Std.Com. X AC- 6
15 & 22.05.2023

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

UPDATED ADDITIONAL AGENDA

For the 6th Meeting of the Standing Committee of

X ACADEMIC COUNCIL

Day & Date

Monday 15th May 2023
&
Monday, 22nd May 2023

Time

10.00 a.m.

Venue
Conference Hall
Administrative Block
Goa University

	a) Scheme of B. E. (Electronics and Computer Science) and Syllabus for subjects of Semester III and IV of B. E (Electronics and Computer Science) is enclosed as Annexure I Refer page No. 2161. **Electronics and Computer Engineering** **b) Modified scheme of B. E. (Electronics and Computer Engineering) and Syllabus for subjects of Semester V and VI of B. E. (Electronics and Computer Engineering) is enclosed as Annexure II Refer page No. 2199.** **c) Curtailed syllabus of the subject Electronic and Devices and Circuits of Semester III of B. E. (Electronics and Computer Engineering) enclosed as Annexure III. Refer page No. 2261.** **d) Modified Scheme for semester IV of B. E. (Electronics and Computer Engineering) enclosed as a part is to be implemented in the current semester itself so as to have total credits of 160.** i. The declaration by the Chairman that the minutes were readout by the Chairman at the meeting itself. Date: 27.04.2023 Sd/- Place: PCCE, Verna (Dr. Jayalaxmi Devate) Signature of the Chairperson **Part G**. The Remarks of the Dean of the Faculty i. The minutes are in order. ii. The minutes may be placed before the Academic Council with remarks if any. iii. May be recommended for approval of Academic Council. iv. Special remarks if any. Sd/- Date: 27.04.2023 Prof. Vinayak N. Shet Place: PCCE, Verna Signature of the Dean **(Back to Index)**
D 3.40	**Minutes of the combined Meeting of the Board of Studies in Computer Science and Board of Studies in Data Science held on 12.04.2023.** **Part A**. i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: a. Major, Minor, Multidisciplinary Courses (MC) and Skill Enhancement Courses (SEC) for the 4 year UG Honors with Computer Science as single Major as per the proposed programme structure under NEP b. Major, Minor, Multidisciplinary Courses (MC) and Skill Enhancement Courses (SEC) for the 4 year UG Honors with Computer Applications as single Major as per the proposed programme structure under NEP. ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: a. MSc-Integrated Data Science updated Syllabus for 4th and 5th year with 1 credit

equal to 12 hours redone and submitted based on recommendation of Academic Council.

b. MCA updated programme structure merging theory and practical for elective papers as suggested in the previous BOS and the SY Syllabus
c. Two year Masters in Data Science as per NEP guidelines has been approved by BOS. The Eligibility Criteria, programme structure and FY Syllabus placed for approval
d. Two year Masters in Artificial Intelligence as per NEP guidelines has been approved by BOS. The Eligibility Criteria, programme structure and FY Syllabus placed for approval.

Part B

i. Scheme of Examinations at undergraduate level: NIL
ii. Panel of examiners for different examinations at the undergraduate level: NONE
iii. Scheme of Examinations at postgraduate level: NIL
iv. Panel of examiners for different examinations at post-graduate level: NONE

Part C.

1. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection: NIL

Part D

i. Recommendations regarding general academic requirements in the Departments of University or affiliated colleges: NIL
ii. Recommendations of the Academic Audit Committee and status thereof: NONE

Part E

i. Recommendations of the text books for the course of study at undergraduate level: Placed References for each course
ii. Recommendations of the text books for the course of study at post graduate level: Placed References for each course

Part F. Important points for consideration/approval of Academic Council

i. The important points/recommendations of BoS that require consideration / approval of Academic Council (points to be highlighted) as mentioned below -

a. Major, Minor, Multidisciplinary Courses(MC) and Skill Enhancement Courses(SEC) for the 4 year UG Honors with Computer Science as single Major as per the proposed programme structure under NEP placed as **Annexure I** **Refer page No.2264.** *Major 4 credits Theory revised to make it 3 credits for Theory and 1 credit for Practical.*
b. Major, Minor, Multidisciplinary Courses(MC) and Skill Enhancement Courses(SEC) for the 4 year UG Honors with Computer Applications as single Major as per the proposed programme structure under NEP placed as **Annexure II** **Refer page No.2325.** *Major 3 credits Theory and 1 credit Tutorial revised to make it 3 credits for Theory and 1 credit for Practical.*

	c. MSc-Integrated Data Science for batches admitted during academic year 2020-21, 2021-22 and 2022-23, updated Structure with 1 credit equal to 12 hours based on recommendation of Academic Council placed as **Annexure III** **(Refer page No. 2362)** d. MCA updated programme structure merging theory and practical for elective papers and the SY Syllabus of all core and elective courses placed as **Annexure IV** **Refer page No.2450.** e. New two year PG **Masters in Data Science degree programme** as per NEP guidelines has been approved by BOS. The Eligibility Criteria, programme structure and FY Syllabus placed as **Annexure V** **Refer page No. 2519** for approval from Academic Council. f. New two year PG **Masters in Artificial Intelligence degree programme** as per NEP guidelines has been approved by BOS. The Eligibility Criteria, programme structure and FY Syllabus placed as **Annexure VI** **Refer page No. 2553** for approval from Academic Council. ii. The declaration by the Chairperson that the revised BOS minutes were shared over email with all members. Place:12.04.2023 Sd/- Date: Goa University **Signature of the Chairperson** **Part G**. The Remarks of the Dean of the Faculty i) The minutes are in order ii) The minutes may be placed before the Academic Council with remarks if any. iii) May be recommended for approval of Academic Council. iv) Special remarks if any. Place:12.04.2023 Sd/- Date: Goa University **Signature of the Dean** **(Back to Index)**
D 3.41	**Minutes of the Board of Studies in Agriculture meeting held on 07.04.2023** Part A. i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: Nil ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: Nil Part B i. Scheme of Examinations at undergraduate level: Nil ii. Panel of examiners for different examinations at the undergraduate level: Nil iii. Scheme of Examinations at postgraduate level: Nil iv. Panel of examiners for different examinations at post-graduate level: Nil Part C. i. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection: Nil

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D 3.40 Minutes of the combined Meeting of the Board of Studies in Computer Science and Board of Studies in Data Science held on 12.04.2023.

