision support system, Knowledge Based CDSS, AI based & Genetic Algorithm based CDSS Human Intensive techniques, Challenges of CDSS Case studies

Text Books

1. Secondary Analysis of Electronic Health Records, By MIT Critical Data · 2016
2. Healthcare data analytics edited by C K Reddy, CC Aggarwal, CRC Press, 2015
3. Handbook of Biomedical image analysis: Eds**.** Koen Leemput, Dirk Vandermeulen, Frederik Maes, Siddharth Srivastava, Emiliano D'Agostino, Paul Suetens, Springer Nature, 2005

Course Code	Course Name	L-T-P -Credits	Level
M3221337	Computer-Aided Drug Design	3-1-2-4	300

Course Outcomes	
CO1	Life Cycle drug discovery
CO2	Molecular recognition and drug - receptor interactions
CO3	Drug design methodologies
CO4	ML in drug design

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	2	1	1
CO2	2	2	2	2	1	1
CO3	2	2	2	2	1	1
CO4	1	2	1	2	1	1

Module	Contents
1	Stages of drug discovery process and its challenges, Protein structure, Classification of receptors, Enzyme kinetics, Michaelis–Menten Equation, molecular descriptors, calculation of physical & chemical data, concept of agonists, antagonists, partial agonists, Inverse agonist and functional

	antagonist.
2	Electrostatics, molecular recognition, Drug-receptor interactions, Pharmacokinetics and Metabolism, Protein Therapeutics, Toxicity, Drug resistance, pharmacology and Dose-response relationship, Therapeutic index, combined effects of drugs and factors modifying drug action
3	Structure-based and Ligand-based drug design, Docking, Pharmacophore mapping, Homology modelling, QSAR and QSPR, Pharmacokinetics(ADMET), Pharmacodynamics, Factors affecting ADME, Lipinski's rule of five, Kinetics of elimination, Finding new drug targets - High throughput/combinatorial approaches, Fragment-based drug design, and retrosynthetic approaches.
4	Machine learning approaches in drug design, ADME databases, chemical, biochemical and pharmaceutical databases, Data mining and visualization methods.

Text Books

1. Marcelo C.R. Melo, Jacqueline R. M. A. Maasch Cesar de la Fuente Nunez, Machine Learning for Drug Discovery (ACS)
2. Dev BukhshSingh ,Computer-Aided Drug Design, Springer
3. Kenneth M. Merz Jr PhD (Editor), Dagmar Ringe PhD (Editor), Charles H. Reynolds PhD (Editor), Drug Design: Structure- and Ligand-Based Approaches, Cambridge University Press

Course Code	Course Name	L-T-P -Credits	Level
M321338	Computational Neuroscience: Introduction to Single Neuron Computation	3-1-2-4	300

Course Outcomes	
CO1	Understand and analyze the biological and electrical behaviour of neurons.
CO2	Solve mathematical problems related to neuroscience.
CO3	Application of Kirchoffs's laws, cable theory and numerical methods in neuroscience.
CO4	Computational modeling and simulation of biological neurons.

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	2	1	3	-	-	-
CO3	2	3	2	-	-	-
CO4	1	2	3	-	-	-

Module	Content
1	Basic neuroscience: The nervous system, central and peripheral nervous system, organization of the brain, brain anatomy and function, neurons, dendrites and axons, electrical and chemical synapses, synaptic and action potentials. Nernst Potential, GHK equation, Electrochemical Driving Force (EDF), Ohm's law, Electrical Equivalent Circuit of a neuronal membrane.
2	The Hodgkin-Huxley theory of action potentials: Voltage Clamp Experiments, activation and non-inactivation parameters (n, m, h), estimation of n, m, h., action potential generation and propagation, HHsim - simulation experiments.
3	Introduction to computational neuroscience: Modeling & understanding, the modeling perspective, formulating a conceptual model, Numerical methods for neural modeling. Compartmental modeling, Kirchoff's current and voltage laws, The cable theory.
4	The NEURON simulation environment: Introduction, Representing neurons with a digital computer, model implementation, signal sources and monitors, running simulation experiments, analyzing results. Simple single cell and network models. Simple exercises using NEURON.

References:

1. Malmivuo, J., &Plonsey, R. Bioelectromagnetism: principles and applications of bioelectric and biomagnetic fields. Oxford University Press, USA.
2. Kandel, E.R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S. A., Hudspeth, A. J. Principles of Neural Science, McGraw Hill.
3. Neuroscience. Edited by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, and Leonard E. White. Sinauer Associates Inc.

4. Gazzaniga, M., Ivry, R. B., &Mangun, G. R. Cognitive neuroscience: the biology of the mind. Cambridge: MIT press.
5. Peter Dayan and L. F. Abbott. Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems. MIT press.
6. J. M. Bower and D. Beeman. The Book of GENESIS: Exploring Realistic Neural Models with the GEneralNEuralSImulation System, Internet Edition.
7. Carnevale, Nicholas T., and Michael L. Hines. The NEURON book. Cambridge University Press, 2006.

