DIGITAL UNIVERSITY KERALA

Curating a responsible digital world

Post Graduate Programme Syllabus

School of Digital Sciences

Kerala University of Digital Sciences, Innovation and Technology

Technocity Campus, Mangalapuram, Thiruvananthapuram, India

-2023-

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 the school's academic activities.

Vision & Mission

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

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

Objectives

Industry Revolution 4.0 mainly depends on artificial intelligence, and most of the developments in AI depend on the knowledge and information we are gathering from the data the entire universe is creating every second. As we live in the emerging data-driven world, decision support systems based on the insights derived from data are receiving much acceptance in every branch of science/technology or even the arts. We can consider data analytics as a trans-disciplinary subject that brings Data, technology, information, statistical/mathematical analysis, and domain knowledge under a single umbrella. The success of the current era can be defined as the amount of useful data the organization is

creating or gathering and processing for fruitful insights using computational methods applying mathematical/statistical frameworks.

Although several organizations started adopting IR 4.0 in our country, India still doesn't have enough human resources to cater to the needs of Industry/Academia or R&D. The parent organization of DUK – IIITMK has made significant progress in this direction. We offered courses in cutting-edge technologies in data analytics, machine learning, and deep learning. To keep the momentum of our state and our country marching towards becoming the industry leader in Information Technology and to take a leadership position for the world in the Industry 4.0 revolution, we need to create trained human resources in this area. The focus of the courses offered by the School of Digital Sciences is to develop quality human resources so that they can lead the digital transformation of our country.

Academics

The proposed MSc courses are designed to cater mainly to the industry needs of Data Analysts, Data Engineers, Data Scientists at various levels in different domains. The suitable skills sets for the industry are:

- In-depth Knowledge of Data Analytics & Machine Learning
- Decent Knowledge of Statistics and Mathematics
- Good skills in Natural Language Processing & Information retrieval
- Deep knowledge in Python Programming and Database management systems
- Basic knowledge of Computer Science
- Spatial Applications of Data Analytics/Machine Learning
- Computational methods to complement data analytics in real life problem solving

Based on the contents in the course, we categorized the courses in five levels which are given below

Course Categorization

- 100 Level - Undergraduate level basic course
- 200 Level - Undergraduate level advance course

- 300 Level - Postgraduate level instruction based course
- 400 Level - Postgraduate level seminar/ research level course
- 500 Level - Research level course

Program Educational Objectives (PEO)

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 computational problem-solving skills and R&D

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

Program learning outcomes

PO1: Develop strong fundamental knowledge in the area of study

PO2: Identify, formulate, and analyze 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, the ability to write grants, entrepreneurial skills, and writing articles for scholarly journals if it is taught by faculty in the department.

Pass Criteria

(a) The student shall obtain a minimum D grade in all core courses and a **C** grade in the project. A minimum CGPA of 5 is required to award the master's degree.

(b) The 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.

(c) Students must comply with the following credit limits to successfully complete a master's program.
   (i) Complete at least 65 Credits, with an upper limit of 70 credits.
   (ii) The students can get maximum of 30 Credits through core/subject specific electives.
   (iii) 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 failing grade if she/he fails to complete a summative or formative assessment. If a student gets, 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, activities as well as one university core course. Details of the credit distribution is given below

Credit distribution of the MSc programmes offered by the School

Program courses (30 credits)		**University courses (20 credits)**		**Final year Projects**	**Additional credits beyond mandatory coursework and project**		
Program Core (Mandatory)	**Program electives** (Mandatory)	**University Core** (Mandatory)	**Open electives** (Mandatory)	**Capstone Project/ Thesis** (Mandatory)	**Activity credits** (Mandatory)	**Activity credits** (Optional)	**Additional courses** (Optional)
15 credits	**15 credits**	**5 credits**	**15 credits**	**15 credits**	**5 credits**	**5credits**	**5 credits**

Project/Internship

A student is required to do a project during the Semester 4, independently under the guidance of any institute faculty member or as an internship project in an industry or any reputed academic/research institute. If a student opts for an internship project in an industry or any other reputed academic/research institute, he must have an internal guide from the institute. The project/internship aims to allow the student 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 must submit a report on 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 an internal committee comprising of the institute's faculty members, including the project guide, and an external committee constituted by the university. The project/internship carries 15 credits.

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

Course level	**Remarks**
100 - 300	- 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	- The school's instructor and/or graduate studies committee shall conduct the summative examination for 400 Level courses. - A committee of two faculty members shall conduct the valuation. The valuation shall be based on the student's open seminar and term report. - The valuation shall be based on the student's open seminar and term report.
500	- 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. - Research output is expected to be suitable for publication in a journal or leading conference.

Grade Point Calculation

A letter grade system evaluates individual work items according to the University's Policies and Procedures requirements. The university follows a 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, and an "I" will represent incomplete.

Curriculum of MSc Programs offered by SoDS

School of Digital Sciences currently offers the following programs in the academic year 2023-24

- MSc in Computer Science with Specialization in Data Analytics
- MSc in Data Analytics & Computational Science
- MSc in Data Analytics & Geoinformatics
- MSc in Data Analytics & BioAI

Semester-wise split of the category of all programs

Semester I

Course Code	Title of the course	Credits
	University core	3

	Programme Core	9
	Programme elective	3
	Scientific Writing & Communication (Activity)	2
	Total	**17**

Semester II

Course Code	**Title of the course**	**Credits**
	University core	2
	Open Elective	6
	Programme Core	6
	Programme elective	3
	Industry readiness programme (Activity)	2
M3220260	Mini project (OE)	1
	Total	**20**

Semester III

Course Code	**Title of the course**	**Credits**
	Open Elective	6
	Programme elective	9
	Industry readiness programme (Activity)	1
M3220360	Mini project (OE)	2
	Total	**18**

Semester IV

Course Code	**Title of the course**	**Credits**
M4220451	Internship/Thesis	15

	Total	**15**

Core Courses for each of the programmes

MSc Computer Science with Specialization in Data Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220151	Introduction to Computer Science (Sem I)	3	300	2-0-1-0
M3220152	Database Systems (Sem I)	3	300	1-2-0-0
M3220153	Data Analytics (Sem I)	3	300	1-1-0-1
M3220251	Predictive Analytics (Sem II)	3	300	1-1-0-1
M3220252	Web Technology (Sem II)	3	300	1-1-0-1

MSc Data Analytics & Computational Science

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220151	Introduction to Computer Science (Sem I)	3	300	2-0-1-0
M3220153	Data Analytics (Sem I)	3	300	1-1-0-1
M3220154	Introduction to Computational Science (Sem I)	3	300	2-1-0-0

M3220251	Predictive Analytics (Sem II)	3	300	1-1-0-1
M3220253	Numerical Methods (Sem II)	3	300	1-1-0-1

MSc Data Analytics & BioAI

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220153	Data Analytics (Sem I)	3	300	1-1-0-1
M3220155	Molecular Biology (Sem I)	3	300	2-0-1-0
M3220156	Bioinformatics (Sem I)	3	300	1-1-1-0
M3220251	Predictive Analytics (Sem II)	3	300	1-1-0-1
M3220254	NGS & Genome Data Analytics (Sem II)	3	300	1-1-0-1

MSc Data Analytics & Geoinformatics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220153	Data Analytics (Sem I)	3	300	1-1-0-1
M3220157	Geographic Information System (Sem I)	3	300	2-1-0-0
M3220158	Remote sensing and earth observation (Sem I)	3	300	2-1-0-0

M3220251	Predictive Analytics (Sem II)	3	300	1-1-0-1
M3220255	Advanced Geospatial Analytics (Sem II)	3	300	1-1-0-1

Courses offered as electives

Students can opt for electives from the following list in the first/second or third semester based on the recommendations of the mentor/course coordinator. The School will decide the list of electives to be offered each semester based on requirements from students and availability of faculty.

List of Elective courses offered by School of Digital Sciences

Course Code	Title of the course	Credits	Programs	Level	Credit Split Lecture-Lab-Seminar-Project	Semester at which the course may be offered
M3220252	Web Technology	3	Computational /Bio AI/ Geoinformatics	300	1-1-0-1	2nd/3rd sem
M3221151	Programming with Python	3	All programs	300	1-1-0-1	1st / 2nd sem
M3222251	Cloud Computing	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221252	Natural Language Processing	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221253	Information Retrieval	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221254	Anomaly detection & Fraud Analytics	3	All programs	300	1-1-0-1	2nd/3rd sem2nd/3rd sem
M3221255	Social Network Analysis &	3	All programs	300	1-1-0-1	2nd/3rd sem

	Semantic Web					
M3221256	Generative AI	3	All programs	300	1-1-1-0	2nd/3rd sem
M3221257	Time series analysis & SEM Modeling	3	Computer Science/ Computational Science	300	1-1-0-1	2nd/3rd sem
M3221258	Healthcare Analytics	3	BioAI	300	1-1-0-1	2nd/3rd sem
M3221259	Deep learning & MLOps	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221260	Advanced Programming	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221261	Advanced Geospatial Programming	3	Geoinformatics	300	1-1-0-1	2nd/3rd sem
M3221262	Advanced Machine Learning	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221263	Spatial Data Analytics	3	Computer Science/Geoinformatics	300	1-1-0-1	2nd/3rd sem
M3221264	Thermal and Hyperspectral remote sensing	3	Geoinformatics	300	1-0-1-1	2nd/3rd sem
M3221265	Microwave remote sensing	3	Geoinformatics	300	1-0-1-1	2nd/3rd sem
M3221266	Spatial Bigdata Analytics	3	Geoinformatics	300	1-1-0-1	2nd/3rd sem
M3221267	Web and Mobile GIS	3	Geoinformatics	300	1-1-0-1	2nd/3rd sem

M3221268	Topographic Data Analysis Techniques and Applications	3	Geoinformatics	300	1-1-0-1	2nd/3rd sem
M3221269	Geospatial Applications in Agriculture	3	Geoinformatics	300	1-1-0-1	2nd/3rd sem
M3221270	Computational Chemistry	3	Computational science/BioAI	300	1-1-0-1	2nd/3rd sem
M3221271	Computational Neuroscience	3	Computational science/BioAI	300	2-0-0-1	2nd/3rd sem
M3221272	Geospatial Applications for Environment and Climate change	3	Geoinformatics	300	2-0-0-1	2nd/3rd sem
M3221273	Geospatial Applications for Hydrological Modeling	3	Geoinformatics	300	1-1-0-1	2nd/3rd sem
M3221274	Geospatial Applications in Urban and Regional Planning	3	Geoinformatics	300	2-0-0-1	2nd/3rd sem
M3221275	AI applications in agriculture	3	BioAI	300	1-1-0-1	2nd/3rd sem
M3221276	Computational Finance	3	Computational Science	300	1-1-0-1	2nd/3rd sem
M3221277	Structural Biology and Drug Design	3	BioAI	300	1-1-0-1	2nd/3rd sem
M3221278	Parallel and GPU programming	3	Computer Science/Computational Sciences	300	1-1-1-0	2nd/3rd sem

M3221279	Ethics in Data	3	All programs	300	1-0-2-0	2nd/3rd sem
M3221280	Data Security	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221281	Data Engineering	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221152	Differential Equations	3	Computational science	300	1-1-1-0	1st/2nd Sem
M3221282	Numerical Linear Algebra	3	Computational Science	300	1-1-1-0	2nd/3rd sem
M3221283	Data Structures and Algorithm	3	All programs	300	1-1-0-1	2nd/3rd sem
M3221284	Functional Genomics	3	BioAI	300	2-0-0-1	2nd/3rd Sem
M3221285	Advanced Healthcare Analytics	3	BioAI	300	2-1-0-0	3rd Sem

- Student may opt for any course offered by other schools/same school as open electives
- Activities include mini projects/group projects/NSS/paper publications/product development etc

Syllabus

Core courses

Introduction to Computer Science

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220151	Introduction to Computer Science	3	300	2-0-1-0

Course Outcomes	
CO1	Analyze and differentiate computer system components and identify the relationships between hardware and software within a computing environment.
CO2	Evaluate and categorize operating system functionalities and understand how these systems manage processes, memory, files, and user interactions.
CO3	Demonstrate the ability to categorize and compare network protocols, devices, and addressing schemes, forming connections between different layers of network architecture.
CO4	Design and appraise the implementation of computer science concepts in real-world scenarios while recognizing and assessing their applications' ethical and societal implications.