Annexure I

UG Degree (Honors) Computer Science effective from 2023-24
Programme Structure for Semester I and II

Semester	Major -Core (3T + 1 P)	Minor (4 T)	MC (3 T)	AEC	SEC (1 T + 2 P)	I	D	VAC	Total Credits	Exit
I	**Major- 1** CSC-100 (Introduction to Computational Thinking and Programming)	**Minor -1** CSC 111 E-Commerce **OR** CSC 112 (Computer Software Fundamentals)	**MC-1** CSC 131 Emerging Trends in Computers **OR** CSC 132 Computer Applications		**SEC-1** CSC 141 PC Troubleshooting **OR** CSC 142 Multimedia and Web Design **OR** CSC 143 Data Analytics using Spreadsheets -I **OR** CSC 144 Desktop Publishing **OR** CSC 145 Basic Computer Applications					
II	**Major-2** CSC-101 (Computer Organisation)	**Minor-2** CSC 113 Digital Marketing **OR** CSC 114 Social Media Marketing	**MC-2** CSC -133 Cyber Security Essentials		**SEC-2** OR CSC 146 Basics of Python Programming **OR** CSC 147 Graphical User Interface Design **OR** CSC 148 Data Analytics using Spreadsheets -II **OR** CSC 149 Data and Business Analytics **OR** CSC 150 Database Management and Analysis					

Major Courses

SR No	Semester	Code paper Name	Credits
1	I	**CSC 100** Introduction to Computational Thinking and Programming	4(3T+1P)
2	II	**CSC 101** Computer Organization	4(3T+1P)
3	III	**CSC 200** Programming using C ++	4(3T+1P)
4		**CSC 201** Mathematical Foundations for Computer Science	4(3T+1P)
5	IV	**CSC 202** Data Structures and Algorithms	4(3T+1P)
6		**CSC 203** Object Oriented Technologies	4(3T+1P)
7		**CSC 204** Operating System	4T
8		**CSC 205** Operating System Lab	2P
9	V	**CSC 300** Database Management System	4T
10		**CSC 301** Computer Networks	4(3T+1P)
11		**CSC 302** Software Engineering	4(3T+1P)
12		**CSC 303** DBMS Lab	2P
13	VI	**CSC 304** Cloud Computing	4(3T+1P)
14		**CSC 305** Foundations of Data Science	4(3T+1P)

15		**CSC 306** Software Quality Assurance	4(3T+1P)
16		**CSC 307** Project	4
17	VII	**CSC 400** Design and Analysis of Algorithms	4(3T+1P)
18		**CSC 401** Artificial Intelligence	4(3T+1P)
19		**CSC 402** Formal Language and Automata Theory	4(3T+1P)
20		**CSC 403** Network Security	4(3T+1P)
21	VIII	**CSC 404** Machine Learning	4(3T+1P)
22		**CSC 405** Internet of Things	4(3T+1P)
23		**CSC 406** Introduction to Parallel Computing	4(3T+1P)
24		**CSC 407** Seminar	4(1T+3 Field Work)

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Minor Courses can be opted by students from any discipline

SR No	Semester	Code paper Name	Credits
1	I	**CSC 111** E-Commerce **CSC 112** Computer Software Fundamentals	4(T) 4(T)
2	II	**CSC 113** Digital Marketing **CSC 114** Social Media Marketing	4(T) 4 (T)
3	III	**CSC 211** Problem Solving and Programming Concepts **CSC 212** Office Administration **CSC 213** Cyber Security	4 (3T + 1P) 4 (3T + 1P) 4 (3T + 1P)

4	IV (VET)	**CSC 221** Introduction to Python Programming **CSC 222** Visual Computing **CSC 223** Multimedia Technologies	4 (3T + 1P) 4 (3T + 1P) 4 (3T + 1P)
5	V(VET)	**CSC 321** Python for Data Science	4 (3T + 1P)
6		**CSC 322** Image Processing	4 (3T + 1P)
7		**CSC 323** Statistical Package	4 (3T + 1P)
8	VI (VET)	**CSC 324** R Programming for Data Science	4 (3T + 1P)
9		**CSC 325** Computer Graphics	4 (3T + 1P)
10		**CSC 326** Business Intelligence	4 (3T + 1P)
11	VII	**CSC 411** Ethical Hacking	4 (3T + 1P)
12	VIII	**CSC 412** Operations Research	4 (3T + 1P)

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Multidisciplinary Courses(MC) can be opted by students from any discipline

SR No	Semester	Code paper Name	Credits
1	I	**CSC 131** Emerging Trends in Computers	3 (T)
2		**CSC 132** Computer Applications	3 (T)
3	II	**CSC 134** Multimedia Essentials (to be dropped as it needs 1 credit Practical, which is now not allowed for MC courses during FY.	3 (2T+1P)
4		**CSC 135** Cyber Security Essentials	3 (T)
5	III	**CSC 231** Web Designing	3 (2T +1P)
6		**CSC 232** Application Software for Social Science	3 (2T +1P)

7		**CSC 233** Application Software for Science	3 (2T +1P)
8		**CSC 234** Application Software for Literature	3 (2T +1P)
9		**CSC 235** Latex	3 (2T +1P)
10		**CSC 236** 3D Graphics Design	3 (2T +1P)

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Skill Enhancement Courses (SEC) can be taken by students from any discipline

SR No	Semester	Code paper Name	Credits
1	I	**CSC 141** PC Troubleshooting	3 (1T+2P)
		CSC 142 Multimedia and Web Design	3 (1T+2P)
2		**CSC 143** Data Analytics using Spreadsheets -I	3 (1T+2P)
4		**CSC 144** Desktop Publishing	3 (1T+2P)
5		**CSC 145** Basic Computer Applications	3 (1T+2P)
7	II	**CSC 146** Basics of Python Programming	3 (1T+2P)
		CSC 147 Graphical User Interface Design	3 (1T+2P)
8		**CSC 148** Data Analytics using Spreadsheets -II	3 (1T+2P)
9		**CSC 149** Data and Business Analytics	3 (1T+2P)
10		**CSC 150** Database Management and Analysis	3 (1T+2P)
11	III	**CSC 241** Mobile App Development	3 (1T+2P)
12		**CSC 242** Digital Marketing	3 (1T+2P)
13		**CSC 243** Embedded Systems	3 (1T+2P)
14		**CSC 244** Game Development	3 (1T+2P)

15		**CSC 245** 3D Modelling and Animation	3 (1T+2P)
16		**CSC 246** Data Management Essentials	3 (1T+2P)
17		**CSC 247** Inventory Management Software	3 (1T+2P)

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Name of the Programme: **UG Degree (Honors) with Computer Science**
Course Code: **CSC-100**
Title of the Course: **Introduction to Computational Thinking and Programming**
Number of Credits: **04 (3T + 1P)** Number of contact hours**: 45L + 30P**
Effective from AY: **2023-24**

Pre-requisites for the Course:	Knowledge of basic mathematical concepts	
Course Objectives:	The students will be able to: 1. Develop Problem solving skills 2. Foster Logical and Analytical thinking. 3. Enhance Computational skills. 4. Develop good Programming Skills	
Theory: (45 hours)	**1. Introduction to Computational Thinking** Computational Thinking: Objectives, definition, principles and applications. Logical Thinking and Algorithmic Thinking: Objectives and approach Ethics and Social implications: Bias and Fairness, sustainability	5 hours
	2. Introduction to Programming 1. Problem Solving Life Cycle – Understanding the Problem Statement, Analyzing the problem, Planning Program design using Hierarchy charts, Expressing Program logic using flowcharts / Pseudocode. 2. Structured Programming concept 3. Modular Programming - Top-Down design, Bottom-up design, Stepwise Refinement	4 hours