Course code	Course name	L-T-P-C	Level
M3220240	Spatial Statistics	4-1-0-4	300

Course outcomes

CO1	Learn the basics of spatial statistics
CO2	Apply practical skills in analysis of point pattern
CO3	Understand spatial interaction and, Spatial Autocorrelation
CO4	Describe various methods for Geostatistical estimation – Kriging and its various types

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	2	2	1	1
CO 2	3	3	3	2	2	2
CO 3	3	3	3	2	2	2
CO 4	3	3	3	2	2	2

Module	Content
1	Data exploration and spatial statistics, statistical methods and spatial data, Exploratory spatial data analysis. Introduction to point pattern analysis, Geostatistics, and lattice data analysis
2	Analyzing Geographic Distributions, Point Pattern Analysis, Spatial Process, Complete Spatial Randomness, First and Second Order Effects Point Pattern Analysis Methods, Nearest Neighbor Analysis, Ripley's K function and the L function Transformation, Kernel Density function
3	Spatial Autocorrelation Global and Local spatial Autocorrelation, Optimized Hot Spot Analysis, Cluster Analysis, Hierarchical Clustering, K means Algorithm, Density Based Clustering, Spatial Regression
4	Geostatistical Estimation – Semi Variogram Analysis, Isotropic and anisotropic models Introduction to kriging and its different types Ordinary kriging, Simple Kriging, Indication Kriging, Co-kriging

Text Books:

1. Peter J Taylor Quantitative Methods in Geography : An introduction to spatial Analysis, Indigo Books, Edition : 2018.
2. Noel Cressie,1991 Statistics for spatial Data, John Wiley and Sons.Isaaks E H and R M Srivastava 1989
3. An Introduction to Applied Geostatistics. Oxford Univ Press New York, Oxford.

References:

1. Lloyd, Christopher D, Spatial Data Analysis: An introduction for GIS users. Oxford : 2010

Course code	Course name	L-T-P-C	Level
M3220232	Geospatial Modelling and Analysis	3-1-2-4	300

Course outcomes

CO1	Understanding the frameworks and models for geospatial modelling and analysis
CO2	Understanding the concepts and developing the skills in network analysis of spatial data
CO3	Understanding of Temporal data and its analysis
CO4	Understanding the concepts of Geocomputation methods and models

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	2	2	1	1
CO 2	3	3	3	2	1	1
CO 3	3	2	3	2	2	1
CO 4	3	2	3	2	1	1

Module	Content
1	Modelling Spatial Problems: Introduction – Need for spatial models - Conceptual Frameworks for geospatial modelling, spatial problems, spatial analysis as a process, PPDAC model, types of spatial models. Descriptive and process models, Site suitability model
2	Network modelling and analysis, Types of networks, Network dataset and model construction, Network Analysis operations – Optimal Routes and Optimal Tours, Location and Service Area Problems, Algorithms related to Network Analysis, Applications
3	Working with spatio-temporal Data, spatio-Temporal data types, managing temporal data, Visualizing and analysingspatio-temporal data – spatio-temporal estimation techniques
4	Geocomputation methods and modelling, Geosimulation, Geospatial Applications of generic algorithms, Artificial Neural Networks, Agent Based Modelling, Cellular Automata

Text Books :

1. Heywood L, Comelius S, and S Carver , An Introduction to Geographical Information Systems, Dorling Kinderseley (India) Pvt Ltd, 2006.
2. Micheal J de Smith, Micheal F Goodchild, Paul A Longley, Geospatial Analysis 5 th edition, Troubador Publishing Ltd, 2015.

References :

1. Tsung Chang Kang , Introduction to Geographic Information Systems, Tata McGraw – Hill Publishing Company Limited, New Delhi, 2002
2. Mitchell A, The ESRI Guide to GIS Analysis Volume 1 : Geographical Patterns and Relationships, Environmental Systems Research Institute, Inc.,Red lands, Calinfornia,USA

Course Code	Course Name	L-T-P - Credits	Level
M3220233	Advanced Image Analytics	3-1-2-4	300

Course outcomes	
CO1	Digital Image Processing and Data management
CO2	Image enhancement Techniques and feature manipulation
CO3	Image classification basics
CO4	Advanced Image classification methods

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	1	2	1	1	2
CO 2	3	2	2	1	1	1
CO 3	2	2	2	1	1	2
CO 4	3	2	2	1	1	1

Module	Content
1	Digital Image Processing: Components, data formats – Image compression techniques – The Histogram and Its Significance to Digital Image Processing of Remote Sensor Data – Image statistics: Univariate and Multivariate Image Statistics – Sampling Theory; Pre-processing: Radiometric and Geometric errors of Remote sensing data – Correction for Sensor System – Correction for environmental attenuation error – Image to Map Geometric rectification implementation
2	Image Enhancement: Image Reduction and Magnification – Contrast Manipulation (Linear and Non-linear, Grey-level Thresholding and Level slicing) – Spatial Feature Manipulation (Low pass, High pass and Convolution filters) Multi-image Manipulation (Band ratio, Principal Component Analysis) – Image transformation (RGB – IHS, CMYK)
3	Image Classification Techniques: Pixel based and object-based classification – Supervised Classification (Training site selection, Algorithms used for supervised classification) – Unsupervised classification (K-means and ISODATA) – Non-parametric & parametric classification techniques – Classification Accuracy Assessment – Change detection analysis
4	Advanced classification techniques - Fuzzy Classification – Machine Learning approaches in Image classification – Support Vector Machine (SVM) classifier – Random Forest (RF) classifier – Decision Tree classifier – Artificial Neural Networks (ANN) – Components and Characteristics – Training and Testing using ANN – Learning Algorithms: MLP neural network with Back Propagation, SOM Neural Network

Text Books:

1. Jensen, John R (2016), Introductory Digital Image Processing: A Remote Sensing Perspective
2. John A. Richards (2012), Remote Sensing and Digital Image Analysis
3. Thomas L., Ralph W. Kiefer, and Jonathan C. (2015), Remote Sensing and Image Interpretation
4. Amy E. Frazier, Kunwar K. Singh (2021), Fundamentals of Capturing and Processing Drone Imagery and Data

References:

1. Robert, G. Reeves, - Manual of Remote Sensing Vol. I and II – American Society of Photogrammetry, Falls, Church, USA, 1983.
2. Richards, Remote sensing digital Image Analysis – An Introduction Springer - Verlag 1993.
3. Digital Image Processing by Rafael C. Gonzalez, Richard Eugene Woods- Pearson/ Prentice Hall,2008
4. Fundamentals of Digital Image Processing by Annadurai Pearson Education (2007)
5. Introduction to Google Earth Engine, Google Earth Outreach.

Course Code	Course Name	L-T-P Credits	Level
M3221233	Microwave Remote Sensing	3-1-2-4	300

Course Outcomes	
CO1	Understand concepts of passive and active microwave system
CO2	Gain knowledge in the principles of Microwave image analysis and interpretation
CO3	Understand the various application domains of microwave satellite data
CO4	Gain exposure to Interferometry and Polarimetry concepts

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	1	1
CO2	2	1	1	1	1	1
CO3	3	2	2	2	1	1
CO4	3	1	1	1	2	1

Module	Content
1	Introduction to microwave remote sensing - active and passive systems, platforms and sensors, Polarizations, Basic microwave radiometer: Antenna and Receivers, Coherent systems, Calibration – Microwave scattering of land surface – Passive Microwave Remote Sensing: Passive microwave sensing components – Emission laws – Roughness and Dielectric Constant
2	Active Microwave Remote Sensing: basic principles of radar – radar equation – resolution – range, phase and angular measurements – microwave scattering and its measurement – Relationships between scene and sensor parameters.
3	Imaging Radar: Need for imaging radar – SLAR: Ground Range Resolution and Azimuth resolution – SAR: Doppler vs Geometry, Radar Equation – Geometric distortions in RADAR images – SAR data formats – Geometric corrections – Speckle: Statistics and Filtering.
4	SAR interferometry – Principles of Interferometry – Interferometric SAR (InSAR) – InSAR viewing geometries – Differential SAR Interferometry – Applications: DEM generation, Vegetation height estimation

Text Books:

1.Lillesand, T., Kiefer, R. W., &Chipman, J. (2015). Remote sensing and image interpretation. John Wiley & Sons.

2.Iain H. Woodhouse (2006), Introduction to Microwave Remote Sensing, CRC Press

References:

1.Ulaby, F.T., Moore, K.R. and Fung, Microwave remote sensing vol-1, vol-2 and vol-Addison - Wesley Publishing Company, London,1986.

2. Floyd.M. Handerson and Anthony, J.Lewis "Principles and applications of Imaging RADAR", Manual of Remote sensing, Third edition, vol.2, ASPRS, Jhumurley and sons, Inc, 1998.

3. Philippe Lacomme,JeanclandeMarchais,Jean-Philippe Hardarge and Eric Normant, Air and spaceborne radar systems - An introduction, Elsevier publications 2001.

4. Roger J Sullivan, Knovel, Radar foundations for Imaging and Advanced Concepts, SciTech Pub, 2004.

5.Ian Faulconbridge, Radar Fundamentals, Published by Argos Press, 2002.

6. Eugene A.Sharkov,Passive Microwave Remote Sensing of the Earth: Physical Foundations, Published by Springer, 2003.

Course code	Course name	L-T-P-C	Level
M3221237	Python Programming for Geospatial Applications	3-1-2-4	300

Course outcomes

CO1	Basic Understanding of geospatial Libraries
CO2	Raster and vector data analysis
CO3	Understanding of developing script tool using arcpy and QGIS plugin development
CO4	Able to understand and handling spatial database

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	2	2	2	1
CO 2	3	3	3	2	2	1
CO 3	3	2	3	2	2	1

CO 4	3	2	3	2	2	1

Module	Content
I	Introduction to geospatial analysis with python ,Geospatial libraries, Geospatial Data Visualization,Interactive geospatial data visualization.
II	Raster and vector data analysis, Raster operations, Raster data analysis using different python modules,Satellite data analysis using python, Vector Data Structures and operations.
III	Introducing Python using the Python window in ArcGIS:arcpymodule,automating Introduction to QGIS Python programming, Developing python plugins with QGIS.
IV	Spatial Database Management Systems, Python interface to PostgreSQL, Introduction to PostGIS,Python interface to PostGIS and QGIS PostGISinterfacing,Worked example: retrieving real-time data from a REST web API

References:

1. Python Geospatial Analysis Cookbook, Michael Diener
2. Mastering Geospatial Analysis with Python, Paul Crickard, Eric van Rees, SilasToms
3. QGIS Python Programming Cookbook, Joel Lawhead

Course Code	Course Name	L-T-P Credits	Level
M3221235	Thermal And Hyperspectral Remote Sensing	3-1-2-4	300

Course Outcomes	
CO1	Explain various concepts of thermal and hyperspectral remote sensing
CO2	Understand Thermal and hyperspectral data products
CO3	Understand various application domains of thermal and hyperspectral data product
CO4	Gain knowledge in thermal and hyperspectral image analysis