Mapping of Course Outcomes with Programme 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	**Contents**					

I	Computer Systems and Architecture - Introduction to Computer Systems: Overview of computer components and their roles, Evolution of computing systems and key milestones, Binary Representation and Data Storage: Binary representation of data and numbers, Data storage units - bits, bytes, kilobytes, etc., ASCII and Unicode, CPU Architecture and Instruction Set: Basic CPU architecture - ALU, registers, control unit, Fetch-execute cycle and instruction execution, Instruction sets and assembly language, Memory hierarchy: registers, cache, RAM, virtual memory, Storage devices: HDDs, SSDs, optical drives, File systems, Output devices: monitors, printers, speakers, etc., I/O communication and device management.
2	Introduction to Operating Systems - Definition and functions of an operating system, Types of operating systems: batch, interactive, real-time, etc., Process Management - Processes and threads: definitions and differences, Process states and life cycle, Context switching and multitasking, Memory Management - Virtual memory concept and paging, Memory allocation: segmentation, paging, demand paging, Memory protection and addressing, File Systems and Storage Management- File system structure and organization, File operations: create, read, write, delete, Disk scheduling and storage optimization, User Interface and System Utilities - Command-line interfaces (CLI) and graphical user interfaces (GUI), System Utilities: text editors, file browsers, terminal commands, User management, and security considerations.
3	Introduction to Computer Networks - Definition of computer networks and their importance, Types of networks: LAN, WAN, MAN, PAN, WLAN, etc., Network Protocols and Layers - OSI model and its layers, Common network protocols: TCP/IP, HTTP, FTP, SMTP, etc., Data encapsulation and packet structure, Networking Devices and Topologies - Network devices: routers, switches, hubs, gateways, etc., Network topologies: star, bus, ring, mesh, hybrid, Network Addressing, and Subnetting - IP addressing: IPv4 vs. IPv6, Subnetting, DHCP, NAT/PAT, Network Security - Network security threats: malware, phishing, DoS, etc., Firewalls, VPNs, and secure communication protocols.
4	Practical Applications and Case Studies - Client-Server Architecture: Understanding client-server interaction, Practical examples: web servers, email servers, game servers, Cloud Computing Fundamentals: Cloud deployment models: IaaS, PaaS, SaaS, Virtualization and cloud service providers, Emerging Trends in Computer Science: Quantum computing, Edge computing, and distributed systems, Ethical and Social Implications of Computing: Privacy concerns and data security, Algorithmic bias and digital divide.

References

1. "Structured Computer Organization" by Andrew S. Tanenbaum
2. "Operating System Concepts" by Abraham Silberschatz, Peter B. Galvin, and Greg Gagne
3. "Modern Operating Systems" by Andrew S. Tanenbaum and Herbert Bos
4. "Computer Networking: A Top-Down Approach" by James F. Kurose and Keith W. Ross
5. "Cloud Computing: Concepts, Technology & Architecture" by Thomas Erl, Ricardo Puttini, and Zaigham Mahmood

Database System

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220152	Database Systems	3	300	1-2-0-0

Course Outcomes	
CO1	Summarize the basic concepts and applications of Database Management System.
CO2	Design Entity – Relationship diagram and convert into the corresponding logical schema.
CO3	Write SQL queries based on the given requirements
CO4	Summarize the architecture and features of distributed databases

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

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	Distributed Databases: Architectures for parallel databases, Parallel query evaluation; Parallelizing individual operations, Sorting, Joins; Distributed database concepts, Data fragmentation, Replication, and allocation techniques for distributed database design; Query processing in distributed databases; Concurrency Control and Recovery in distributed databases. NoSQL- The Emergence of NoSQL, MongoDB, Cassandra, HBASE, Neo4j use and deployment, Application, Challenges NoSQL approach, Key-Value and Document Data Models, Column-Family Stores

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.

Data Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220153	Data Analytics	3	300	2-1-0-0

Course Outcomes	
CO1	Introducing data science
CO2	Building data models
CO3	Data Quality and ethics, Data Visualization and story telling
CO4	Data warehousing

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	0	2

Module	Content

1	Introduction to Data Science, Data Science and It's applications, Building models, Data Science Project Life Cycle4 Data Quality and Data Preparation, Data Exploration, Data types Data cleaning: Problems with data and data cleaning methods, Data Integration, Redundancy and correlation analysis Data Transformation and discretization: Converting data types, Normalizing and scaling numerical features, Encoding categorical variables, Creating derived features and aggregating data
2	Feature Engineering:: Selecting relevant features for analysis, Creating new features that capture valuable information from the existing data., Understanding domain knowledge to engineer meaningful features. 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 Validation and Sanity Checks: Verifying the integrity and accuracy of data using validation rules and logic checks. Cross-validating data against external sources or known benchmarks. Ethics in data. Data security
3	Data Visualization : Theory of data visualization, Univariate visualizations: Different types of data visualizations, Color theory, Choosing the right data visualizations. Visual hierarchy, Associability and inclusivity, Interactive data visualizations Multivariate visualizations : Scatterplot, Bubble chart, Visualizing high dimensional data, Exploratory data Analytics. Data Storytelling
4	Data Warehousing and Online Analytical Process Introduction to data warehousing:, Data modeling, Data extraction, transformation, and loading (ETL): Data warehouse design: Data warehouse administration, Data warehouse applications.

Text Books

Géron, Aurélien. The Data Science Handbook: A Practical Guide to Getting Started with Data Science. O'Reilly Media, 2017.

CareerFoundry. "What is Data Analytics? A Complete Guide for Beginners." CareerFoundry, 2023.

Pauwels, Michael C. J. Data Science and Analytics: An Introduction. Cambridge University Press, 2021.

References:

Bard. Introduction to Data Analytics. Mindmajix, 2023.

Introduction to Computational Science

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220154	Introduction to Computational Science	3	300	2-1-0-0

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

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	0	0	0
CO2	3	2	2	0	0	0
CO3	3	2	2	0	0	0
CO4	3	2	2	0	0	0

Module	Content
1	Introduction to scientific computing, its 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, Secant method, Brent's method, Error Analysis, Accelerating Convergence, Polynomial Evaluation – Horner's rule, Zeros of polynomials and Muller's Method, Systems of Linear Equations: Gaussian Elimination, Triangular decomposition, LU decomposition, Cholesky decomposition, Pivoting strategies, Error analysis and Operations count, Ill-conditioning and condition number of system, Jacobi, Gauss-Seidel, Conjugate Gradient,
3	Evaluation of determinants, Eigenvalue Computations : Diagonalization of system of ODE, Power Method, Given's and Householder's methods for Tridiagonalization, Lanczos Method, QR Factorization
4	Curve fitting and Approximation : Lagrange's interpolation, Newton interpolation, Polynomial wiggle problem, Polynomial extrapolation, Spline interpolation, Least Square Method – line and other curves, Orthogonal Polynomials, Tchebyshev interpolation, Fourier approximation and Fast Fourier, Transforms (FFT) algorithm.

References:

1. Numerical Methods in Engineering with Python, Jaan Kiusalaas, Cambridge University Press, 2010.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, New Age International Publishers, 2007, 5th edition.
3. R.L. Burden, J. D. Faires, Numerical Analysis, Richard Stratton, 2011, 9th edition.
4. S.D. Conte and Carl de Boor, 'Elementary Numerical Analysis; An Algorithmic Approach'. International series in Pune and Applied Mathematics, McGraw Hill Book Co., 1980.
5. S. S. Sastry, Introductory methods of Numerical Analysis, 2012, PHI Publishers, 5th edition,

Molecular Biology

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220155	Molecular Biology	3	300	2-0-1-0

Course Outcomes	
CO1	Understanding nucleic acids ands and their functions
CO2	Exploring protein structure and function
CO3	Molecular processes and flow of genetic information
CO4	Importance of enzymes and their functions

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

Module	Content

1	Importance of molecular biology, introduction to central dogma of life. Nucleic acids: Nucleic acid as the genetic material, structure and functions of nucleic acids, nucleosides and nucleotides, purines and pyrimidines, biologically important nucleotides, Watson and Crick model of DNA, structure and types of RNA.
2	Amino acids: Amino acids as the building blocks of proteins, structure of standard amino acids, classification of amino acids, essential amino acids, zwitterions, physical and chemical properties. Proteins: Classification of proteins on the basis of composition and solubility, nutritive value, conformation and function; structural organization of proteins - primary, secondary, tertiary and quaternary structures; forces stabilizing protein structure and shape, structure of peptide bond, denaturation of proteins, Ramachandran Plot
3	Central dogma of molecular biology DNA replication: semi-conservative model, different enzymes and their functions in replication, types of DNA damage and repair mechanisms. Transcription: 3 stages-initiation, elongation and termination; sense and antisense strands, promoter, post-transcriptional modifications, introns and exons, splicing, reverse transcription. Translation: 3 stages-initiation, elongation and termination, ribosome-E, P, A sites, codons and anti-codons, stop codons, gene and genetic code. Mutations: Point mutations-transitions and transversions; silent, missense, nonsense mutations; Frame shift mutations.
4	Enzymes: Nomenclature, classification and characteristics of enzymes; holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups; enzyme catalysis- activation energy and transition state; enzyme activity and specificity, factors affecting enzyme activity, active site, Enzyme kinetics - concept of ES complex, Michaelis-Menten Equation, Enzyme inhibition: reversible – competitive, non-competitive and un-competitive inhibitions, irreversible inhibition.

References:

1. Fundamentals of Biochemistry-Life at the Molecular Level, Donald Voet, Judit G Voet, Charlotte W Pratt, Wiley, ISBN 978-1-118-91840-1.
2. Biochemistry, U Satyanarayana, U Chakrapani, Elsevier, ISBN 978-81-312-3601-7.