	3. Understanding basic Program Designing Tools 1. Algorithms: Definition & its attributes, algorithm constructs, Statements: Input-Output, Decision-Making, &Looping, Examples 2. Flowchart: Definition & its attributes, symbols, Statements: Input-Output, Decision-Making & Looping, Module representation, Drawing conventions and standards, Examples. 3. Pseudo-code: Definition & its attributes, constructs, and Examples	6 hours
	4. **Basic Program Structures** Data & its types (Integer, Floating-point, Character, String), Constants & Variables, scope, Instructions & its types, how computer stores data, Operators (Arithmetic, Assignment, Relational, Logical, etc), Expressions and Equations, Evaluation of expressions, Keywords. Local and Global Variables, Parameters, Return Values, naming conventions & standards, Understanding literals, syntax and semantics, functions and modules. The Decision Logic Structure, Multiple If/Then/Else Instructions, Using Straight-Through Logic, Using Positive & Negative Logic, Logic Conversion, Decision Tables, Case Logic Structure Arrays Concepts: One dimensional Arrays, Creating, iterating, accessing and modifying array elements. Concept of Strings, String as array of characters. The Loop Logic Structure, Incrementing, Accumulating, While/While End, Repeat/Until, Automatic-Counter Loop, Nested Loops, Indicators (flags).	10 ours
	5. **Understanding functions** Functions: Definition and its need & constructs, designing simpler functions, function communication using arguments & return statements. scope of functions, function declaration and prototype, call by Value and Call by reference. Concept of Recursive functions: why, when and how. Designing recursive functions and recursive call. Base case and recursive case.	8 hours

	6. Testing and evaluation Dealing with errors: Finding bugs, mitigating errors, deciding which errors to fix, Anticipating bugs, Verification and validation, Testing in parts, testing the whole, Debugging, Program state, Opportunities for improvement	7 hours
	7. Evaluating a solution Solution evaluation criteria, correctness, efficiency, feasibility, usability, trade-offs	5 hours
Practical: **30 hours**	Using any suitable programming language (eg C, C++, etc.,), the concepts learnt in the units above are required to be implemented practically. The broad area of practical problems are mentioned / suggested below.	30 hours
	8. Basic Program Structure • At-least 10 basic programming problems related to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	
	9. Basic Sequential Instructions • At-least 08 programming problems related to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	
	10. Programing using Conditional Constructs • At-least 08 programming problems related to be completed using decision making constructs during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	
	11. Programming – Iterative constructs • At-least 06 programming problems to be completed using iterative constructs during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	
	12. Understanding functions • At-least 08 programming problems using functions to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	

Pedagogy:	Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use Video/Animation to explain various concepts. Collaborative, Peer, Flipped Learning etc.
Reference/Readings:	1. Karl Beecher, Computational thinking: A beginner's Guide to problem solving and programming, BCS Learning and Development Limited 2. Peter J. Denning and Matte Tedre, Computational Thinking, The MIT Press, Cambridge, Massachusetts, London, England 3. G Venkatesh, Madhavan Mukund, Computational Thinking, Notion Press
Course Outcome:	At the end of the course, students will be able to: 1. Use Problem Solving Skills. 2. Apply Logical and Analytical thinking. 3. Develop Computational Skills and Creativity. 4. Apply Computational thinking to solve real world problems.

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Name of the Programme: -**UG Degree(Honors) with Computer Science**
Course Code:**CSC-101**
Title of the Course: **Computer Organization**
Number of Credits: **4**
Effective from **AY: 2023-24**

Pre-requisites for the Course:	Nil	
Course Objectives:	1. Conceptualize the basics of Computer Organizational and Architectural issues and classify the computers based upon performance and machine instructions. 2. Learn various data transfer techniques and the I/O interfaces 3. Estimate and compare performances of various classes of memory 4. Understand the basics of ALU implementation, hardwired and microprogrammed control unit, pipelining and parallel architectures	
Theory:	1. Introduction to Logic Gates and Boolean Algebra: Logic Gates, Boolean Algebra, Combinational circuits, Karnaugh Map	4 hours

	1. Introduction to Computer Architecture: Introduction to Computer Architecture, Flynn's Classification of Computers, Performance Metrics (like Latency, throughput), Fundamental Blocks of Computer (like CPU, I/O subsystems, memory, control unit), computer function, interconnection structures, Bus interconnections	8 hours
	2. Instruction Set Architecture (ISA): Introduction to Instruction Set, Types of ISA; RISC, CISC; Processor Organization, Registers organization, Instruction Execution Cycle, Instruction formats, Addressing Modes; Register Transfer Language (RTL), Assembly Language Programming, X86 -Architecture, ARM Architecture	13 hours
	3. Memory Hierarchy: Hierarchical memory organization, Types of Memory-internal and external, Cache memory, Memory interleaving,	5 hours
	4. Data representation: Data Type Representation, Number System, Signed number, fixed, floating point, character representation, Addition, Subtraction, Multiplication - Shift and Add, Booth's Algorithm, Division	7 hours
	5. Peripheral devices: Types of Peripheral Devices, I/O subsystem,programmed I/O, Interrupt-driven I/O, DMA, I/O channels and processors	8 hours
Practical:	Sample Assignments for the Practical Component - 1. Introduction to 8086 architecture and instruction set and Writing assembly language programs in 8086 using MASM or compatible assembler either in windows or Linux 2. Find the sum of 1 + 2 + 3 .... + n 3. Display the multiplication table of a number 4. Store and retrieve numbers from memory 5. Sort the numbers stored in the memory 6. Installing Linux / Windows Operating System, Partitioning and formatting disk, Installing	30 hours

	applications device drivers, working with files, mounting file systems, checking system space, creating, modifying and deleting user accounts 7. Study of Linux Commands 8. Shell Programming in Unix/Linux, arithmetic operations, loops, files Ex. Write a BASH shell script prime which will accept a number b and display first n prime numbers in standard output. 9. Shell scripting using general-purpose utilities. Ex. A) Write a menu driven shell script which will print the following menu and execute the given task to display result on standard output. Display calendar ~~of current month~~ Display today's date and time Display usernames ~~those are currently logged in~~ the system Display your name ~~at given x, y position~~ Display your termin~~al number~~ Exit 10. Shell programming using filters (including grep, egrep, fgrep)	
Pedagogy:	PowerPoint, Tutorials, Hybrid learning	
References/ Readings:	1. Computer Architecture: A Quantitative Approach by John L. Hennessy & David A. Patterson, 5th Edition, Morgan Kaufmann 2. William Stallings, "Computer Organization and Architecture : Designing for Performance", 9th Edition, Prentice Hall of India.	
Course Outcomes:	At the end of the course, students will be able to: 1. Explain the theory and architecture of central processing unit, I/O and memory organization 2. Analyze some of the design issues in terms of speed, technology, cost, performance, CPU architecture. 3. Describe the concepts of parallel processing, pipelining and interprocessor communication. 4. Represent different number systems, and perform various binary operations	