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	2	1	2	2	2

CO3	3	2	1	2	3	2
CO4	3	3	2	2	2	2

Module	Content
1	ermal radiation principles, thermal process and properties – Characteristics of rmal IR images and factors affecting thermal images – Interaction of thermal iation with terrain elements – Thermal sensors and their characteristics – MUST edium Scale Surface Temperature Missions) – radiometric calibration of thermal nners
2	ermal image and types of available data products – Interpretation of thermal ges - day and night images – LST retrieval methods – Application of thermal ote sensing data in crop health monitoring, pollution monitoring, oil spill ection, Atmospheric modelling, Sea Surface Temperature
3	perspectral Remote Sensing – Imaging Spectroscopy – representation systems – ctral cube – Airborne and spaceborne hyperspectral sensors – Hughes nomenon – multivariate analysis for data reduction – Spectral library – perspectral image compression – Feature selection and feature extraction niques
4	perspectral Image Analysis: Calibration and normalization of hyperspectral ges –Observing signatures of various features and comparing with spectral aries – Spectral mapping methods: Spectral Angle Mapper (SAM), Spectral rrelation mapper, Spectral Feature Filtering (SFF), Linear Spectral Unmixing U) – Application of hyperspectral remote sensing: Agriculture, Soils, Forestry, vironmental and Resource Management

Text Books:

1.Dale A Quattarochi and Jeffrey C Luvall, “Thermal Remote Sensing in Land surface Processes” e-book, 2005 Taylor &Fancis, ISBN 0 203 50217 5

2.John A. Richards and XiupingJia, “Remote sensing digital Image Analysis – an introduction” fifth edition, Springer Verlag., 2012 ISBN 978 3 642 30061 5.

3.Chein I Chang, “Hyperspectral Imaging: Techniques for Spectral Detection and Classification”, Kluwer Academic/Plenum Publishers, New York, N.Y., 2003. (ISBN: 0-306-47483-2)

4.Marcus Borengasser and William C., Hungate and Russel Watkins Hyper spectral Remote sensing: principles and application” CRC, 2008, ISBN 13: 9781566706544

5.Chein I Chang, “Hyperspectral Data Exploitation: Theory and Applications, Wiley Inter Science, 2006 (ISBN: 9780470124628)

References:

1. Liguo Wang and Chunhui Zhao., Hyperspectral Image Processing, Springer, 2016
2. Michael T, Eismann., Hyperspectral Remote Sensing, SPIE press, USA, 2012

Course Code	Course Name	L-T-P Credits	Level
M2220234	GA Lab-II (Image Analytics)	0-0-4-2	200

Course Outcomes	
CO1	Acquiring Skills on Satellite Image types
CO2	Hands on training in unsupervised learning
CO3	Develop skills in Image Enhancement and Interpretation
CO4	Accuracy assessment of Image processing outputs

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	2	1	2	2	2
CO3	3	2	1	2	3	2
CO4	3	3	2	2	2	2

List of exercises/Lab programs:

1. Reading and Displaying satellite data, Generating True and False Colour Composite (FCC)
2. Generating Histogram, Spectral profile and scatter plots using satellite data
3. Geometric correction of satellite image
4. Radiometric Enhancement: Stretching of Imagery
5. Spatial Enhancement: Filters and Convolution
6. Spectral Enhancement: Band Ratios and Spectral Indices
7. Principal Component Analysis (PCA)
8. Unsupervised Classification
9. Supervised Classification
10. Accuracy Assessment and Change detection study

Text Books:

1. American Society of Photogrammetry, Manual of Remote Sensing, (2nd edition), ASP, Falls Church, Virginia, 1983
2. Lillisand T.M., R.W.Kiefer and Chipman. Remote sensing and image interpretation, John Wiley & Sons, New York, 2004.

References:

1. Ekstrom, M. P., Digital image processing techniques. New York, Academic Press, 1984
2. Harris, R, Satellite Remote Sensing - An Introduction. London, Routledge, 1987
3. Moffit, H.F., and Edward, M.M., Photogrammetry, Harperand Row Publishers, New York, 1980

Course Code	Course Name	Credits	Level
M2220225	MINI PROJECT I	3	300

Course Outcomes

CO1	Explore and gather Spatio-temporal data, plan and execute spatial analysis/spatial modeling with a scientific, societal and environmental relevance
CO2	Choose modern tools and technologies that are appropriate for the project development.
CO3	Develop the capability to manage projects as an individual or as a member /leader in a team.
CO4	Develop effective presentation and oral communication skills

Course code	Course name	L-T-P-C	Level
M3220340	Geospatial Applications for environment and climate change	3-1-2-4	300

Course outcomes

CO1	Understanding the basic aspects of Environmental GIS
CO2	Able to apply GIS to a range of problems within the environmental sciences
CO3	Understanding the different impacts of climate change and its analysis using GIS
CO4	Knowledge of wide range of problems and its solutions in environment and climate filed through GIS and Remote sensing Techniques

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	1	1	1	2
CO 2	3	2	3	2	2	2

CO 3	3	2	2	2	3	3
CO 4	3	2	3	2	3	3
Module	Content					
1	Introducing GIS in environment management, Different aspects in environment, applied aspects of environmental GIS, Introduction to key sources of spatial data related to environment management- Using public domain environmental data					
2	Environmental assessment and monitoring with GIS, Studying Spatial and Temporal variability of environmental data for change detection analysis, Environmental spatial decision support system, Impact assessment – basic concepts, environmental impact assessment (EIA) methods.					
I	Geospatial Technology for Climate studies, Floods and Water Resource Management, Droughts and Food Security, Land Cover, land Use Change and Ecosystems, Air Quality and Health,					
4	Climate Change and climate adaptation planning, impacts of sea level rise, Impact of rising temperature and Urban heat island, impact on public health. technical approaches to formulating mitigation and adaptation strategies					

Text Books :

Mitsova, Diana, and Ann-Margaret Esnard. Geospatial Applications for Climate Adaptation Planning. Routledge, 2019.