Bioinformatics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220156	Bioinformatics	3	300	1-1-1-0

Course Outcomes	
CO1	Foundations of bioinformatics
CO2	Bioinformatics databases and tools
CO3	Genomic data analysis and alignment techniques
CO4	Exploring proteomics and its applications

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

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

Module	Content
1	Introduction to Bioinformatics, cell as the basic unit of life- gene, genome, genetic code; Omics-genomics, proteomics, pharmacogenomics, phenomics, metabolomics, transcriptomics, interactomics, epigenomics; applications of bioinformatics. Human Genome Project: an overview of the project, goals and major scientific strategies of HGP, expected scientific and medical benefits of the project.
2	Bioinformatics databases: Categories of databases- sequence databases, structure databases, genome databases, proteomic databases, chemical databases, enzyme databases, expression databases, pathway databases, disease databases; primary databases and secondary databases. Nucleotide sequence databases-GenBank, EMBL, DDBJ; Protein databases-UniProt, Swiss-Prot, TrEMBL, PDB, PIR-PSD; Genome Databases- NCBI, EBI, TIGR, SANGER; Protein-Protein interaction databases-STRING; Structure databases- Protein Data bank (PDB), Nucleic Acid Data Bank (NDB), Molecular modelling Data Bank (MMDB), PubChem, ChEMBL, ZINC; Gene expression databases- GEO, SAGE.
3	Genomics: Genome Mapping, DNA Sequencing methods, basic concepts of similarity searching and sequence alignments, genomic data and data organization, DNA sequence analysis, identity and homology, local and global alignment, Smith Waterman and Needleman-Wunsch algorithms, scoring matrices- PAM and BLOSUM matrices, gap penalty. Functional genomics, pairwise sequence alignments, Multiple sequence alignments, BLAST (Basic Local Alignment Search Tool), Nucleotide BLAST, Protein BLAST, PSI-BLAST, PHI-BLAST, PSSM, Analysis of BLAST results, E Value, sensitivity and specificity of BLAST, FASTA sequence similarity search, ClustalW, TCoffee.
4	Proteomics: Protein-isolation, identification and characterisation methods, protein sequence analysis and structure prediction, homology modelling, branches of proteomics- phosphoproteomics and glycoproteomics, expression proteomics, structural proteomics and functional proteomics; applications of proteomics in medicine-biomarker discovery and drug discovery.

References:

1. Bioinformatics-Databases, tools and algorithms, Orpita Bosu, Simminder Kaur Thukral, OXFORD Higher Education, ISBN0-19-567683-1.
2. Bioinformatics for Beginners-Genes, genomes, molecular evolution, databases and analytical tools, Supratim Choudhuri, Elsevier, ISBN: 9780124104716.

Geographic Information System (GIS)

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220157	Geographic Information System (GIS)	3	300	2-1-0-0

Course Outcomes	
CO1	Understanding the relevance of spatial cognition/information and spatial processes
CO2	Have a basic understanding of the nature of spatial data
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						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	1
CO2	2	3	1	2	1	1

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

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, neighborhood analysis. Terrain analysis, spatial interpolation, surface analysis. Spatial data visualization.

References:

[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 edition: Oxford University Press, 2016.

Remote Sensing and Earth Observation

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220158	Remote Sensing and Earth Observation	3	300	2-1-0-0

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	3	2	1	1	1	1
CO2	2	2	1	2	1	1
CO3	2	1	2	2	1	1
CO4	3	2	2	1	1	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 patterns.
2	Earth observation systems – Platforms – Orbits – Sensors – Concept of Resolution: Spatial, Spectral, Radiometric and Temporal – Multispectral Scanning. Elements of Visual Image Interpretation – Visual Data interpretation keys. Characteristic of Earth Observation satellites: IRS, Landsat, Sentinel.
3	Types of Remote Sensing System: Based on Energy sources and Range of EMS – Characteristics of Optical, Thermal and Microwave and Hyperspectral Remote Sensing. 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 cloud-based geospatial platform– Code editor – Datasets and case studies.

References:

[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.

[4] Borengasser, M., Hungate, W. S., & Watkins, R. (2007). Hyperspectral remote sensing: principles and applications. CRC press.

[5] Chang, C. I. (Ed.). (2007). Hyperspectral data exploitation: theory and applications. John Wiley & Sons.

[6] Kuenzer, C., &Dech, S. (2013). Thermal infrared remote sensing. Remote Sensing and Digital Image Processing. doi, 10(1007), 978-94.

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

Predictive Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220251	Predictive Analytics	3	300	1-1-0-1

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

Module	Content
1	Types of Analytics, Introduction to Predictive Analytics, Types of Predictive Analytics: Supervised, Unsupervised, Semi-supervised, and Reinforcement Learning, , Model Evaluation: Metrics such as accuracy, precision, recall, F1-score, and confusion matrix,

	Email spam detection using Naive Bayes classifier (Supervised Learning), Clustering customer segments in an e-commerce dataset (Unsupervised Learning).
2	Supervised Machine Learning Algorithms: Linear Regression: Single and multiple variables, gradient descent, and regularization, Logistic Regression: Binary and multiclass classification, softmax function, Decision Trees and Random Forests: Ensemble methods, bagging, and boosting techniques, Support Vector Machines (SVM): Linear and kernel SVM, hyperplane, and margin, Predicting housing prices using Linear Regression, Image classification using Logistic Regression and SVM.
3	Clustering, Hierarchical clustering, k-means clustering, Birch clustering, Measuring cluster goodness, Association rules, Affinity and Market Basket analysis, Reinforced Learning Introduction to reinforcement learning, Markov decision processes, Q-learning. Policy gradients, Applications of reinforcement learning

Text Books :

(1) Introduction to Machine Learning" by Ethem Alpaydin
(2) Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow; by Aurélien Géron
(3) Pattern Recognition and Machine Learning by Christopher M. Bishop
(4) Interpretable Machine Learning by Christoph Molnar

Web Technology

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220252	Web Technology	3	300	1-1-0-1

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.

References :

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.

Numerical Methods

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220253	Numerical Methods	3	300	1-1-0-1

Course Outcomes	
CO1	Implementing numerical methods to solve ordinary differential equations
CO2	CO2 Employ numerical techniques to compute derivatives and integrals of functions, evaluating their accuracy and error bounds.
CO3	Understanding and visualizing the numerical solution of differential equations
CO4	Evaluate the stability and convergence properties of finite difference schemes.

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	0	0	0
CO2	3	2	2	0	0	0
CO3	3	2	2	0	0	0
CO4	3	2	2	0	0	0

Module	Content
1	Classification of ODEs (Linear, Non-linear, Exact), Geometric meaning of $y' = f(x, y)$, Direction Fields, Numerical methods for solving ODEs, Euler's Method, Runge-Kutta methods, Multistep methods (e.g., Adams-Bashforth, Adams-Moulton), Implicit methods (e.g., backward Euler, implicit trapezoidal)

2	Integrating Factor, Bernoulli Equations, Initial Value Problem, Boundary value problems Existence and Uniqueness, Picard's method, Modeling (Free falling object, Radioactivity, RL-circuit).
3	Homogeneous Linear ODEs, Modeling of Free Oscillations of a Mass-Spring System Euler-Cauchy Equations, Modeling Engineering problems (Electric Network, Mixing problem in two tanks etc.) as systems of ODEs, Couette flows, Pharmacokinetics, Modeling with delay differential equations
4	Numerical Integration,Trapezoidal rule, Simpson's rule, Composite numerical integration, Gaussian quadrature, Modeling with matrices, Shooting methods, Finite difference methods for boundary value problems, Initial Value Problems:- Predictor-corrector methods, Multistep methods, Numerical Solutions to PDE, Finite difference methods, Finite element methods, Finite volume methods, Spectral methods

References :

1. Numerical Methods in Engineering with Python, Jaan Kiusalaas, Cambridge University Press, 2010. 2. M.K. Jain, S.R.K. Iyengar and R.K. Jain,
2. Numerical methods for scientific and Engineering computation, New Age International Publishers, 2007, 5th edition,
3. R.L. Burden, J. D. Faires, Numerical Analysis, Richard Stratton, 2011, 9th edition.
4. S.D. Conte and Carl de Boor, 'Elementary Numerical Analysis; An Algorithmic Approach'. International series in Pune and Applied Mathematics, McGraw Hill Book Co., 1980.
5. S. S. Sastry, Introductory methods of Numerical Analysis, 2012, PHI Publishers, 5th edition
6. Willaim Boyce and Richard DiPrima, Elementary Differential Equations and Boundary Value Problems, 11th Edition, Wiley-India
7. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley-India.

NGS & Genome Data Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220254	NGS & Genome Data Analytics	3	300	1-1-0-1

Course Outcomes	
CO1	Proficiency in NGS data analysis
CO2	Genomic variation and functional annotation
CO3	Omics data integration and phylogenetic analysis
CO4	Multi OMICS and its applications in precision medicine

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

Module	Content
1	Next Generation Sequencing (NGS) Technologies, NGS data formats and data quality check, sequence assembly concepts and challenges in assembling short reads, algorithms for assembling short reads using graph theory, genetic variant detection and CNV analysis, gene prediction and annotation, gene ontology, concepts and algorithms to measure transcriptional regulation, methylation and alternative splicing, gene expression analysis

	using RNA-seq data, mass-spec protein sequencing for proteome annotation and analysis.
2	Genome-wide association study (GWAS) and whole-genome sequencing (DNA-seq), Sequence Read Archive (SRA) and Gene Expression Omnibus (GEO) databases, integrative analysis of omics data- concatenation based, transformation based and model-based integration, machine learning for predictive modelling and analysis of omics data, tools for omics data analysis, challenges for omics data analysis, metabolomics: analysis workflow and its main analysis softwares- MetaboAnalyst.
3	Phylogenetic analysis: Basics of phylogeny, gene phylogeny versus species phylogeny, phylogenetic tree of life, phylogenetic tree construction methods: distance-based methods, character-based methods, phylogenetic analysis tools-PHYLIP, ClustalW. Detection of functional sites, gene expression, codon-bias detection, OMIM database analysis, comparative genomics-basic concepts, identification of protein coding genes, genome analysis tools-Artemis.
4	Multi-omics: Multi-omics databases- OASIS, BCIP, ProteomicsDB, data integration and interpretation- bioCancer, MiBiOmics, PaintOmics, Precision medicine- gene therapy and gene editing technology, CRISPR technology, importance of pharmacogenomics in precision medicine.

References:

1. Bioinformatics-Databases, tools and algorithms, Orpita Bosu, Simminder Kaur Thukral, OXFORD Higher Education, ISBN0-19-567683-1
2. Next Generation Sequencing and Data Analysis 2021, Melanie Kappelmann-Fenzl, Springer, ISBN: 978-3-030-62489-7
3. Data Analysis and Visualization in Genomics and Proteomics, Francisco Azuaje, Joaquin Dopazo, Wiley, ISBN: 978-0-470-09439-6.

Advanced Geospatial Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3220255	Advanced Geospatial Analytics	3	300	1-1-0-1

Course Outcomes	
CO1	CO1 Understanding manipulation of vector and raster data for geospatial modeling and analysis
CO2	CO2 Understanding and approaching spatial analysis based on map algebra
CO3	CO3 Understanding the concepts and developing the skills in network analysis of spatial data
CO4	CO4 Understanding of Temporal data and its analysis

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

Module	Content

1	Advanced manipulation of vector and raster data. Spatial joins, aggregations, and advanced filtering techniques. Network modeling and analysis, Types of networks, Network data set and model construction, Network Analysis operations – Optimal Routes and Optimal Tours, Location and Service Area Problems, Algorithms related to Network Analysis, Applications
2	Working with spatio-temporal Data, spatio-temporal data types, managing temporal data, Visualizing and analysing spatio-temporal data – spatio-temporal estimation techniques.
3	Geo-computation methods and modeling, Geo-simulation, Geospatial Applications of generic algorithms, Artificial Neural Networks, Agent Based Modelling, Cellular Automata

References :

[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 5th edition, Troubador Publishing Ltd, 2015.