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-111**
Title of the Course: **E-Commerce**
Number of Credits: **4 (4 Theory)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	None	
Course Objectives:	This Course aims - ● To develop an understanding of Web-based Commerce ● To equip students to assess-commerce requirements of a business ● To enable students to develop - business plans and e-commerce applications	
Content:	**1. Introduction to Electronic Commerce** Meaning, Nature and scope of e-commerce,History of e-commerce, Business applications of e-commerce, E-CommerceModels:-(B2B,B2C,C2C,B2G),Advantages and Disadvantages of e-commerce, Applications of M-Commerce	6 hours
	2. E-Commerce Web-sites Websites as marketplace, Role of website in B2C e-commerce, Website design principles, Alternative methods of customer communication such as e-mail, Email etiquette and e-mail security	6 hours
	3. Online Marketing Online marketing and advertising, Push and pull approaches, Web counters, Web advertisements, Content marketing, Need of Digital Marketing for an e-commerce Business, Search Engine Optimization(SEO),Search Engine Marketing(SEM),Social Media Marketing(SMM), Web Analytics	10 hours
	4. Applications of E-commerce Applications of e-commerce to Supply chain management Applications of e-commerce to Customer Relationship Management, Product and service digitization, Remote servicing	6 hours
	5. Business to Consumer E-CommerceApplications Cataloguing,Order planning and order generation,Cost estimation and pricing,Order receipt and accounting,Order selection and prioritization,Order scheduling,Order fulfilling,Order delivery,Order	6 hours

	billing,Post sales service	
	6. BusinesstoBusinessE-Commerce Need and Models of B2B e-commerce,Using public and private computer networks for B2B trading; EDI and paperless trading, Characteristic features of EDI service arrangement,EDI architecture and standards,Reasons for slow acceptability of EDI,Value Added Networks	10 hours
	7. ElectronicPaymentSystem Types of payment systems, credit cards, debit cards, mobile all etc,Electronic Fund Transfer(EFT),Operational credit and legal risk of e-payment,Risk management options for e-payment systems	6 hours
	8. Security Issues in E-Commerce Risks of e-commerce,Types and sources of threats to e-commerce;Protecting electronic commerce assets and intellectual property,Firewalls,Client server network security,Security Protocols–SSL,SET,S-HTTP,Data and message security,Security tools, Digital identity and electronic signature, Encryption and concept of public and private key infrastructure;Risk management approach to ecommerce security	10 hours
Pedagogy:	PowerPoint presentations, Case studies	
References/ Readings:	ReferenceBooks: 1. Agarwala,KalesN.,AmityAll DeekshaAgarwala, 2. Business on the Net: An Introduction to the Whats and Hows of E Commerce,Macmillan India Ltd, 2000 3. Diwan, Pragand Sunil Sharma, Electronic Commerce- A Manager's Guide to E Business,Vanity Books International, Delhi. 4. Fitzgerald, Business Data Communication Network, McGrawHill, 1998. 5. Kalakota,Ravi and Andrew.Whinston, Frontiers of Electronic Commerce, Addison Wesley, 1999. 6. Dishek J. Mankad,Understanding Digital Marketing: Strategies for online success, 2019 NPTELResources: https://nptel.ac.in/content/storage2/courses/106108103/pdf/PPTs/mod13.pdf	

Course Outcomes:	On completion of the course students will be able to:- 1. Describe the basics of e-commerce. 2. Explain the design principles of e-commerce websites. 3. Explain the different models of e-commerce. 4. Describe the different electronic payment systems. 5. Explain the security issues, security mechanism and threats to e-commerce applications.

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Name of the Programme: **Students from any discipline can opt for this**
Course Code: **CSC 112**
Title of the Course: **Computer Software Fundamentals**
Number of Credits: **4 (4T)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	Nil	
Course Objectives:	This course will enable the student to gain an understanding of the core concepts and technologies which constitute Information Technology	
Content:	**Unit I : Introduction of IT** Information: Prerequisites of Information, Need for Information Technology and its advantages;Information Technology: Definition and components Basic Computer Organization Application of IT (Science and Engineering, Business & Commerce, Education, Governance, Medicine, Entertainment)	5 hours
	Unit II : Data And Information ● Data and Information: Definition, Types of data, Qualities of Information ● Data Representation: Character formats- ASCII, Unicode (Definition, Adding regional languages, Phonetic keyboards ● Number system: Binary, decimal, Conversion ● Data Organization: Directory structure, File formats and Compression (Text, Audio, Image, Video) ● Data Backup: Techniques, Scheduler, Online backup, Advantages ● Device Interfaces and Data Storage: Data device Interface access methods (USB, IDE /SATA), ● Optical memory (Blue ray), Flash memory (USB Sticks, Memory Cards, SD, MMC, Micro SD), Magnetic Memory (External disks), New Devices (Solid state drives)	15 hours

	Unit III : Software: System and Applications ● Relationship between Hardware and Software ● Programming Languages: Low level, High level, Translators ● System Programs: Operating systems: Operating systems ● Definition and functions of operating system, Examples of operating System (Windows, Linux, Online OS, Virtual OS, Comparison), Multi boot systems ● (disk partitions and logical drives) Directory Structure: System directories, Users (administrator, limited rights user and guest), User directories (directory permission) ● Services, drives and hardware interfaces ● Application Programs : Definition , Examples Introduction to Mathematical Computation Packages Human computer interaction (HCI)	15 hours
	Unit IV : Basics of Computer Networking and data communication Networking basics, why networking of computers is needed, Types of networks-LAN, MAN, WAN, Network Components – H/W, Software, Communication channels, Network Devices, Network topologies. Communication Process, Data Transmission speed, Communication Types (modes) Internet – role and importance, IP Addressing – public Vs Private, Static Vs Dynamic; WWW & related protocols;	15 hours
	Unit V : Future IT trends ● Artificial Intelligence (AI) and Automation (Definition, Applications) ● IoT and Edge Computing ● Cloud Infrastructure ● Virtual reality & Augmented Reality ● Business Intelligence	10 hours
Pedagogy:	Lecture method using ICT tools	
References/ Readings:	1. A. Goel, Computer Fundamentals, Pearson Education, 2010. 2. P. Aksoy, L. DeNardis, Introduction to Information Technology, Cengage Learning, 2006 3. P. K.Sinha, P. Sinha, Fundamentals of Computers, BPB Publishers, 2007	

Course Outcomes:	At the end of the course, learner will be able to: 1. Explain basic concepts and terminology of information technology. 2. Explain basics of personal computers and their operations. 3. Identify various I/O devices, storage and networking devices 4. Familiarize with recent trend of IT

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-113**
Title of the Course: **Digital Marketing**
Number of Credits: **4 (4 Theory**)
Effective from AY: **2023-24**

Pre-requisites for the Course:	None	
Course Objectives:	• To acquaint the students with basic principles and concepts of digital marketing & advertising • To understand and familiarize the students with the concept of Digital Marketing techniques like Adwords, search advertising, display advertising. • To understand the concept of Search Engine Optimization (SEO)	
Content:	**1. Fundamentals of Digital Marketing** Marketing in the digital world; Integrated marketing- The Phygital; Global trends inDigital Marketing; Digital channels- Paid, Owned and Earn; Fundamentals on the primary asset-yourwebsite; Careers in digital marketing; Skill development in Digital marketing	5 hours
	2. Ad Words Fundamentals Understanding Pay-per-click Advertisement; Significance and evolution of Ad Words in PPC Bing Ads V/s Google Ads- overview; AdWords Certification- Overview, Benefits and Preparation; Google Ad Networks; Different Ad Formats;Keywords - significance and planning; Using Keyword Planner and other tools; Keyword matches and their usage; Campaign Structure and Organization Quality, Rank and Relevance of Ads; Bidding and budget; Targeting Setting Extensions and their usage; Ad policies and approvals; Reports and Analysis Metrics; Conversion Tracking; Campaign Optimization	10 hours
	3. Search & Display Advertising with Adwords Search with Adwords Keywords - planning, matching and combination; Specifications of an Ad and how to put it to	15 hours