Sundaresan, Janardhanan, et al., editors. Geospatial Technologies and Climate Change. Springer International Publishing, 2014. DOI.org (Crossref), https://doi.org/10.1007/978-3-319-01689-4.

References :

Geospatial Modelling for environmental Management; case studies from south asia edited by Shruthi Kanga, Suraj Kumar Singh, GowharMeraj, Majid Farooq

Course code	Course name	L-T-P-C	Level
M3220340	Geospatial Applications for Hydrological Modeling	3-1-2-4	300

Course outcomes

CO1	Understanding the concepts of GIS and RS applications of hydrology
CO2	Applying learned concepts on hydrological modelling
CO3	Applying learned concepts on flood modelling
CO4	Management and mitigation of hydrological phenomena.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	1	2	2
CO 2	3	3	3	1	2	2
CO 3	3	3	3	1	2	2

CO 4	2	3	3	1	3	2

Module	Content
1	Basic concepts of hydrology - aspects, parameters and sciences involved in hydrology, hydrologic cycle - Remote sensing and GIS applications in Water Resources Management; sources of hydrological data.
2	Hydrological mapping and modelling – surface water and groundwater inventory, watershed delineation and flow modelling, run-off estimation
3	Water balance - principles, components, water systems and types; global water balance scenario, blue and green water perspective. Assessment of water balance
4	Flood management - potential flood zone mapping, flood risk assessment, flood hazard simulation; mitigation methods for flood management.

References:

1. John G Lyon, GIS for Water Resources and Watershed management, ISBN-1 9788184892932.
2. Tim Davie, Fundamentals of Hydrology 3rd edition,, ISBN-10 : 0415858704, 2019.
3. A. M. Gurnell and D. R. Montgomery, Hydrological Applications of GIS (Advance Hydrological Processes) 1st edition, 2000.

Course code	Course name	L-T-P-C	Level
M3220342	Spatial Big Data Analytics	3-1-2-4	300

Course outcomes

CO1	Geospatial Big Data basics and core concepts
CO2	Geospatial Big Data technologies and tools
CO3	Advanced GIS and machine learning algorithms
CO4	Open-source geospatial big data analysis and applications

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	2	1	2	2
CO 2	3	2	2	1	2	2
CO 3	3	2	2	1	2	2
CO 4	3	2	2	1	2	2

Module	Content
1	Introduction to big data computing for geospatial applications Spatially referenced big data, Map-reduce based problems in geospatial big data, Societal applications and challenges, Hadoop GIS vs parallel SDBMS, Geospark
2	Spatial big data, Data cleaning in spatial big data Challenges in using the big data in spatial technologies, Databases supporting spatial data - Hive based spatial data storage, Real-time query engine, Workflow Data partitioning & storage. Spatial data wrangling with Geospark Values in spatial big data, visualizations, GeosparkVis
3	Decision support systems using spatial big data: Data intelligence, machine learningwith spatial big data. Common algorithms such as association rule of mining, clustering and classification rule etc in geospatial context
4	Case studies with spatial bigdata in 1. Societal applications 2. environment and economics 3. Agriculture 4. Disaster Management

References:

1. Chaowei , Yang et al; Introduction to GIS Programming and Fundamentals with Python and ArcGIS; CRC Press.
2. Aurelia Moser, Jon Bruner, Bill Day; Geospatial Data and Analysis; O'Reilly Media, Inc.
3. Zhe Jiang , Shashi Shekhar Spatial Big Data Science: Classification Techniques for Earth Observation Imagery Hardcover
4. Hassan A. Karimi, : Big Data Techniques and Technologies in Geoinformatics
5. Sandy Ryza , Uri Laserson , Sean Owen , Josh Wills : Advanced Analytics with Spark: Patterns for Learning from Data at Scale

Course Code	Course Name	Credits	Level
M3220326	MINI PROJECT II	3	300

Course Outcomes	
CO1	Identify a real world problem with a spatio-temporal context. Using AI/ML develop a model for a spatial/spatio-temporal prediction
CO2	Choose modern scientific programming that are appropriate for the project development.
CO3	Develop the capability to manage projects as an individual or as a member /leader in a team.
CO4	Develop effective presentation and oral communication skills

Course Code	Course Name	L-T-P - Credits	Level
M2220343	GIS Lab III Spatial Data Analytics Lab	0-0-4-2	300

Course Outcomes	
CO1	Apply spatial statistics in spatial data
CO2	Perform Spatial Point Pattern Analysis in spatial event data
CO3	Apply various Spatial Estimation techniques
CO4	Apply Spatial Regression Analysis

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	2	1	1

CO2	2	2	2	2	1	1
CO3	2	2	2	2	1	1
CO4	1	2	1	2	1	1

List of exercises/Lab programs:

1.Exploratory Spatial Data Analysis
2.Density based Point Pattern Analysis

3.Distance based Point Pattern Analysis

4.Spatial Autocorrelation

5.Local Indicators of Spatial Association

6.Semi-Variogram Analysis

7.Ordinary and Simple Kriging

8.Regression Kriging

9. Empirical Bayesian Kriging
10.Spatial Regression Analysis

Text Books:

2. Peter J.Taylor, Quantitative Methods in Geography: An introduction to Spatial Analaysis, INDIGO BOOKS, ISBN: 9788131609545, 8131609545, Edition: 2018

3.Geographic Information Analysis, 2nd Edition, David O'Sullivan, David Unwin, 2010, wiley, ISBN: 978-0-470-28857-3

4.Lloyd, Christopher D. Spatial Data Analysis: An Introduction for GIS Users. Oxford: Oxford UP, 2010.