[3] Tsung Chang Kang , Introduction to Geographic Information Systems, Tata McGraw – Hill Publishing Company Limited, New Delhi, 2002

[4] Mitchell A, The ESRI Guide to GIS Analysis Volume 1 : Geographical Patterns and Relationships, Environmental Systems Research Institute, Inc.,Red lands, Calinfornia,USA

Courses offered as electives

Programming with Python

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221151	Programming with Python	3	300	2-0-1-0

Course Outcomes	
CO1	Apply data encoding and computational problem solving skills
CO2	Practice algorithm implementation to solve computational problems involving control structures and built-in data structures.
CO3	Obtain modularization, basic object oriented programming and basic graphical programming skills
CO4	Develop file processing, exception handling, multithreading and CGI skills

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	0	0	0
CO2	3	2	2	0	0	0
CO3	3	2	2	0	0	0
CO4	3	2	2	0	0	0

Module	Content
1	Basics: Information & Data, Analog & Digital systems, Bits, Bytes & Bit patterns, Numeral Systems, 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.
2	Data and expressions: Comment statements, Literals, Variables and identifiers, Keywords, Operators, Expressions and Data Types, Operator precedence and associativity, Type conversion. Environment variables, Formatting numbers, the format method. Control structures: Boolean expressions, One and multi-way selection, Iterative control, Nested loops, Indentation, break and continue statements.
3	Collections: Range function, Lists, Tuple, Sets and Dictionaries - Creating, Accessing, Basic operations and Methods, Sorting and Copying. String formatting and processing. Functions: 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.
4	Object-oriented programming basics: Objects, abstraction, encapsulation, classes, the __init__() method. Modules: Modules, Packages, Standard Library modules. Iterators: Sequences, iterables, iterator protocol. Generators: Generator functions and expressions.
5	Files: Types of files, Opening, Closing, Reading and Writing files. Exceptions: Catching and handling exceptions, multiple exceptions. Graphics: Turtle Module, Drawing with colors, Drawing basic shapes using iterations, Creating bar charts. Multi-threading, CGI, Data processing pipelines.

References:

1. Charles Dierbach, “Introduction to Computer Science Using Python: A Computational Problem-Solving Focus”, Wiley.
2. Ashok Namdev Kamthane, Amit Ashok Kamthane, “Programming and Problem Solving with Python”, McGraw Hill Education.
3. Jake Vander Plas, “Python Data Science Handbook – Essential Tools for Working with Data”, O’Reilly Media, Inc.
4. Zhang.Y. , “An Introduction to Python and Computer Programming”, Springer Publications.
5. Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython” O’Reilly Media.
6. Haslwanter, T., “An Introduction to Statistics with Python”, Springer.

Differential Equations

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221152	Differential Equations	3	300	1-0-1-1

Course Outcomes	
CO1	Implementing numerical methods to solve ordinary differential equations
CO2	Employ numerical techniques to compute derivatives and integrals of functions, evaluating their accuracy and error bounds.
CO3	Understanding and visualizing the numerical solution of differential equations
CO4	Evaluate the stability and convergence properties of finite difference schemes.

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	0	0	0
CO2	3	2	2	0	0	0
CO3	3	2	2	0	0	0
CO4	3	2	2	0	0	0

Module	Content
1	Some basic differential equation models and Euler's Method. More accurate methods for Initial Value Problems. Theory and Error analysis for Initial Value Problems. Adaptive, multistep, and other numerical methods for IVPs , Systems of First Order Differential Equations. Notations and relations. Two-dimensional First Order Systems. Phase-plane analysis for First-Order systems. General First-Order systems and higher-order differential equations.

2	Boundary Value problems. How can they be solved numerically, BVP: the linear shooting method, the nonlinear shooting method. The finite difference method for linear BVPs. Rayleigh-Ritz methods
3	Introduction to Partial Differential Equations. How to get a 3d-plot in Matlab. Some concepts of PDEs. Finite Difference Methods for Elliptic Equations. General boundary conditions for elliptic problems and block matrix formulations. Concepts of Hyperbolic PDEs. Finite difference methods for hyperbolic PDEs. Finite difference methods for Parabolic PDEs.
4	An introduction to the finite element method. Two-dimensional mesh generation and Basis Functions. The finite element method for Elliptic PDEs.

References:

1. ADZIEVSKI K, SIDDIQI AH, 2014 Introduction to Partial Differential Equations for Scientists and Engineers
   Using Mathematica. CRC Press, Taylor & Francis Group.

2. STANOYEVITCH A, 2005 Introduction to Numerical Ordinary and Partial Differential Equations Using Matlab. Primera Edición. New Jersey: John Wiley & Sons.

3. WATTS RG, 2007 Essentials of Applied Mathematics for Scientists and Engineers. Morgan & Claypool Publisher series.

Cloud Computing

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M322251	Cloud Computing	3	300	1-1-0-1

Course Outcomes	
CO1	Understand the key concepts and terminology related to cloud computing. Differentiate between various cloud service models (IaaS, PaaS, SaaS) and deployment models (public, private, hybrid).
CO2	Analyze the benefits, challenges, and risks of adopting cloud solutions. Evaluate cloud providers and choose appropriate services based on specific requirements.
CO3	Deploy and manage virtual machines and containers in a cloud environment. Implement scalable and fault-tolerant applications using cloud services.
CO4	Understand security and compliance considerations in cloud computing. Explore emerging trends and technologies in the cloud computing landscape.

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	0	1	0
CO2	3	2	2	0	0	1
CO3	3	3	2	0	0	0
CO4	3	2	2	0	1	1

Module	Content
1	Introduction to Cloud Computing: Introduction to cloud computing; Historical evolution and driving factors Cloud service models: IaaS, PaaS, SaaS; Cloud deployment models: Public, private, hybrid; Cloud benefits, challenges, and risks ,Cloud Infrastructure and Virtualization, Virtualization concepts and technologies,Virtual machines (VMs) and containers, Creating and managing VMs and containers
2	Platform as a Service (PaaS) overview,Container orchestration: Kubernetes Serverless computing,Database as a Service (DBaaS),Developing applications for the cloud,Scalability and elasticity,Microservices architecture
3	Cloud architecture Architectural design of compute and storage clouds. Cloud providers: AWS, Azure, Google Cloud, etc.Cloud software: Eucalyptus, Nimbus, Open Stack,Cloud programming
4	Total Cost of Ownership (TCO) in the cloud,Cloud cost management and optimization Vendor lock-in and multi-cloud strategies,Case studies of successful cloud adoption Machine Learning and AI in the cloud,Serverless computing advancements Future directions and challenges in cloud technology

References:

1. "Mastering VMware vSphere 7" by Nick Marshall, Mike Brown, et al.
2. "Kubernetes: Up and Running" by Kelsey Hightower, Brendan Burns, and Joe Beda
3. "AWS Certified Solutions Architect Study Guide" by Ben Piper, David Clinton, and David Cook

Natural Language Processing

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221252	Natural Language Processing	3	300	1-0-1-1

Course Outcomes	
CO1	Understand the fundamental concepts, historical development, linguistic essentials, and text preprocessing techniques in NLP.
CO2	Apply various machine learning algorithms and text representations to perform sentiment analysis and text classification tasks.
CO3	Explore deep learning models and Transformer-based architectures to tackle complex NLP tasks, such as sentiment analysis and language generation.
CO4	Develop practical skills in building information retrieval systems, question-answering models, and text summarization while considering ethical implications in NLP.

Mapping of Course Outcomes with Programme Outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	1	1	1
CO2	3	3	3	1	1	1
CO3	3	3	3	1	1	1
CO4	3	3	3	1	1	2
Module	Contents					
1	Foundations of Natural Language Processing - Introduction to NLP: Definition, Scope, and Historical Background, Linguistic Essentials for NLP: Phonetics, Phonology, Morphology, Syntax, Semantics, and Pragmatics, Text Pre-processing: Tokenization, Stemming, and Lemmatization, Stop word removal, Part-of-speech tagging, Named Entity Recognition (NER), Language Modeling: N-grams, Hidden Markov, Models (HMM), Introduction to neural language models.					

2	Natural Language Processing Techniques - Machine Learning for NLP: Supervised, unsupervised, and semi-supervised learning in NLP, Feature extraction for text data, Sentiment analysis as a classification problem, Text Classification: Naive Bayes Classifier, Support Vector Machines, Neural Network for Text Classification (CNN, RNN), Language Understanding: Introduction to Word Embeddings (Word2Vec and Glove), Distributional Semantics and Word Similarity, Text Representation using TF-IDF, Sequence-to-Sequence Models, Attention Mechanisms, Applications
3	Advanced NLP Topics - Deep Learning for NLP: Transformer-based models (BERT, GPT, XLNet), Fine-tuning pre-trained models, Sentiment Analysis and Emotion Recognition: Aspect-based Sentiment Analysis, Detecting emotions from text using deep learning, Named Entity Recognition and Entity Linking, Entity Linking with knowledge bases, Natural Language Generation: Text Generation with Recurrent Neural Networks, Introduction to Generative Adversarial Networks (GANs) for text.
4	NLP Applications and Ethics - Information retrieval models: Boolean Retrieval, Vector Space Models, Evaluation Metrics, Question Answering Systems: QA pipelines, Reading comprehension with attention-based models, Text Summarization: Extractive vs. Abstractive Summarization, Sequence-to-Sequence models for summarization, Ethics, and Bias in NLP: Addressing bias in language models, Ethical considerations in NLP applications, Responsible use of NLP in society

Textbooks

1. Speech and Language Processing by Daniel Jurafsky and James H. Martin
2. Natural Language Processing in Action by Lane, Howard, and Hapke
3. Deep Learning for Natural Language Processing by Palash Goyal, Sumit Pandey, and Karan Jain
4. Ethics of Artificial Intelligence and Robotics edited by Vincent C. Müller

Information Retrieval

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221253	Information Retrieval	3	300	1-1-0-1

Course Outcomes	
CO1	Understand and describe the principles and components of information retrieval systems.
CO2	Apply and analyze core algorithms, term weighting, and probabilistic models in information retrieval systems.
CO3	Evaluate and synthesize advanced techniques like Latent Semantic Indexing, web search algorithms, and cross-language retrieval within information retrieval systems.
CO4	Create and evaluate information retrieval systems using test collections, user-centered approaches, and ethical considerations.