		good use; Managing Invalid Clicks; Ad extensions and usage; Dynamicsearch ads; Landing page - your virtual front; Campaign Experiment; Opportunities Tab; AdWords APIs; Ad Words editor-Benefits and usage; Managing multiple accounts Display with Adwords Google Display Network and Partnerships; Double click Ad Exchange and AdSense Campaign Creation and Structuring for display; Keyword and targeting through display network; Campaign Metrics, Analysis and optimization	
		4. SEO Basics How search engines work; Different Search results and significance; Query types and significance; What is SEO and key factors determining the same; Components on SEO-onsite and off page; Keyword Planning; Using tools to get effective keywords; Long tail keywords-the hidden gems; Art and science of tags-URL, title, meta, H1, alt text, etc.; Write a good meta description; Page speed - its impact and improvement areas; All about links- broken, internal et al; Dealing with duplicate content; Robot. Txt and Sitemap; Structured data and schema.org	15 hours
		5. SEO Advance Concepts Link building basics; Avoiding harmful links; Finding and leveraging link building opportunities; Creating a link building plan; Major Google updates and their implication son SEO; Using Search Console for SEO; KPIs of SEO; Tools for SEO; Moz SEO Products; SEM rush Competitive Research and Business Intelligence Software; Competition Analysis for SEO; Overall planning for SEO; Understanding nuances of local and international SEO; Accelerated mobile pages and SEO; Artificial Intelligence,Voice search and SEO–what to look forward	15 hours
Pedagogy:	PowerPoint presentations, Case studies		

References/ Readings:	Recommended Reference Books: 1. Dave Chaffey & Fiona Ellis-Chadwick, DigitalMarketing: Strategy, Implementation and Practice, Pearson Education 2. Ekaterina Walter, The Power of Visual Storytelling, McGraw-Hill Education 3. Ben Hunt, Convert!: Designing Websites For Traffic and Conversions, John Wiley &Sons 4. Lon Safko, The Social Media Bible: Tactics, Tools, & Strategies for Business Success, Brilliance Audio; Unabridged Edition 5. Pam Didner,Global Content Marketing, McGraw-Hill Education 6. Joe Pulizzi, Content Inc.: How Entrepreneurs Use Content to Build Massive Audiences and Create Radically Successful Businesses, McGraw-Hill Education 7. Mike Monteiro,You're My Favorite Client, A Book A part 8. Seth Godin, All Marketers Are Liars, Portfolio 9. JayBaer,Youtility:Why Smart Marketing Is About Help Not Hype, Portfolio 10. Russell Glass & Sean Callahan,The Big Data-Driven Business,Wiley 11. Damian Ryan and Calvin Jones, Understanding Digital Marketing: Marketing Strategies for Engaging the Digital Generation, Kogan Page 12. Ryan Deiss and Russ Henneberry, Digital Marketing for Dummies, JohnWileyand Sons 13. Corey Rabazinski, Google Adwords for Beginners: A Do-It-Yourself Guide to PPC Advertising, Create Space Independent Publishing Platform
Course Outcomes:	At the end of the course learner will be able to 1. Apply the understanding of digital landscape and building a case to leverage online channels 2. Strategize, implement and optimize online campaigns successfully 3. Develop and design Online Advertising campaigns, AdWords Campaign management and Campaign Basics across search. 4. Drive organic traffic through Search Engine Optimization 5. Apply advance concept of Search Engine Optimization to capture the right intent

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-114**
Title of the Course: **Social Media Marketing**
Number of Credits: **4 (4 Theory)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	None	
Course Objectives:	● To understand the concept of Social Media Marketing platform. ● To understand video and mobile platform advertising. ● To understand and apply the concept of web and google analytics. ● To acquire understanding of LinkedIn, Twitter, Pinterest Marketing ● To Measure, Analyze and Optimize Social Media Marketing Campaigns ● To create an effective Digital Marketing Plan.	
Content:	**1. Introduction to Social Media Marketing** Evolution and importance of Social Media ;What social media can do for you?; Different social media platforms; Unwritten rules of Social Media ;Facebook for business; Using of Facebook groups, pages and events; Using of Facebook tabs and apps; Running Facebook ads; Ad Manager and Power Editor in Facebook; Targeting –the structured approach; Facebook page Insights	15 hours
	2. YouTube Video and Mobile Advertising YouTube - why do you need to be there?; YouTube format, tools & targeting; Video Campaign Creation; Video Campaign track and optimization; Video Ad performance & best practices; YouTube Analytics. Importance of Mobile and Opportunities to Leverage; Key Objectives for Mobile Marketing; Ad Formats and Networks for Mobile; Mobile Site: Key Considerations; Mobile App :Key Considerations; Mobile specific bidding and targeting; Apps Marketing, Mobile Analytics, Reporting and Optimization	10 hours
	3. Media Marketing with Twitter, LinkedIn, Instagram & Snapchat Introduction to Twitter and its terminologies; Creating a good Twitter profile; Building followers on Twitter;Using Twitter Chats;Twitter as an influencer marketing tool; Twitter ads; Twitter Analytics; LinkedIn for Business; Profile, pages and Pulse in LinkedIn; LinkedIn Ad; LinkedIn Analytics; B2B marketing using LinkedIn; Introduction to Pinterest for Business; Pinterest strategies; Instagram for business; Instagram strategies;New kid on the block–Snapchat;Online Reputation Management ;Social media tool sand how to use them;Creating social media calendar and workflow	15 hours

	4. WebAnalytics Introduction to web analytics; How web analytics works, Analytics Framework; Goals, Objectives and KPIs; Contextualizing of Data; Segmentation of Data; Making analytics actionable; Attribution Modeling; URL tracking and UTM builder; Clickstream, HeatMap and other forms of WebAnalytics; A/B testing	10 hours
	5. GoogleAnalytics How Google Analytics (GA) work; Dimensions ,metrics and other common terminologies;Setting up Google analytics;Tracking,Reports and Dashboards ;Acquisition, Behaviour and Conversion;Visitors Analysis; Source and Medium analytics; Conversion tracking; Content Performance Analytics; Userflow;Leveraging real time analytics; Content Experiment; Linking Search Console and AdWords with Google Analytics; Intro to Google Data Studio	10 hours
Pedagogy:	PowerPoint presentations, Case studies	
References/ Readings:	Recommended Reference Books: 1. Dave Chaffey & Fiona Ellis-Chadwick, Digital Marketing: Strategy, Implementation and Practice,PearsonEducation 2. Ekaterina Walter, Jessica Gioglio; The Power of Visual Storytelling : How to Use Visuals, Videos, and Social Media to Market Your Brand, McGraw Hill Education 3. BenHunt, Convert!: Designing Websites For Traffic and Conversions, John Wiley & Sons 4. Lon Safko, The Social Media Bible: Tactics, Tools, & Strategies for Business Success, Brilliance Audio; Unabridged Edition 5. PamDidner, Global Content Marketing, McGraw-Hill Education 6. Joe Pulizzi,ContentInc.: How Entrepreneurs Use Content to Build Massive Audiences and Create Radically Successful Businesses, McGraw-Hill Education 7. MikeMonteiro,You'reMyFavoriteClient,ABookApart 8. Seth Godin, All Marketers Are Liars, Portfolio 9. JayBaer, Youtility: Why Smart Marketing Is About Help Not Hype, Portfolio 10. Russell Glass & Sean Callahan, The Big Data- Driven Business,Wiley 11. Damian Ryanand Calvin Jones, Understanding Digital Marketing: Marketing Strategies for Engaging the Digital Generation, KoganPage 12. Ryan Deiss and Russ Henneberry, Digital Marketing for Dummies, John Wiley and Sons	