Course code	Course name	L-T-P-C	Level
M3221344	Topographic Data Analysis Techniques and Applications	3-1-2-4	300

Course outcomes	
CO1	Understanding the concepts of Elevation data products
CO2	Able to perform Topographic Analysis from DEM
CO3	Volumetric and Bathymetric Analysis from DEM
CO4	Understanding the application s of DEM in real world problems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	**3**	**1**	**1**	**2**	**1**	**1**
CO 2	3	1	1	2	1	1
CO 3	3	2	2	2	1	1

CO 4	3	3	3	2	1	1

Module	Content
I	Basics of Digital Elevation Model and Digital Surface Model; Terrain visualization. Methods of representing DEM; Image methods, Point models; Data sources and sampling methods for DEMs; Data registration and geo-coding;Global Elevation Data Sources, DSM from UAV/Drone data,LiDAR data
II	Topographic Analysis : Contour. Slope, aspect, Hillshade, Viewshed Analysis, Line-of-Sight
III	Volumetric Analysis and Computation, Cut-Fill Analysis, Bathymetric applications Analysis and estimation, Reservoir Volume Calculation.
IV	Application of Digital Elevation Models in Water Resource Management, Disaster Risk Management, Infrastructure planning

References:

1. Christopher Zhu, Chris Golc, Zhi Lin Li, Digital Terrain Modelling - Principles and Methodology, 2004, CRC Press, ISBN - 9780415324625
2. John p Wilson, John C Gallant, Terrain Analysis , Principles and Applications, 2000, ISBN - 978-0-471-32188-0

Course code	Course name	L-T-P-C	Level
M3221345	Web and Mobile GIS	3-1-2-4	300

Course outcomes

CO1	Understanding the basic concepts of web and Mobile GIS.
CO2	Understanding the working principles of Web GIS.
CO3	Applying skills on open source web GIS platforms.
CO4	Applying skills on Mobile GIS apps.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	2	1	1	1
CO 2	3	3	2	2	3	2
CO 3	3	3	3	2	2	2
CO 4	3	3	3	2	2	2

Module	Content
I	Introduction to web GIS, Enterprise GIS, Client server computing - introduction and architecture. Various file transfer models and protocols. Open Geo-spatial Consortium standards - WMS, WFS, interoperable and non interoperable systems, GML.
II	Introduction to Geo-server and leaflet - configuration and installation, interface familiarization, handling vector and raster data, geoprocessing operations, styling, publishing web maps.
III	Introduction to ArcGIS server - configuration and installation, interface familiarization, handling vector and raster data, geoprocessing operations, styling, publishing web maps.
IV	Mobile GIS applications, Mobile GIS Architecture, Mobile GIS Programming, Hybrid apps, real-time data collection and editing apps in the field, location-based services and augmented reality (AR) services using camera, GPS

Textbooks:

1. Zhong-Ren Peng, Ming-Hsiang Tsou, Internet GIS 1st Edition,

   ISBN : 0471359238, 2003.
2. Paul Crickard III, Leaflet.js Essentials 1st edition, ISBN-10 : 1783554819, 2014.
3. Stefano Iacovella, Geoserver Beginner's Guide 2nd Edition,

   ISBN-10 : 1788297377, 2017.
4. Pinde Fu, GETTING TO KNOW WEB GIS 3nd Edition, ISBN-10 : 1589485211, 2018
5. Roland Billen, Elsa Joao, David Forrest, *Dynamic and mobile Gis: Investigating changes in space and Time*. CRC PRESS. (2019). ISBN 9780367389932

Course code	Course name	L-T-P-C	Level
M3221346	Geospatial Applications in Urban and Regional Planning	3-1-2-4	300

Course outcomes

CO1	Understand the basics in the field of urban and regional planning
CO2	Get the idea regarding the different data, and its scales and technologies for urban and regional planning
CO3	Different modelling techniques used in urban and regional planning
CO4	Different case studies

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	**PO 5**	**PO 6**
CO 1	3	2	1	1	**2**	**2**
CO 2	3	2	2	1	**2**	**2**

CO 3	3	2	2	1	**3**	**3**
CO 4	3	2	2	1	**3**	**3**

Module	Content
I	GIS and Remote Sensing in Urban and regional Planning – Overview. Basics in urban planning, Region planning Regions Definition Characteristics Need for regional Planning, Levels of planning
II	Data requirement, Dataset and Innovative technologies for urban Planning and regional Planning, High resolution satellite for mapping, cadastral databases in urban areas, Levels and scales of mapping, Detection, Interpretation, delineation and analysis of different settlements – rural, urban, slum, etc
III	Urban Growth modelling, Roof Top solar protection assessment, 3D Modelling and Visualization of urban areas, Database design and analysis for urban and regional resource mapping
IV	Site selection and suitability analysis for urban development. Urban sprawl and change detection studies. Urban hazards and risk management through GIS – Flood modelling using Hydrological tools in GIS.