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

Module	Content

1	Introduction to Information Retrieval - Information Retrieval: Definition and Importance, Real-world Applications, Challenges of Handling Large Volume of Information, Need for Efficient Retrieval Techniques, Retrieval Models: Boolean, Vector Space and Probabilistic Models, Query Processing and Document Indexing, Evaluation Matrices in Information Retrieval: Precision, Recall, F1-Score, Mean Average Precision
2	**Information Retrieval Algorithms** - Inverted Index Construction and Compression, Term Weighting: TF-IDF, Vector Space Model and Cosine Similarity, Probabilistic Retrieval Models: Okapi BM25, Handling Queries with Multiple Terms, Relevance Feedback and Query Expansion
3	**Advanced Information Retrieval Techniques** - Latent Semantic Indexing (LSI) and Singular Value Decomposition (SVD), Web Search and Link Analysis: PageRank, HITS algorithm, Machine Learning for Information Retrieval, Cross-language Information Retrieval, Handling Multimedia Content in Retrieval Systems.
4	**Evaluation and Optimization of Information Retrieval Systems** - Test Collections and Evaluation Methodologies, Information Retrieval Evaluation Metrics, Performance Optimization Techniques, User-centered Evaluation and User Studies, Ethical Considerations in Information Retrieval

References:

1. "Introduction to Information Retrieval" by Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schütze
2. "Modern Information Retrieval" by Ricardo Baeza-Yates and Berthier Ribeiro-Neto
3. "Information Retrieval: Algorithms and Data Structures" by William B. Frakes and Ricardo Baeza-Yates
4. "Information Retrieval: Implementing and Evaluating Search Engines" by Stefan Büttcher, Charles L. A. Clarke, and Gordon V. Cormack

Anomaly Detection & Fraud Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221254	Anomaly detection & Fraud Analytics	3	300	1-1-0-1

Course Outcomes	
CO1	Foundations of Anomaly Detection
CO2	Anomaly Detection Algorithms and Techniques
CO3	Fraud Detection and Analytics
CO4	Machine Learning for Fraud Detection

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	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
CO5	3	3	2	1	1	2

Module	Content
1	Introduction to anomalies, Data pre-processing for anomaly detection, Types of anomalies, Benefits and limitations of anomaly detection. Anomaly detection algorithms Statistical methods: Z-score; Interquartile range (IQR), Mean absolute deviation (MAD)Tukey's fences, Robust covariance estimation
2	Machine learning methods: Isolation forest, Local outlier factor (LOF), One-class support vector machine (OCSVM), Gaussian mixture model, One-class Support Vector Machines (OCSVM), Autoencoders; Time Series Anomaly Detection: Moving averages, Exponential Smoothing.Seasonal decomposition and trend analysis. Techniques like ARIMA, LSTM for time series anomalies. Dealing with concept drift and evolving anomalies. Anomaly detection in high-dimensional data. Handling noisy data and false positives/negatives.
3	Introduction to fraud analytics; Types of fraud; Benefits and limitations of fraud analytics. Exploratory Data Analysis for Fraud Detection; Profiling data to identify patterns, trends, and anomalies. Unsupervised Anomaly Detection for Fraud: Using clustering techniques (K-Means, DBSCAN) to identify unusual patterns.Local Outlier Factor (LOF) and other proximity-based methods.
4	Model-Based Fraud Detection: Applying logistic regression and decision trees for fraud prediction. Ensemble methods (Random Forest, Gradient Boosting) for improved accuracy. Network Analysis for Fraud Detection, Building and analyzing graphs to identify unusual connections.Centrality measures and community detection.
	Time Series Analysis for Fraud Detection

References:

1. Anomaly Detection Principles and Algorithms, By Kishan G. Mehrotra, Chilukuri K. Mohan, HuaMing Huang · 2017

2. Practical Machine Learning: A New Look at Anomaly Detection books.google.co.in › books Ted Dunning, Ellen Friedman · 2014

3.Anomaly Detection: Techniques and Applications, Saira Banu · 2021

Social Network Analysis & Semantic Web

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221255	Social Network Analysis & Semantic Web	3	300	1-1-0-1

Course Outcomes	
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

Module	**Content**
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.

References:

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

Generative AI

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221256	Generative AI	3	300	1-1-1-0

Course Outcomes	
CO1	Introduction to generative AI
CO2	Text, Video and Image generation
CO3	Prompt engineering
CO4	Transformer architecture

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

Module	Content
1	Introduction to generative AI, Genertive Models; Autoencoders; Variational autoencoders, Generative adversarial networks, Normalizing follows

2	Text Generation: Recurrent Neural networks; LSTM networks, Transformer models (GPT, BERT) Image generation: CNN, Conditional GANs; Sequence Generation, Evaluation of Generative models Video generation
3	Introduction to prompt engineering: Understanding language models,, Fine Tuning and prompt based approaches, Effective Promt designing; Prompt Engineering for question answering Text generation with prompts
4	Transformer architecture; Pre trained Language Mdels, Training ChatGPT; Conversational AI and chatbots; Deploying ChatGPT and LLM

References:

1. Generative Adversarial Networks by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2017

2. Deep Generative Models by Hugo Larochelle, Yoshua Bengio, and Aaron Courville MIT Press, 2029.

3. Generative AI: A Modern Approach by David Barber. Cambridge University press, 2022

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Time Series Analysis & SEM Modeling

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221257	Time series analysis & SEM Modeling	3	300	1-1-0-1

Course Outcomes	
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

Module	Content

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

References:

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

Healthcare Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221258	Healthcare Analytics	3	300	1-1-0-1

Course Outcomes	
CO1	Introduction to healthcare analytics
CO2	Electronic healthcare records
CO3	Predictive techniques in healthcare
CO4	Image & signal analysis; NLP applications

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

Module	Content

1	Introduction to Healthcare Data Overview of healthcare data sources and formats; Privacy and security considerations in healthcare data; Data preprocessing and cleaning techniques for healthcare data
2	Electronic Health Records (EHR) Introduction to Electronic Health Records (EHR) systems; EHR data structure, components, and challenges; Analyzing EHR data for patient insights; Sensor Data in Healthcare Types of sensor data in healthcare; Collection, storage, and processing of sensor data Case studies: Analyzing sensor data for disease monitoring and prevention
3	Predictive Analytics: Predictive modeling for disease risk assessment; Early disease detection using ML techniques; Feature selection and model validation in healthcare prediction Clinical Decision Support Systems: Role of ML in clinical decision-making; Building clinical decision support systems using ML; Ethical considerations in deploying ML models in healthcare
4	Image and Signal Analysis in Healthcare: Medical image analysis using ML techniques Signal processing for healthcare applications; Case studies: Image analysis for disease diagnosis and treatment Natural Language Processing (NLP) in Healthcare: NLP techniques for processing clinical text data Extracting information from medical texts and reports; Applications of NLP in healthcare research and practice

References:

1.Healthcare Analytics for Quality and Performance Improvement by Trevor L. Strome

2.Introduction to Machine Learning with Python: A Guide for Data Scientists by Andreas C. Müller and Sarah Guido

3.Clinical Decision Support Systems: Theory and Practice by Eta S. Berner

4.Machine Learning and Healthcare Analytics by Kelleher, Mac Namee, and D'Arcy

5.Medical Image Analysis by Atam P. Dhawan and Jasjit S. Suri

6.Natural Language Processing for Health and Life Sciences by Aakash Bansal, Karthik Raman, and Sumit Agarwal

Deep Learning & MLOps

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221259	Deep learning & MLOps	3	300	1-1-0-1

Course Outcomes	
CO1	Apply knowledge of deep learning principles to create and implement a simple feedforward neural network.
CO2	Analyze and evaluate deep learning architectures for specific tasks in computer vision, NLP, and generative modeling.
CO3	Design and optimize data preprocessing techniques, loss functions, and regularization methods to train deep learning models effectively.
CO4	Synthesize and demonstrate proficiency in advanced activation functions, normalization techniques, transfer learning, and state-of-the-art research in deep learning for complex model development.

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

CO1	3	3	3	1	1	1
CO2	3	3	3	1	1	1
CO3	3	3	3	1	1	1
CO4	3	3	3	1	1	1

Module	Content
1	**Fundamentals of Deep Learning** - Introduction to Deep Learning: Definition and Motivation, Overview and Key Milestones behind Deep Learning, Deep Learning vs. Traditional Machine Learning: Comparison, Advantages and limitations of Deep Learning, Neural Network Basics: Structure and Function of Artificial Neuron, Activation Functions, Building Blocks: Layes, Weights, Bias, Forward and Backward Propagation, Implementation of Feedforward Neural Network
2	Deep Learning Architectures - Multi-Layer Perceptron, Back Propagation Algorithm, Convolutional Neural Networks (CNN): Architecture, Pooling, Usecases: Image Classification, Object Detection, and Image Segmentation, Recurrent Neural Networks (RNNs): Architecture, Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), Generative Adversarial Networks (GANs): Training to generate images, music, or text, Applications of GAN: art generation and data augmentation, Applications of Deep Learning: Case Studies
3	**Deep Learning Operations (DLOps)** - Introduction to Deep Learning Operations: Significance and Management, DL Models in Production: Challenges, Complexities, Model Versioning, and Collaboration, Tools for collaborative development and model versioning, Continuous Integration and Continuous Deployment (CI/CD), Scalability and Distributed Training, Monitoring and Logging, Model Governance and Ethics, Automated Machine Learning (AutoML)
4	**Practical Applications of Deep Learning** - Image Classification: Use CNN for Image Classification, Natural Language Processing (NLP): Train RNN for Sentiment Analysis, Computer Vision: Object Detection using Pre-trained Models, Image Generation using GAN

References:

1. "Deep Learning" *by* Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

2."Neural Networks and Deep Learning: A Textbook" by Charu Aggarwal.

3."Dive into Deep Learning" by Aston Zhang, Zack C. Lipton, Mu Li, and Alexander J. Smola.

4."Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play" by David Foster.

Advanced Programming

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221260	Advanced Programming	3	300	1-1-0-1

Course Outcomes	
CO1	Advanced OOP features
CO2	Lambda expressions, Error Handling, Multi threading
CO3	Web API's
CO4	Python coding standards and quality checking

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	Content
1	Advanced OOP features of Python, Inheritance, Multiple Inheritance, Polymorphism, Object Introspection, Dunder Methods, Method Resolution Order, Practice with Objects, and Extending Lists.
2	Lambda Expressions, List Comprehensions, Set and Dictionary Comprehension, Decorators, Multiple Decorators, Magic Methods, Collections, Higher Order Functions, Error Handling in Python, Generators, Practice with decorators, and Error Handling, Multi-threading.
3	Web APIs, Integration of Web APIs in modules, Request and Response, Status Codes, Custom Headers, Authentication of an API, API Keys, Practices on Visualization of data from a Web API to a web application module, Web Scrapping.
4	Python coding standards and best practices for code quality, Development Cycle, Flask Restful APIs, API Module development with MongoDB, Unit testing, Practices on writing Unit Tests with unit testing frameworks, and introduction to automation testing with Selenium and Python.

References:

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.