	13. Corey Rabazinski, Google Adwords for Beginners: A Do-It-Yourself Guide to PPC Advertising, CreateSpace Independent Publishing Platform
Course Outcomes:	On completion of the course learner will be able to: 1. Explain basics of Social Media Marketing. 2. Able to use mobile and video media for online advertising, & AdWords campaign management. 3. Able to use Twitter, LinkedIn, Instagram & similar media for promotion. 4. Comfortably apply relevant tools and concepts to execute measure and monitor an annual online marketing plan and use analytics to drive action able improvements 5. Use new digital marketing techniques into strategic marketing plan

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Name of the Programme: **Students from any Programme can opt for this**
Course Code:**CSC-131**
Title of the Course: **Emerging Trends in Computer**
Number of Credits: **3**
Effective from AY: **2023-24**

Pre-requisites for the Course:	NIL	
Course Objectives:	This course will enable students to explore current breakthrough technologies in the areas of Artificial Intelligence (AI), Big data and Business Intelligence, IOT, Blockchain that have emerged over the past few years. It will also prepare the students to use technology in their respective professional preparations.	
Content:	**Unit 1 : Artificial Intelligence** AI Concept, Scope of AI, Components of AI, Types of AI, Machine Learning (ML) and Natural Language Processing (NLP), Applications of AI, the state of art AI today	8 hours
	Unit 2 : Business Intelligence (BI) and Big data BI- Definition, Importance, Benefits of Business Intelligence, How BI process works, Stages of Business Intelligence, Big data – Definition, Characteristics, Challenges with Big Data, Traditional Business Intelligence (BI) versus Big Data. Big Data Applications in Business	10 hours

	Unit 3 : Internet of Things (IoT) and Embedded Systems Definition, Characteristics of Embedded System, Real time systems, Real time tasks. Processor basics: General Processors in Computer Vs Embedded Processors, Microcontrollers, Microcontroller Properties, Components of Microcontrollers, Components of Embedded Systems, Introduction to embedded processor Definition, Characteristics of IoT, Trends in Adoption of IoT, IoT Devices, IoT Devices Vs Computers, Societal Benefits of IoT, Technical Building Blocks. IoT functional blocks, IoTenabling technologies, IoT levels and deployment templates, Applications in IoT	12 hours
	Unit 4 : Cloud Computing Importance of Cloud Computing, Characteristics, Pros and Cons of Cloud Computing, Migrating into the Cloud, Seven-step model of migration into a Cloud, Trends in Computing. Cloud Service Models: SaaS, PaaS, IaaS, Storage, Cloud Architecture: Cloud Computing Logical Architecture, Developing Holistic Cloud Computing Reference Model, Cloud System Architecture, Cloud Deployment Models	8 hours
	Unit 5: Blockchain and Cryptocurrency Introduction to Blockchain Technology and its Importance, Evolution of the Blockchain Technology, Elements of a Blockchain A basic crypto currency, Creation of coins, Payments and double spending, Bitcoin –Digital Signatures as Identities – eWallets – Personal Crypto security - Bitcoin Mining	7 hours
Pedagogy:	PowerPoint, YouTube Videos	
References/ Readings:	1. Artificial Intelligence: A Modern Approach, Stuart Russel and Peter Norvig, Pearson 3 rd 2015 2. Big Data Analytics, RadhaShankarmani, M Vijayalakshmi, Second Edition, 2017, WileyBig Data and Hadoop, V.K Jain Khanna Publishing, First 2018 3. Getting Started with the Internet of Things, Cuno Pfister O‟Reilly Sixth 2018 4. Internet of Things: A Hands-On Approach by Arsheep Bahga 5. Cloud Computing by Anandamurugan, T.Priyaa et al 6. Blockchain for Beginners: The Art of Decentralisation &	

	Cryptography, Tejaswini N and Yathish R
e-Resources and other Digital Material	1. https://nptel.ac.in/courses/106/104/106104189/ 2. https://www.coursera.org/specializations/big-data 3. https://www.edx.org/course/big-data-fundamentals 4. https://www.edx.org/course/artificial-intelligence-ai 5. https://www.udemy.com/course/artificial-intelligence-az
Course Outcomes:	At the end of the course, students will be able to: 1. Identify different emerging technologies 2. Select appropriate technology for a given task 3. Identify necessary inputs for applications of emerging technologies 4. Define emerging trends in Computer Science

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-132**
Title of the Course: **Computer Applications**
Number of Credits: **3**
Effective from AY: **2023-24**

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide an understanding of essential Information Technology concepts To familiarize and learn use of various types of IT tools	
	Unit 1 : (Computer Basics) Introduction to computers – Definition, Characteristics, Classification of computers, Components of a Computer System –Hardware Components - Central Processing Unit, Input devices, Output devices, Computer Memory. Categories of Software - System Software and Application Software, Operating Systems - definition and functions. Data - Definition, Types, Data Representation, Types of Number system- Binary, Octal, Hexadecimal Conversion between number bases	8 hours

	Unit 2 : (Word Processor) Word processing concepts: Use of Templates, Working with word document: Editing text, Find and replace text. Formatting- Text, Paragraphs, Styles, Columns. Bullets and numbering, Tabs, Indent, Page Formatting. Design Themes, Page Background. Page setup Insert: Tables, Illustrations, Links, Comments, Header and Footer, Symbols. Tables: Inserting, filling and formatting a table, Changing cell width and height, Alignment of Text in cell, Delete / Insertion of Row, Column and Merging & Splitting of Cells, Border and Shading. Referencing- Captions, Footnotes and Endnotes Citations and Bibliography, Reference Tables and Indexes, Bookmarks and Cross-References.	10 hours
	Unit 3 : Spreadsheets Spreadsheet concepts: Managing worksheets; Formatting, Conditional formatting, Entering data, Editing, Handling operators in formula, Project involving multiple spreadsheets, Organizing Charts and graphs, Generally used Spreadsheet functions: Mathematical, Statistical, Financial, Logical, Date and Time, Lookup and reference, Database, and Text functions, Summarizing data using filter. Pivot tables to analyze data. Using What-If Scenario Manager, Goal Seek. Printing a worksheet-working with page breaks, adding headers or footers, choosing what to print.	10 hours
	Unit 4 : Presentation Software Creating a presentation, creating a Presentation Using a Template, Creating a Blank Presentation, Inserting & Editing Text on Slides, Inserting and Deleting Slides in a Presentation, Saving a Presentation, Manipulating Slides, Inserting Table, Adding ClipArt Pictures, Inserting Other Objects, Resizing and Scaling an Object, Creating & using Master Slide, Presentation of Slides, Choosing a Set Up for Presentation, Running a Slide Show, Transition and Slide Timings, Automating a Slide Show, Providing Aesthetics to Slides & Printing, Enhancing Text Presentation, Working with Color and Line Style, Adding Movie and Sound, Adding Headers, Footers and Notes, Printing Slides and Handouts.	10 hours