References:

1. Henk J Scholten, John C H Stillwill, Geographical Information Systems for Urban and Regional Planning, 2007,The Geojournal Library
2. Martin Van Maarseveen, Javier Martiniz, Johannes Flack,GIS in Sustainable Urban Planning and Management - A Global Perspective, 2019, CRC press, ISBN : 9781138505551
3. MohdAktar Ali, Kabir Mohan Sethy, MuzafirWani, Urban Environment and Spatial Science, Ane Books Pvt Ltd, First Edition (2021) , ISBN : 9390658284

Course code	Course name	L-T-P-C	Level
M3221346	Geospatial Applications in Agriculture	3-1-2-4	300

Course outcomes

CO1	Understanding the concepts of Agricultural science.
CO2	Familiarization of GIS & RS concepts specific to the agricultural domain.
CO3	Application of learned skills to familiarize and create real world models
CO4	Familiarization to various case studies and use cases.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	2	2	2
CO 2	3	3	3	2	2	2
CO 3	3	3	3	2	2	3
CO 4	2	3	3	2	2	3

Module	Content
I	Introduction : Crop types, cropping patterns and cropping seasons; agricultural practices of major crops - various stages of crop cultivation. Crop yield monitoring, condition assessment, important insects and pest infection of major crops; precision agriculture.
II	Applications of GIS and remote sensing in agriculture - various techniques; spectral characteristics of leaf - structure of leaf; Vegetation indices- NDVI, SVI, PCA, TVI - Vegetation classification and mapping - Estimation of Leaf area index, Biomass estimation. Detection of pest and diseases.
III	Spectral behavior of different crops and vegetation in VIS, NIR, MIR, TIR and Microwave regions. Microwave back scattering behavior of crop canopy – crops identification and crop inventory – crop acreage estimation -reflectance properties of stressed crops, detection of stressed plants. Land use and land cover analysis
IV	Digital Soil Mapping, ML/Deep Learning for soil nutrient, disease and crop yield prediction.

References:

1. P. Christy Nirmala Mary, P. Kannan, Geospatial Technologies for Agriculture,

   ISBN: 9789390082766, 2020.
2. Bhagowati Kaushik, GIS Assisted Farm Management Information System,

   ISBN: 9783844333695, 2012.
3. V M Abdul Hakkim, GIS Integrated Site Specific Drip Fertigation,

   ISBN: 9783659261480, 2013.

Course Code	Course Name	Credits	Level
M4220421	Project/Internship	20	400

University Core

Course Code	Course Name	L-T-P -Credits	Level
M3222120	Computer Systems	4-1-0-4	300

Course Outcomes	
CO1	Computer models
CO2	Different types of data and storage
CO3	Operating systems, Programming languages, Data structures
CO4	Different types of data & security aspects

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	1	2
CO2	3	2	2	1	1	1
CO3	2	2	2	1	1	2
CO4	3	2	2	1	1	1

Module	Contents
1	Computer: Model of a computer, Data processing using a computer, Representation of numeric data and characters in computers, Acquiring text and Image data, Acquisition of textual data, Acquisition of pictures, Storage formats of pictures, Image compression fundamentals
2	Acquiring of Audio data, Basics of audio signals, storing and compression of audio signals, Capturing videl data and it's compression. Data storage, RAM, DOM, Secondary storage, Interconnection of CPU

	with memory and I/O units
3	Operating systems, Programming languages and it's classification, Computer networks, Local Area network, Wide area network, Internet, Naming of computers connected to internet Data organization, Organizing a database, Structure of a database
4	Processing different types of data, Markup languages, Audio signal processing, Business information systems, Management structure and their information needs, System life cycle Cyber security: Introduction, CIA triad, Cyber security components, Type of network attacks, Application security, Endpoint security, data security, infrastructure security, Disaster recovery.

Text Books

1. Introduction to Information Technology
   Rajaraman, V., Jan 2018 · PHI Learning Pvt. Ltd
2. Analysis and Design of Information Systems
   V. Rajaraman · 2018
3. Fundamentals of Information Technology
   By Bharihoke · 2009, Publisher:Excel Books

Course Title:	Digital Experience Laboratory (DEL)
Course Code:	M3110001
Credits:	4
Prerequisites:	Non-EE undergraduates

Course description

The main aim of this course is to provide an introduction to basic building blocks of digital technologies through labs in electronics and embedded boards that can be used for building various real-time systems projects, and seminars that give an overview of the field undergoing rapid digital transformation. The students will get a high-level overview of various technologies and how they can program them.