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

Advanced Geospatial Programming

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221261	Advanced Geospatial Programming	3	300	1-1-0-1

Course Outcomes	
CO1	Basic understanding of geospatial libraries
CO2	Geospatial libraries for raster and vector analysis
CO3	Understanding about ArcGIS Customization and development of script tool using arcpy
CO4	QGIS customization and plugin development
CO5	Able to understand and handle spatial database

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	3	2	1	2	1	2

CO4	2	3	2	1	2	1
CO5	3	3	2	1	2	1

Module	Content
1	Introduction to geospatial analysis with python, Geospatial libraries, Geospatial data visualization Interactive geospatial data visualization.
2	Raster and vector data analysis, Raster data operation, Raster data analysis using different python modules, satellite data analysis using python, Vector data structure and operation. Vector data analysis using python libraries.
3	Introducing python using python window in ArcGIS, arcpy module, Automation of arcGIS software. Developing script tool using arcpy
4	Introduction to QGIS python programming, Developing python plugins with QGIS Spatial Database management Systems, Python interface to postgreSQL Introduction to postGIS, Python interface to postGIS and QGIS postGIS interfacing Worked example: Retrieving real time data from REST web API

References:

1. Python Geospatial Analysis Cookbook, Michael Diener

2. Mastering Geospatial Analysis with Python, Paul Crickard, Eric van Rees, Silas Toms

3. QGIS Python Programming Cookbook, Joel Lawhead

Advanced Machine Learning

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221262	Advanced Machine Learning	3	300	1-1-0-1

Course Outcomes	
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

Module	Content
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

References:

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

Spatial Data Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221263	Spatial Data Analytics	3	300	1-1-0-1

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;Hierarchical Clustering,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 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

Textbooks

1. "Data Engineering with Python" by Paul Crickard, Packt Publishing, 2020
2. "Data Engineering with Apache Spark, Delta Lake, and Lakehouse" by Manoj Kukreja, Danil Zburivsky, Packt Publishing, 2021
3. "Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems" by Martin Kleppmann, 2017
4. "Fundamentals of Data Engineering" by Joe Reis, Matt Housley, O'Reilly Media, Inc., 2022

Thermal and Hyperspectral Remote Sensing

Course Code	Title of the course	Credits	Level	Credit Split

				Lecture-Lab-Seminar-Project
M3221264	Thermal and Hyperspectral remote sensing	3	300	1-0-1-1

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	3	2	1	2	1
CO2	2	3	2	1	1	1
CO3	2	2	1	2	3	2
CO4	3	3	2	1	2	1

Module	**Content**
1	Thermal radiation principles, thermal process and properties – Characteristics of thermal IR images and factors affecting thermal images – Interaction of thermal radiation with terrain elements – Thermal sensors and their characteristics – MUST (Medium Scale Surface

	Temperature Missions) – radiometric calibration of thermal scanners
2	Thermal image and types of available data products – Interpretation of thermal images - day and night images – LST retrieval methods – Application of thermal remote sensing data in crop health monitoring, pollution monitoring, oil spill detection, Atmospheric modelling, Sea Surface Temperature
3	Hyperspectral Remote Sensing – Imaging Spectroscopy – representation systems – Spectral cube – Airborne and spaceborne hyperspectral sensors – Hughes phenomenon – multivariate analysis for data reduction – Spectral library – Hyperspectral image compression – Feature selection and feature extraction techniques
4	Hyperspectral Image Analysis: Calibration and normalization of hyperspectral images – Observing signatures of various features and comparing with spectral libraries – Spectral mapping methods: Spectral Angle Mapper (SAM), Spectral Correlation mapper, Spectral Feature Filtering (SFF), Linear Spectral Unmixing (LSU) – Application of hyperspectral remote sensing: Agriculture, Soils, Forestry, Environmental and Resource Management

References:

[1Dale 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).

[6] Liguo Wang and Chunhui Zhao., Hyperspectral Image Processing, Springer, 2016.

[7] Michael T, Eismann., Hyperspectral Remote Sensing, SPIE press, USA, 2012.

Microwave Remote Sensing

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221265	Microwave remote sensing	3	300	1-0-1-1

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	3	2	1	2	1

CO2	2	3	3	1	1	1
CO3	3	2	1	2	1	2
CO4	2	3	3	2	3	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.

References:

[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.

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

[4] 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.

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

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

[7] Ian Faulconbridge, Radar Fundamentals, Published by Argos Press, 2002.

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

Spatial Bigdata Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221266	Spatial Bigdata Analytics	3	300	1-1-0-1

Course Outcomes	
CO1	CO1 Understanding geospatial big data basics and core concepts
CO2	CO2 Geospatial big data technologies and tools
CO3	CO3 Understanding about advanced GIS and machine learning algorithms

CO4	CO4 Open-source geospatial big data analysis and applications

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	2	1
CO2	3	3	2	1	1	1
CO3	3	2	1	2	1	2
CO4	3	3	2	3	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 and storage.
3	Spatial data wrangling with geospark values in spatial big data, visualizations, GeosparkVis Decision support systems using spatial big data: Data intelligence, Machine learning with spatial big data. Common algorithms such as association rule of mining, clustering and classification rule etc in geospatial context

4	Case studies with spatial big data in 1. Societal applications 2. Environment and economics 3. Agriculture 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 Technologies in Geoinformatics
5. Sandya Ryza, Uri Laserson, Sean Owen, Josh Wills: Advanced Analytics with Spark: Patterns for Learning from Data at scale

Web and Mobile GIS

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221267	Web and Mobile GIS	3	300	1-1-0-1

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	Understanding server based GIS technologies

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

Module	Content
1	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.
2	Introduction to Geo-server and leaflet - configuration and installation, interface familiarization, handling vector and raster data, geoprocessing operations, styling, publishing web maps.
3	Introduction to ArcGIS server - configuration and installation, interface familiarization, handling vector and raster data, geoprocessing operations, styling, publishing web maps.

4	Mobile GIS applications, Mobile GIS Architecture, Mobile GIS Programming, Hybrid apps, real-time data collection and editing apps in the field, locationbased services and augmented reality (AR) services using camera, GPS

References:

[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

Topographic Data Analysis Techniques and Applications

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221268	Topographic Data Analysis Techniques and Applications	3	300	1-1-0-1

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 applications of DEM in real world problems

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

Module	Content
1	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.
2	Topographic Analysis : Contour. Slope, aspect, Hillshade, Viewshed Analysis, Line-of-Sight.
3	Volumetric Analysis and Computation, Cut-Fill Analysis, Bathymetric applications Analysis and estimation, Reservoir Volume Calculation.

4	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

Geospatial Applications in Agriculture

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221269	Geospatial Applications in Agriculture	3	300	1-1-0-1

Course Outcomes	
CO1	Understanding the concepts of Agricultural Science
CO2	Familiarization of GIS and RS concepts specific to the agricultural domain
CO3	Application of learned skills to familiarize and create models in agricultural domain
CO4	Different crop disease and pest identification techniques in GIS and RS

Mapping of course outcomes with program outcomes

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

Module	**Content**
1	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
2	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.
3	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.
4	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 Assissted Farm Management Information System, ISBN: 9783844333695, 2012

3. V M Abdul Hakkim, GIS Integrated Site-Specific Drip Fertigation, ISBN: 9783659261480, 2013

Computational Chemistry

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221270	Computational Chemistry	3	300	1-1-0-1

Course Outcomes	
CO1	Quantum mechanics basics
CO2	Introduction to computational chemistry
CO3	Abinitio methods
CO4	Molecular Mechanics

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

Module	Content
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, energy minimization, basis functions-Slater type orbitals (STO) and Gaussian type orbitals (GTO), Hartree-Fock and post Hartree-Fock methods, Basis sets: minimal, split valence, polarization and diffuse functions, contracted basis sets, Pople's style basis sets and their nomenclature, effective core potentials (ECP).
3	Ab initio and semi-empirical methods (AM1, PM3, MNDO etc), Hückel method, SCF theory, Density Functional theory (DFT), Møller-Plesset (MP) methods, hybrid and double hybrid methods, Analysis of output for Gaussian programmes: geometry optimization, electron densities and electrostatic potentials, molecular frequencies.

4	Molecular mechanics, force field, parameters and other problems with molecular mechanics, molecular dynamics, simulated annealing, Monte Carlo simulations.

References:

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

Computational Neuroscience

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221271	Computational Neuroscience	3	300	2-0-0-1

Course Outcomes	
CO1	Understand and analyze the biological and electrical behaviour of neurons.
CO2	C3omputational modeling and simulation of biological neurons
CO3	Application of Kirchoffs's laws, cable theory and numerical methods in neuroscience.
CO4	Solve mathematical problems related to neuroscience.

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: Modelling & understanding, the modelling perspective, formulating a conceptual model, Numerical methods for neural modelling. Compartmental modelling, Kirchoff's current and voltage laws, The cable theory. Time constant and space constant.

4	The NEURON simulation environment: Introduction, representing neurons with a digital computer, model implementation, signal sources and monitors, running simulation experiments, analysing results. Simple single cell and network models. Simple exercises using the NEURON module in Python.

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.

Geospatial Applications for Environment and Climate change

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221272	Geospatial Applications for Environment and Climate change	3	300	2-0-0-1

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 GISs
CO4	Understanding technical know-hows of real world environment challenges

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

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.

3	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

References:

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

[2] 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.

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

Geospatial Applications for Hydrological Modeling

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221273	Geospatial Applications for Hydrological Modeling	3	300	1-1-0-1

Course Outcomes	
CO1	Understanding the concepts of GIS and RS applications of hydrology

CO2	Applying learned concepts on hydrological modeling
CO3	Applying learned concepts on flood modeling
CO4	Management and mitigation of hydrological phenomena

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

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

5	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-10 : 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 (Advances in Hydrological Processes) 1st edition, 2000.

Geospatial Applications in Urban and Regional Planning

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221274	Geospatial Applications in Urban and Regional Planning	3	300	2-0-0-1

Course Outcomes	
CO1	Understanding the basics in the field of urban and regional planning
CO2	Get the idea regarding the different data, and its scale and technologies for urban and regional planning
CO3	Different modeling techniques used in urban and regional planning
CO4	Management and mitigation in urban development

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

CO1	3	2	1	1	1	1
CO2	3	3	3	2	1	1
CO3	3	1	2	1	1	1
CO4	3	3	1	1	1	1

Module	Content
1	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
2	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
3	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
4	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. Mohd Aktar Ali, Kabir Mohan Sethy, Muzafir Wani, Urban Environment and Spatial Science, Ane Books Pvt Ltd, First Edition (2021), ISBN : 9390658284

AI applications in agriculture

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221275	AI applications in agriculture	3	300	1-1-0-1

Course Outcomes	
CO1	Demonstrate a fundamental understanding of the principles and concepts of artificial intelligence as applied to agriculture, distinguishing between different AI techniques and their potential benefits.
CO2	Analyze and evaluate agricultural data using AI-driven techniques, leading to improved decision-making for precision farming practices.
CO3	Develop the ability to design and implement AI-based solutions for early detection, diagnosis, and management of crop diseases, thereby enhancing agricultural productivity and sustainability.
CO4	Assess emerging trends in AI applications within the agriculture sector and demonstrate an awareness of ethical, social, and environmental implications associated with integrating AI technologies.