	Unit 5 : User Generated Content Blogs and Wikis. Online Data Capture Tools: Types of data capture form templates (Personal, Work and Education). Question Formats for data capture (short answer, paragraph, multiple choice, check- box, drop-down, linear-scale, multiple choice grid). Data form design (Add new question, add section, add title/description/image/video). Data form distribution techniques (Send via email, publish on social media, send as link). Response management (Print responses, Export to spreadsheet, View analysis, Include analysis in word processing reports)	7 hours
Pedagogy:	PowerPoint, Tutorials	
References/ Readings:	1. Introduction to Information Technology by ITL Education Solutions Limited, second edition. 2. "O" Level made simple "Introduction to ICT resources" by Satish Jain, Shashank Jain, Shashi Singh & M. Geetha Iyer, BPB publication. 3. Computer fundamentals fourth edition by Pradeep K. Sinha and Priti Sinha BPB publications 4. Information Technology The breaking wave by Dennis Curtin Tata McGraw-hill edition	
Course Outcomes:	At the end of the course the learner will be able to: 1. Understand the essential of Information Technology Concepts 2. Develop practical skills in data capture, analysis and presentation, report formatting 3. Use a range of current, standard, Office Productivity software applications 4. Apply the basic concepts of a word processing package, electronic spreadsheet and PowerPoint tool	

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-134**
Title of the Course: **Multimedia Essentials**
Number of Credits**: 3(2T + 1P**)
Effective from AY: **2022-23**

Pre-requisites for the Course:	• Basic Knowledge of Computers and Internet.

Course Objectives:	• To make the students aware of Color Models and Color harmony • Raster and Vector Graphics formats & basic Graphic editing • Font types, selection of fonts • Audio formats, codecs, basic audio editing, filters • Video formats, codecs, basic video editing, filters and transitions • Data compression.	
Content:	**(Theory)**	**No of Lectures**
	1. Multimedia - Introduction, Uses of Multimedia, Social & Ethical considerations, Digital Representation.	3L
	2. Color Theory- ColorBasics, ColorSystems, Color Wheel, Complementary Colors,After Images, Color Combinations, Color & Contrast, Proportion & Intensity, Shades, Tones & Tints.	4L
	3. Introduction to Computer Graphics: Difference between Raster and Vector Graphics,Raster graphics: resolution, image compression, file formats, manipulation; Vector graphics fundamentals, file formats, shapes, transforms and filters	5L
	4. Text and Layout: character set,fonts & faces, using TextinMultimedia, Font Editing & Tools.	4L
	5. Sound: Introduction, Digital Audio, MIDI Audio, Audio Codec & file formats, Making Digital Audio files.	5L
	6. Animation: Principles of Animation, Types of Animation, Keyframe, Sprite, file formats.	4L
	7. Video: How Video Works and is Displayed, Aspect Ratio, Frame size, Frame Rate, Video Codec & File formats, Processing & Delivery.	5L

	(Practical) List of Practical : (at least 8 Practical from the following) 1. Image compositing: Remove background and combine images to create a work of art 2. Learn to create images for Print,WebandVideo 3. Design a Logo for a company 4. Design a Brochure for given Product and details. Learn about different file formats 5. Design a poster with given information and learn about image compression 6. Edit the sound file and Learn about Effects and Filters of sound. 7. Record your voice and learn about Audio Compression 8. Learn Audio mixing and streaming of audio content 9. Learn about Video editing. Prepare a video with rough cuts. 10. Prepare video content with title and special effects. 11. Record video content and learn about video compressions. 12. Prepare Video content for vimeo/ youtube. Note : Practical can be done using GIMP, Inkscape, Scribus, Photoshop, Illustrator, Flash, Blender, Audacity, Lightworks.
Pedagogy:	Conventional Lecture method Case based learning Experiential Design Thinking Formative and summative assessments Live experimental projects

References/ Readings:	Single Author Book: 1. Vaughan Tay, Multimedia: Making it Work, 8th edition, TataMcGraw-Hill 2. Ranjan Parekh, Principles of Multimedia McGraw Hill Education; 2nd edition Edited Book : Ze-Nian Li & Mark S Drew; Fundamentals of Multimedia; Pearson Education International Edition Two or More Authors : 1. Nigel Chapman, Jenny Chapman; Digital Multimedia; Wiley India Edition, 2nd Edition 2. Adobe Creative Team, Adobe Photoshop Classroom in a Book, AdobePress 3. Adobe Creative Team, Adobe Illustrator Classroom In A Book, AdobePress 4. Adobe Creative Team, Adobe Flash Professional CS6 Classroom in a Book, Adobe Press, 1st Edition E-books: 1. Jeffcoate Judith, Multimedia in Practice, Technology and Applications,PHI. 2. Multimedia Technologies: Concepts, Methodologies, Tools, and Applications - Syed Mahbubur Rahman Minne sota State University, Mankato, US. Article in Online Encyclopedia: 1. Britannica, The Editors of Encyclopaedia. "raster graphics". Encyclopedia Britannica, 7 Oct. 2022, https://www.britannica.com/technology/raster-graphics. Accessed 11 April 2023. 2. Nassau, Kurt. "colour". Encyclopedia Britannica, 27 Mar. 2023, https://www.britannica.com/science/color. Accessed 11 April 2023. 3. Color Theory: https://www.worqx.com/ 4. Animation: http://en.wikipedia.org/wiki/Animation_software Journal Article in Scholarly Journal : Jan L. Plass, Steffi Heidig, Elizabeth O. Hayward, Bruce D. Homer, Enjoon Um, “Emotional design in multimedia learning: Effects of shape and color on affect and learning”, Learning and Instruction,Volume 29, 2014,Pages 128-140, ISSN 0959-4752, https://doi.org/10.1016/j.learninstruc.2013.02.006. Available: (https://www.sciencedirect.com/science/article/pii/S0959475213000273)

Course Outcomes:	Students will be able to: 1. Explore the fundamentals and underlying theories of Multimedia. 2. Use audio editing. 3. Design and develop 2D/3D animations 4. Create films, visual effects for the creative media. 5. Innovate best practices for elements of design, virtual reality and gaming.

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-135**
Title of the Course:**Cyber Security Essentials**
Number of Credits: **03**
Effective from AY: **2023-24**

Pre-requisites for the Course:	The student should have basic knowledge on how to use computers and internet technology.	
Course Objectives:	• To introduce principles of cyber security and have an understanding on the cyber-crimes taking place. • To have an understanding of the existing legal framework and laws on cyber security. • To enable students to adopt safe practices when using social media platforms and digital payment systems.	
Content:	**1. Introduction to Cyber security** Defining Cyberspace and Overview of Computer and Web-technology, Architecture of cyberspace, Communication and web technology, Internet, World Wide Web, Advent of internet, Internet infrastructure for data transfer and governance,Internet society,Regulation of cyberspace, Concept of cyber security, Issues and challenges of cyber security.	5 hours