Course learning outcomes

CO1 Develop programming and assembly skills using various embedded boards like raspberry pi,jetson or NI Elvis tools / MyRio tools etc.
CO2 Apply basic programming skills to build simple control systems
CO3 Obtain hardware/system debugging skills
CO4 Analyze the output of the system using the basic measurements
CO5 Practice digital implementations in an application

Program Outcomes (POs)

PO 1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engg. specialization to the solution of *complex engineering problems*

PO 2. Problem analysis: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO 3. Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, *safety*, *legal*, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9. Individual and team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO 10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions

PO 11. Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

PO 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Outcome mapping

	General Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	0	0	0	0	0	0	0	0	0	0	3
CO2	3	0	0	0	0	0	0	0	0	0	0	0
CO3	3	3	0	3	0	3	0	0	0	0	0	3
CO4	3	3	0	0	3	0	0	0	0	0	0	0
CO5	3	3	0	3	2	3	3	3	3	3	3	3

Module-wise syllabus

Module 1:	Difference between sensor and transducer, Concept of IoT and Industry 4.0, What are sensor networks?, Programming examples of embedded boards (Arduino, Raspberry PI etc) and sensor interface. Basics of identifying circuit components, Basics of Breadboard,Multimeter, and CRO. *Seminar:* Evolution and history of computing, IoT/sensing in computing

Module 2:	Programming sensor interface: Arduino IDE and programming, Wiring components and breadboard, Arduino sketch and libraries, Programming controls for sensors and actuators such as: Motor and Servo, Discrete LED, seven-Segment LED Display, Pushbutton Switch, DIP Switches, Relay, Potentiometer, Thermistor, Photocell, Buzzer/Speaker *Seminar:* IoT in agriculture and GIS, Sensors for environment condition monitoring
Module 3:	Introduction to detecting movements and programming I/O: IR Range Finder, Sonic Range Finder, Accelerometer, Gyroscope; connecting to Keypad, LCD Character Display – UART Interface, and other interfaces to LCD, LED matrix *Seminar:* Sensing for gaming and multimedia, Applications in virtual and augmented reality
Module 4:	Introduction to communications:Bluetooth Module, Wifi modules, programming incloud, sensor analytics *Seminar:* Applications to edge and AI, Applications to data analytics and cloud
Module 5:	Python for programming embedded boards: Programming examples in Raspberry Pi,running standalone applications, reading camera and performing object detections *Seminar:* Applications in computer vision and imaging

Teaching plan and syllabus

Sessions	Content	Learning outcomes	Delivery type
1	Module 1 topics	1-3	Lecture, Lab
2	Module 1 topics	1-3	Lecture, Lab
3	Module 1 topics	1-3	Lecture, Lab

4	Module 2 topics	1-3	Lecture, Lab
5	Module 2 topics	1-3	Lecture, Lab
6	Module 2 topics	1-3	Lecture, Lab
7	Module 3 topics	1-3	Lecture, Lab
8	Module 3 topics	1-3	Lecture, Lab
9	Module 3 topics	1-3	Lecture, Lab

10.	Module 4 topics	2-4	Lecture, Lab
11.	Module 4 topics	2-4	Lecture, Lab
12.	Module 5 topics	2-4	Lecture, Lab
13	Module 5 topics	2-4	Lecture, Lab
14	Mini-project	5	Lecture, Lab
15	Mini-project	5	Lecture, Lab

Assessment Mapping

Assessment type	Weightage	CLO	Assessment Weeks
Quiz	10%	1-3	Week 5
Final exam	40%	4,5	Week 15
Homework	20%	1-5	Weeks 5,9, 11, 13
Lab works	30%	1-5	Week 8, Week 13

Assessment Process

Assessment type	Method	Grading Method	Remarks on Mode
Quiz	Written	Relative	Open book
Final exam	Written	Relative	Open Book
Homework	Written	Absolute	Take home

Lab works	Report and presentation	Relative	Face to face

Tools and equipment required

1. LTSpice or HSPICE or NI Elvis 3/My Rio
2. Python

Lab details

The labs are designed as introductory to embedded circuits and systems using Arduino, and Raspberry PI, with several sensors. The labs focus on providing essential skills to program microcontrollers and microprocessor based kits, and use it for various applications.

Lab session	**Content**
1	Programming with Arduino; using IDE – simple examples of using onboardsensors
2	Getting familiar with breadboards and measurements
3	Explore Arduino libraries and sketch; examples with LEDs
4	Examples with motors and LEDS using Arduino
5	Programming examples of Piezoelectric-Effect Sensor and IR sensing formonitoring environmental conditions
6	Using displays and keyboards with Arduino – example applications of user interactions
7	Connecting through wifi – examples on level control, and remote data collection over cloud
8	Programming raspberry pi through python: example of reading webcams
9	Implementing object detections through raspberry pi: example of using OpenCV

Reference books and articles

1. SPICE Circuit Handbook by Steven Sandler, McGraw-Hill Professional; 1 edition
2. Boxall, J., 2021. *Arduino workshop: A Hands-On introduction with 65 projects*. No StarchPress.
3. Schwartz, M., 2016. *Internet of things with arduino cookbook*. Packt Publishing Ltd.
4. Pajankar A. Raspberry Pi Computer Vision Programming: Design and implement computer vision applications with Raspberry Pi, OpenCV, and Python 3. Packt Publishing Ltd; 2020 Jun29.

5. Meijer, Gerard CM, ed. Smart sensor systems. J. Wiley & Sons, 2008. https://onlinelibrary.wiley.com/doi/book/10.1002/9780470866931
6. Spence, Robert. Introductory circuits. John Wiley, 2008. https://onlinelibrary.wiley.com/doi/book/10.1002/9780470694466

Class Specific Policies

Plagiarism policy: All student submissions shall be checked using Turnitin. In case, the similarity score is higher than 20%, such submissions will be marked fail.

Class attendance: There is no weightage given for class attendance in the assessment. It is required that student attend 70% of the lectures to be eligible for writing the final exam.

Cheating: Cheating in any form during exams will result in automatic failure of the course. All cases of cheating will be referred to the school disciplinary committee and relevant university policy regarding this will apply.

Lecture recording: All lectures delivered online shall be recorded and provided to the students