Mapping of course outcomes with program outcomes

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

Module	Content
1	**Foundations of AI in Agriculture** - Introduction to AI in Agriculture: Narrow AI vs. General AI, supervised learning, unsupervised learning, AI-driven crop monitoring, agricultural automation, precision farming, Machine Learning Fundamentals: Regression, classification, clustering, reinforcement learning, Feature engineering, model evaluation, cross-validation, Transfer learning, image segmentation, object detection
2	**Data Analytics and Precision Agriculture** - Remote Sensing and IoT in Agriculture: Multispectral imaging, hyperspectral imaging, LiDAR, Wireless sensor networks, smart sensors, data fusion, Data Preprocessing, and Feature Selection: Outlier detection, data normalization, data imputation, Principal Component Analysis (PCA), Recursive Feature Elimination (RFE), Predictive Modeling for Crop Management: Decision trees, random forests, gradient boosting, Support Vector Machines (SVM), ensemble learning, hyperparameter tuning, Decision Support Systems in Precision Agriculture: Geographic Information Systems (GIS), spatial analysis
3	**Crop Health and Disease Management** - Image Analysis for Disease Detection: Leaf-level disease recognition, plant phenotyping, hyperspectral imaging, Instance segmentation, transfer learning with pre-trained models, fine-tuning, Sensor-based Disease Detection: Disease-related stress indicators, Wireless sensor networks for disease monitoring, data fusion techniques, AI-driven Pest Management: Pest species identification, insect behavior modeling, Genetic algorithms for optimizing pest control schedules, swarm intelligence, Sustainable Agriculture and AI: Precision application of agrochemicals, site-specific nutrient management, Predictive models for sustainable irrigation practices, water use efficiency

4	**Future Trends and Ethical Considerations in AI Agriculture** - Emerging Trends in AI Agriculture: Swarm robotics, drone technology, blockchain in agriculture, Ethical and Social Implications: Algorithmic bias, fairness in AI, explainable AI in Agriculture, Data privacy regulations, digital divide, farmer livelihoods, Environmental Sustainability and AI: Renewable energy integration and climate-resilient agriculture, AI and remote sensing to assess soil erosion and land degradation

References:

1. "Artificial Intelligence In Agriculture" by Singh Rajesh and Anita Gehlot, New India Publishing Agency, 2020
2. "Using R for Digital Soil Mapping", Malone, Minasny, and McBratney, Springer, ISBN: 978-3-319-44325-6.
3. "Agriscience Fundamentals and Applications" by L. DeVere Burton, 2009
4. "Agricultural Technology: Emerging Trends" by Caroline Walters, 2022
5. "Soil and Crop Sensing for Precision Crop Production" by Minzan Li, Chenghai Yang, Qin Zhang, Springer, 2022

Computational Finance

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221276	Computational Finance	3	300	1-1-0-1

Course Outcomes	
CO1	Understanding Financial Asset Dynamics and Models:
CO2	Master numerical techniques for pricing financial derivatives, particularly European options, using methods like the COS (Characteristic Function Expansion) method.
CO3	Analyze pay-off coefficients and conduct error analysis when using the COS

	method.
CO4	Introduce the fundamental concepts of portfolio management, including portfolio objectives, constraints, risk, and return.

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

Module	**Content**
1	Introduction to Computational Finance, Financial asset dynamics; Proportional dividended model Martingales and asset prices; Black scholes option pricing equations; local volatality models
2	Numerical Methods for Pricing Financial Derivatives: Pricing europian options by the COS method Pay off coefficients, error analysis by COS methods, Numerical COS method results; Geometric Brownian Motion; Stochastic Volatility models; Introduction, CIR process of variance, Monte Carlo Simulation: Introduction, Simulation of CIR models

3	Financial Data Analysis; Statistical Modeling of Financial Data; Time series analysis of financual data Financial forecasting; Rsik management, Types of risks, measuring risks, Fiancial risk management
4	Portfolio Optimization: Introduction to portfolio management Portfolio objectives and constraints; Risk and return; Portfolio diversification; Asset allocation Security selection; Portfolio performance evaluation;Active and passive portfolio management Algorithmic trading; Machine learning for portfolio optimization

References:

Maheshwari, Anil. Financial Data Analytics: Theory and Application. 2nd ed. Pearson, 2023. Print

Benninga, Simon. Financial Modeling: Equilibrium, Capital Structure, and Asset Pricing. 3rd ed. Wiley, 2016

Structural Biology and Drug Design

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221277	Structural Biology and Drug Design	3	300	1-1-0-1

Course Outcomes	
CO1	Fundamentals of drug discovery

CO2	Drug design and drug property prediction
CO3	Cheminformatics and data analysis
CO4	Computational chemistry to predict the structural features of a molecule

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

Module	**Content**
1	Stages of drug discovery process and its challenges, drug targets and their classification, enzyme kinetics, Michaelis–Menten Equation, active site and types of inhibition, classification of drugs, ADMET properties of drugs, molecular descriptors, calculation of physical and chemical data, drug-receptor interactions, molecular recognition, concept of agonists and antagonists.
2	Structure-based and ligand-based drug design, concept of de novo design for lead identification, docking-rigid and flexible, pharmacophore mapping, quantitative structure-activity and quantitative structure-property relationships (QSARs and QSPRs), 3D QSAR techniques: CoMFA and CoMSIA, pharmacokinetics (ADME/T),

	pharmacodynamics, Lipinski's rule of five, fragment-based drug design and retrosynthetic approaches, finding new drug targets - high throughput/combinatorial approaches, molecular dynamics.
3	Role of cheminformatics in pharmaceutical research: Chemical structure representation file format- 1D, 2D and 3D structures, molecular file formats (SMILES, PDB, SDF, MOL), machine learning approaches in drug design, molecular descriptor and finger print generation using different tools, ADME/T databases, chemical, biochemical and pharmaceutical databases, data mining and visualization methods.
4	Introduction to computational chemistry: Classical mechanics vs quantum mechanics, potential energy surface-stationary point and saddle point, energy minimization, basis functions-Slater type orbitals (STO) and Gaussian type orbitals (GTO), basis sets, ab initio and semi-empirical methods (as AM1, PM3, MNDO etc), SCF theory, HF method, Density Functional theory (DFT).

References:

1. Computer Aided Drug Design (CADD): From Ligand-Based Methods to Structure-Based Approaches, Mithun Rudrapal, Chukwuebuka Egbuna, Elsevier, ISBN: 9780323906081
2. A First Course in Systems Biology, Voit E, Garland Science, ISBN: 0815344678
3. Artificial Intelligence in Drug Design, Alexander Heifetz, Springer, ISBN: 9781071617892

Parallel and GPU programming

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-

				Seminar-Project
M3221278	Parallel and GPU programming	3	300	1-1-1-0

Course Outcomes	
CO1	**CO1 Comprehensive Understanding of High-Performance Computing (HPC) Foundations.**
CO2	**CO2 Proficiency in Parallel Programming Models and Techniques.**
CO3	**CO3 Mastery of GPU Computing and Acceleration.**
CO4	**CO4 Expertise in Program Execution Analysis and Concurrent Programming.**

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	0	0
CO2	2	1	3	0	0	0
CO3	2	3	2	0	0	0
CO4	1	2	3	0	0	0

Module	**Content**
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

References:

[1] Sterling, Thomas, Maciej Brodowicz, and Matthew Anderson. High performance computing: modern systems and practices. Morgan Kaufmann, 2017.
[2] Michael J Quinn. Parallel programming in C with MPI and OpenMP. Tata McGraw Hill, 2003.
[3] Kai Hwang, Naresh Jotwani. Advanced Computer Architecture: Parallelism, Scalability, Programmability, 2nd edition. Mcgraw-Hill Education, 2008.
[4] Brian Tuomanen. Hands-On GPU Programming with Python and CUDA: Explore high-performance parallel computing with CUDE. Packt Publishing, 2018.

Ethics in Data

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221279	Ethics in Data	3	300	1-0-2-0

Course Outcomes

CO1	Understand the historical evolution and ethical considerations of data-driven decision-making.
CO2	Apply ethical principles to assess and mitigate bias in data collection and analysis.
CO3	Analyze the societal implications of data-driven technologies and their ethical consequences.
CO4	Evaluate and design ethical data policies and practices for responsible data usage.

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

Module	**Content**
1	Introduction to Data Ethics - Data ethics: Definition and scope, Overview of computer components and their roles, Historical context, Evolution of data ethics, Ethical considerations in data-driven decision-making: utilitarianism, deontological ethics, etc., Case studies on ethical challenges in data usage: Cambridge Analytica scandal, Target's pregnancy prediction, etc.
2	**Ethical Considerations in Data Collection and Analysis** - Privacy rights and data protection regulations: General Data Protection Regulation - (GDPR), California Consumer Privacy Act (CCPA), Digital Personal Data Protection Bill (DPDPB - India), Ethical data collection: Role of informed consent, Bias and fairness in data analysis: algorithmic bias, fairness-aware machine learning, Transparency and accountability in algorithmic decision-making: Explainable AI, Algorithm auditing, Real-world examples of ethical dilemmas in data collection and analysis: facial recognition technology, predictive policing, etc.

3	**Social and Cultural Impacts of Data Use** - Data-driven discrimination and social inequality, Algorithmic bias and its impact on marginalized communities, Ethical considerations in AI and machine learning applications, Digital surveillance and its effects on civil liberties, The role of data ethics in shaping public policy - data protection regulations, ethical AI guidelines by governments.
4	**Building Ethical Data Practices** - Ethical frameworks for data use and decision-making, Establishing data governance and responsible AI practices - Data Ethics Committees, AI Ethics Guidelines, Privacy Impact Assessments - PIAs, data anonymization techniques, Ethical considerations for data sharing and collaboration, Case studies of organizations leading in ethical data practices - Microsoft's AI Ethics principles, Google's Responsible AI practices

References:

1. "Ethics of Big Data" by Kord Davis and Doug Patterson
2. "Data and Goliath: The Hidden Battles to Collect Your Data and Control Your World"
3. "Ethics for Robots: How to Design Ethical Robots and AI" by Matthias Scheutz
4. "Responsible AI: A Global Policy Framework" by IFG Advisory Board and Paula Goldman

Data Security

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221280	Data Security	3	300	1-1-0-1

Course Outcomes	
CO1	Define data security, identify various types of sensitive data, categorize potential threats, and analyze the legal and ethical implications of data security.
CO2	Demonstrate the ability to assess secure data storage options, implement encryption techniques for data transmission, formulate data retention and disposal strategies, and design comprehensive data backup and recovery plans.

CO3	Evaluate network security threats, apply secure software development practices, analyze vulnerabilities in web applications, and devise security measures for mobile and IoT devices.
CO4	Formulate incident response plans, execute appropriate steps during data breaches, evaluate compliance frameworks, and anticipate the impact of emerging technologies on data security practices.

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

Module	**Content**
1	**Introduction to Data Security** - Data Security: Definition and Importance, Types of sensitive data: personal, financial, healthcare, intellectual property, etc., Threats to data security: unauthorized access, data breaches, malware, social engineering, Legal and Ethical Aspects of Data Security: Data protection laws and regulations (such as GDPR, HIPAA, CCPA), Ethical considerations in data security and privacy, Consequences of data breaches: legal, financial, reputational, Principles of Cryptography: Introduction to cryptography and its role in data security, Symmetric vs. asymmetric encryption, Hash functions, digital signatures, and encryption algorithms, Access Control Mechanisms: Role-based access control (RBAC) and its implementation, Mandatory and discretionary access control, Multi-factor authentication (MFA) and its significance.
2	**Secure Data Handling and Storage** - Secure Data Storage: Encryption of data at rest: full disk encryption, database encryption, Data masking and tokenization techniques, Secure storage solutions: cloud storage security, on-premises storage best practices, Secure Data Transmission: Transport Layer Security (TLS) and Secure Sockets Layer (SSL), VPNs (Virtual Private Networks) for secure remote access, Secure file transfer protocols: SFTP, SCP, HTTPS, Data Retention and Disposal: Data retention policies

	and legal requirements, Secure data disposal methods: shredding, wiping, degaussing, Challenges of data retention in the digital age, Importance of data backups in data security, Different backup strategies: full, incremental, differential, Disaster recovery planning and testing.
3	**Network and Application Security** - Network Security Fundamentals: Network threats: malware, phishing, DDoS attacks, Firewalls, intrusion detection systems (IDS), intrusion prevention systems (IPS), Secure Software Development: Secure coding practices: input validation, output encoding, error handling, Threat modeling and risk assessment in software development, Web Application Security: SQL injection, cross-site scripting (XSS), cross-site request forgery (CSRF), Web application firewalls (WAF) and their role, Security challenges in mobile and IoT devices.
4	**Incident Response and Compliance** - Incident Response Planning: Importance of incident response in data security, Incident response lifecycle: preparation, identification, containment, eradication, recovery, lessons learned, Handling Data Breaches: Immediate steps to take during a data breach, Communicating with stakeholders: customers, partners, regulatory authorities, Forensics and evidence preservation, Compliance and Auditing: Regulatory compliance frameworks: ISO 27001, NIST, PCI DSS, Conducting security audits and assessments, Emerging Trends in Data Security: AI and machine learning in data security, Blockchain technology and its impact on data security

References:

1."Data and Goliath: The Hidden Battles to Collect Your Data and Control Your World" by Bruce Schneier

2."Cryptography and Network Security: Principles and Practice" by William Stallings

3."Web Application Security: A Beginner's Guide" by Bryan Sullivan and Vincent Liu

4."The Practice of Network Security Monitoring: Understanding Incident Detection and Response" by Richard Bejtlich

Data Engineering

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project

M3221281	Data Engineering	3	300	1-1-0-1

Course Outcomes	
CO1	Analyze, explain, and apply foundational concepts and principles of data engineering.
CO2	Selecting, utilizing, and configuring appropriate data storage and processing technologies for different scenarios.
CO3	Design, construct, and manage data pipelines for efficient and reliable data movement and transformation.
CO4	Analyze complex data engineering challenges, implement advanced techniques, and optimize data processes for different use cases.

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

Module	Content
1	**Fundamentals of Data Engineering** - Introduction to Data Engineering, Data Lifecycle and Data Flow, Data Modeling: Conceptual, Logical, Physical, ETL (Extract, Transform, Load) Processes, Data Warehousing Basics, Introduction to Big Data Technologies, Data Quality and Data Governance
2	**Data Storage and Processing** - Relational Databases and SQL, NoSQL Databases (Document, Columnar, Key-Value, Graph), Data Lake Architecture and Technologies, In-Memory Databases, Introduction to Distributed Computing, Batch Processing vs. Stream Processing.Introduction to Apache Hadoop and Spark

3	**Building Data Pipelines** - Data Pipeline Architecture, Workflow Orchestration, Data Ingestion Methods (Batch and Real-time), Data Transformation and Enrichment, Data Pipeline Monitoring and Error Handling, Introduction to Data Orchestration Tools (Airflow, Luigi, Prefect), Best Practices for Pipeline Scalability and Performance
4	**Advanced Topics in Data Engineering** - Data Security and Privacy, Data Versioning and Lineage, Microservices Architecture for Data, Data Serialization Formats (Avro, Parquet, JSON), Real-time Data Processing and Streaming Platforms, Data Warehousing and Data Lake Integration, Performance Tuning and Optimization Strategies

References:

1. "Data Engineering with Python" by Paul Crickard, Packt Publishing, 2020
2. "Data Engineering with Apache Spark, Delta Lake, and Lakehouse" by Manoj Kukreja, Danil Zburivsky, Packt Publishing, 2021
3. "Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems" by Martin Kleppmann, 2017
4. "Fundamentals of Data Engineering" by Joe Reis, Matt Housley, O'Reilly Media, Inc., 2022

Numerical Linear Algebra

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221282	Numerical Linear Algebra	3	300	1-1-1-0

Course Outcomes	
CO1	Understand the importance of numerical methods in solving linear algebra problems encountered in various scientific and engineering applications
CO2	Apply matrix factorization techniques, such as LU and Cholesky factorizations, to solve linear systems efficiently and accurately.
CO3	Compute and interpret the singular value decomposition (SVD) for data compression, principal component analysis, and image processing.

CO4	Apply numerical linear algebra techniques to practical problems, fostering problem-solving skills and computational thinking.

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	0	0	0
CO2	3	2	2	0	0	0
CO3	3	2	2	0	0	0
CO4	3	2	2	0	0	0

Module	Content
1	Linear systems, LU decompositions, Gaussian elimination with partial pivoting, Banded systems, Positive definite systems, Cholesky decomposition. Vector and matrix norms, Perturbation theory of linear systems, Condition numbers, Estimating condition numbers, IEEE floating point arithmetic, Analysis of roundoff errors.
2	Gram-Schmidt orthonormal process, Orthogonal matrices, Householder transformation, Givens rotations, QR factorization, Roundoff error analysis of orthogonal matrices, Stability of QR factorization. Solution of linear least squares problems, Normal equations, Singular Value Decomposition(SVD), Polar decomposition, Moore-Penrose inverse, Rank deficient least squares problems, Sensitivity analysis of least-squares problems.

3	Review of eigenvalues and canonical forms of matrices, Sensitivity of eigenvalues and eigenvectors, Reduction to Hessenberg and tridiagonal forms, Power and inverse power methods, Rayleigh quotient iteration, Explicit and implicit QR algorithms for symmetric and non-symmetric matrices, Implementation of implicit QR algorithm.
4	Computing the SVD, Sensitivity analysis of singular values and singular vectors. Overview of iterative methods: Jacobi, Gauss-Seidel and successive overrelaxation methods, Krylov subspace method, The Arnoldi and the Lanczos iterations.

References:

1. L. N. Trefethen and David Bau, Numerical Linear Algebra, SIAM, 1997.
2. D. S. Watkins, Fundamentals of Matrix Computation, Wiley, 1991.
3. G. H. Golub and C.F.Van Loan, Matrix Computation, John Hopkins U. Press, Baltimore, 1996.
4. G. W. Stewart, Introduction to Matrix Computations, Academic Press, 1973.
5. J.W. Demmel, Applied numerical linear algebra, SIAM, Philadelphia, 1997.

Data Structures and Algorithim

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221283	Data Structures and Algorithm	3	300	1-1-0-1

Course Outcomes	
CO1	**Analyze an algorithm and find its efficiency**
CO2	**Apply the concepts of Stack, Queue and Linked List in problem solving**
CO3	**Obtain the skill to use recursion for problem solving**
CO4	**Practice algorithm design and implementation to solve searching and sorting problems**

Mapping of course outcomes with program outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	0	0	0
CO2	3	2	3	0	0	0
CO3	3	1	3	0	0	0
CO4	3	2	3	0	0	0

Module	Content
1	Introduction to ADT and Algorithms: Data types, Data structures, Abstract data types, Algorithms, Algorithm analysis, Best case, worst case and average case complexities, Big-O notation, Analysis of Python List and Dictionary operations.
2	Stacks: 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 prefix and postfix notations, Evaluation of expression using stack.

3	Queues: Introduction to queues, the queue ADT, basic operations, Python implementation, computational problems related to queue. Linked List: The unordered list ADT, linked list, linked list operations, doubly linked list, Python implementation, applications. Recursion: The laws of recursion, format of a recursive function, applications of recursion such as converting an integer to a string, Fibonacci series, Towers of Hanoi, reversing a string.
4	Searching: Sequential and binary search, hashing. Sorting: Selection, bubble, insertion and quick sorts. Trees: Vocabulary, Definitions, Tree operations, List of lists implementation, Nodes & references implementation, Binary trees, Balanced binary tree, Complete binary tree, Extended binary tree, binary search tree, balanced binary search tree, tree traversals, AVL trees, B-trees.
5	Heap: Introduction to binary heap, max heap, min heap, min heap operations, the heap order property, representation. Graphs: Weighted graphs, spanning trees, Kruskal's algorithm, Prim's algorithm, traversal, DFS and BFS, shortest path, Dijkstra's algorithm.

References:

[1] Bradley N. Miller, David L. Ranum Problem Solving with Algorithms and Data Structures Using Python, Franklin, Beedle & Associates.
[2] T.H. Cormen, Introduction to algorithms, MIT Press.
[3] A.D Aho, J. E. Hopcroft and J. D. Ullman, Data Structures and Algorithms, Pearson education Asia.
[4] Y. Langsam, M. J. Augenstein and A. M. Tenenbaum, Data Structures using C, Pearson Education Asia.
[5] Adam Drozdek, Data Structures and Algorithms in Java, Published by Brooks/Cole.

Functional Genomics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221284	Functional Genomics	3	300	2-0-0-1

Course Outcomes	
CO1	Knowledge regarding major advancements in functional genomics

CO2	Provide deep insight into epigenomics, including concepts such as imprinting, chromatin folding, and epigenetic modifications like DNA methylation and histone modification
CO3	Get understanding of transcriptomics data, including familiarity with key databases
CO4	Understanding metabolomics, particularly MS-based metabolomics

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

Module	**Content**
1	Introduction to Functional Genomics: Pre- and post-genomic era, major advancements in genomic approaches, specific functional genomic approaches-DNA level (genomics and epigenomics), RNA level (transcriptomics), protein level (proteomics) and metabolite level (metabolomics); forward versus reverse genetics, role of functional genomics in drug discovery.
2	Epigenomics: imprinting, chromatin folding, epigenetic modifications-DNA methylation, patterns of histone modification, gene silencing; factors make change in epigenome, epigenome data analysis, importance of epigenome in studying complex

	diseases.
3	Transcriptomics: databases-Transcriptome Shotgun Assembly (TSA) database, CrusTome, Human Brain Transcriptome (HBT), spatial transcriptomics, spatial transcriptomics technologies, analysis and visualization of spatial transcriptomic data.
4	Metabolomics: MS-based metabolomics, data analysis and metabolite identification, metabolomics in health and disease- metabolic phenotyping and metabolome-wide association studies (MWAS), precision metabolomics, role in understanding drug action and toxicity, role in understanding biochemical mechanisms of disease.

References:

1. Bioinformatics and Functional Genomics, Jonathan Pevsner, Wiley, ISBN: 978-1-118-58178-0
2. Functional Genomics-Methods and Protocols, Michael Kaufmann, Claudia Klinger, Andreas Savelsbergh, Springer, ISBN: 978-1-4939-7230-2

Advanced Healthcare Analytics

Course Code	Title of the course	Credits	Level	Credit Split Lecture-Lab-Seminar-Project
M3221285	Advanced Healthcare Analytics	3	300	2-1-0-0

Course Outcomes

CO1	Proficiency in Analyzing Medical Imaging Data
CO2	Understanding Sensor Data in Healthcare
CO3	Genomic Data Analysis and Personalized Medicine
CO4	Advanced Techniques in Healthcare Data Mining

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

Module	**Content**
1	Analytics on Medical Imaging data: Applications in Radiography, Nuclear Medicine,Positron Emission Tomography (PET), Analytics of Sensor Data in Healthcare: Taxonomy of Sensors Used inMedical Informatics, Sensor Data Mining Applications, Chronic Diseaseand Wellness Management, Activity monitoring BehaviouralModification using ML,
2	Genomic data analysis and personalized medicine, Genomic datageneration, Methods and standards of genomic data, Genetics andGenomics for Personalized Medicine, The Potential of Machine-learning in Pharmacogenetics, Pharmacogenomics and Pharmacoepidemiology

3	Mining of digital clinical text using NLP and IR; Social Media analytics and healthcare Tracking of infectious diseases,outbreak detection using search query and website access logs,Tempral data mining in healthcare, Association analsis, Temporal pattern mining
4	Infectious data analysis using temporal methods: Descriptive epidemiology, Time series analysis; Outbreak detection and response, Spatial Analysis; Bayesian methods in infectious disease data analytics

References:

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