	2. **Cyber crime and Cyber law** Classification of cyber-crimes, Common cyber-crimes, cyber-crime targeting computers and mobiles, cyber-crime against women and children, financial frauds, social engineering attacks, malware and ransomware attacks, zero day and zero click attacks, Cybercriminals modus-operandi, reporting of cyber-crimes, Remedial and mitigation measures, Legal perspective of cyber-crime, IT Act 2000 and its amendments, Cyber-crime and offences, Organisations dealing with Cyber-crime and Cyber security in India, Case studies.	10 hours
	3. Social Media Overview and Security Introduction to Social networks. Types of Socialmedia, Social media platforms, Social media monitoring, Hashtag, Viralcontent, Social media marketing, Social media privacy, Challenges, Opportunities and pitfalls in online social network, Security issues related to social media, Flagging and reporting of inappropriate content, Laws regarding posting of inappropriate content,Best practices for the use of Social media,Case studies.	10 hours
	4. E-Commerce and Digital Payments Definition of E- Commerce, Main components of E-Commerce, Elements of E-Commerce security, E-Commerce threats, E-Commerce security best practices, Introduction to digital payments,Components of digital payment and stakeholders, Modes of digital payments-BankingCards, Unified Payment Interface (UPI),e-Wallets, Unstructured SupplementaryService Data (USSD), Aadhar enabled payments, Digital payments related common frauds and preventive measures.RBI guidelines on digital payments and customer protection in unauthorised banking transactions. Relevant provisions ofPayment Settlement Act,2007.	10 hours
	5. Digital Devices Security, Tools and Technologies for Cyber Security End Point device and Mobile phone security, Password policy, Security patch management, Data backup, Downloading and management of third-party software, Device security policy, Cyber Security best practices, Significance of host firewall and Ant-virus, Management of host firewall andAnti-virus, Wi-Fi security, Configuration of basic security policy and permissions.	10 hours

Pedagogy:	Lecture method, Case Studies, Hands-on Training, Group Discussions
References/ Readings:	1. Cyber Crime Impact in the New Millennium, by R. C Mishra, Author Press. Edition 2010. 2. Cyber Security Understanding Cyber Crimes, Computer Forensics and LegalPerspectives by Sunit Belapure and Nina Godbole, Wiley India Pvt. Ltd. (First Edition, 2011) 3. Security in the Digital Age: Social Media Security Threats and Vulnerabilities by Henry A. Oliver, Create Space Independent Publishing Platform. (Pearson, 13th November, 2001) 4. Electronic Commerce by Elias M. Awad, Prentice Hall of India Pvt Ltd. 5. Cyber Laws: Intellectual Property & E-Commerce Security by Kumar K, Dominant Publishers. 6. Network Security Bible, Eric Cole, Ronald Krutz, James W. Conley, 2nd Edition, Wiley India Pvt. Ltd. 7. Fundamentals of Network Security by E. Maiwald, McGraw Hill.
Course Outcomes:	At the end of the course, learner will be able to: 1. Explain the concept of Cyber security and issues and challenges associated with it. 2. Explain the cyber crimes, their nature, legal remedies and as to how to report the crimes through available platforms and procedures. 3. Explain various privacy and security concerns on online social media and the reporting procedure of inappropriate content, underlying legal aspects and best practices for the use of Social media platforms. 4. Explain the basic concepts related to E-Commerce and digital payments, digital payment modes and related cyber security aspects, RBI guidelines and preventive measures against digital payment frauds.

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-141**
Title of the Course: **PC Troubleshooting**
Number of Credits: **3 (1 Theory + 2 Practical)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	Nil

Course Objectives:	To make the students capable of understanding the functioning of hardware parts and develop skills in diagnosing the faults and troubleshooting the computer system.	
Content:	**1. Hardware Basics** Basic terms, concepts, and functions of system modules (System board,firmware, storage devices, monitor, boot process, ports).CMOS and BIOS,Motherboard, SMPS	3 hours
	2. Memory Module and Hard disk Different types of Memory Modules, Tips on installing memory chips.Disk structure: Cylinders, heads, platters, tracks and sectors, structure of a disk, hard disk controllers.Types of interface controller and drives.	4 hours
	3. Input/OutputDevices Keyboard and Mouse, Scanner and its types, CD-ROM Drives, Monitors: Display basics, Display adapter cards, VGA and super VGA, Printer: Types, Interfaces, Connection to Computers.	4 hours
	4. TroubleshootingandPreventive Maintenance Troubleshooting basics,Troubleshooting by visual Inspection,PreventativeMaintenance. POST: Functions, Test Sequence, Error messages, Troubleshooting Procedures andPreventative Maintenance. Power Supply and UPS.	4 hours
Pedagogy:	PowerPoint Presentations, Hands on	
References/ Readings:	1. IBM PC & Clones: Hardware Troubleshooting and Maintenance byB.Govindarajalu, Tata McGraw Hill 2. PC Upgrade & Repair Bible, Wiley India. 3. Computer Installation and Servicing by D Balasubramanian	
Course Outcomes:	At the completion of this course, the student will be able to: 1. Explain Basics of Hardware Components. 2. AcquireknowledgeofFindingFaultsinComponents 3. Install, Configure and maintain various components in computer systems and peripherals. 4. DiagnosefaultsofDifferentComponents 5. Repair and maintain computer systems and its peripherals.	

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List of Experiments:
(Perform at least 10 experiments from the list given below)

Sr.No.	Name of the Experiment
1	Disassemble the PC carefully. Assemble the same PC you have disassembled and boot the system.
2	Observe various connectors, ports back and front side of the computer and write their purpose. (e.g. Power, PS/2keyboard and mouse, Serial and parallel, USB, VGA, LAN, Audio & microphone, Firewire, HDMI, games, SATA etc.)
3	Identify the on-board features of the motherboard like network capabilities, and gaming capabilities. Install the given driver and test the computer for proper functioning. Remove the drivers for some devices like sound, display, network etc. and again install them and check the proper functioning of the computer. Upgrade the given PC by adding RAM and additional HardDisk.
4	Observe the power supply (SMPS) and measure their voltage levels of a given SMPS. Measure various voltage levels, such as motherboard, storage devices and fan etc. using a multimeter. Do a detailed study on all the components and devices on the given power supply. Observe different types of Switch Mode Power Supply – AT, ATX, NLX. Record the different types of power connectors on the motherboard.
5	Identify BIOS settings, demonstrate starting BIOS, identify how to disable unused devices to decrease security risks. Change booting of computer with different secondary storage CD,HDD,USBetc.
6	Perform low-level and high-level formatting of Hard Disk. Format the given Hard Disk using any one technique and create three partitions, two for operation systems and one for data.
7	Install OS of different types (Windows and Linux). Also,search for various data recovery software on pendrive/HDD.
8	Open different types of keyboards and mouse and observe the internal circuits. Observe and write steps to troubleshoot, maintain and clean the keyboard and mouse.
9	Observe different types of printers. Install driver and interface the printers with PC/Laptop on any operating system (connect the printer to one PC directly using USB/Serial/Parallel/Wi-Fi as per the availability; test the functioning of the printer.)

10	Learn the interfacing, installation and working of various devices such as scanner, projector, web cam etc. Connect all these devices with the given PC, install & test them.
11	Identify the problem in the given PC, using the given troubleshooting sequence, fix the issue, record the given problem, and produce proper documentation of your work.
12	Recognize common symptoms associated with diagnosing and troubleshooting PCs and utilize Windows built-in diagnostic tools. ● Identify general troubleshooting techniques and strategies ● Utilize scandisk, control panel, boot-up menu, and startup disk as diagnostic tools. ● Access Microsoft Knowledge Base on the Internet to solve common problems. ● Identify the common problems associated with shutdown, configuration, and cabling. ● Identify problems associated with heating and cooling of the internal components. ● Identify problems with installing internal devices such as hard drive, tape drives, or CD-ROM drive. ● Recognize and interpret the meaning of common error codes and start up messages. ● Recognize windows-specific printing problems and corrections.
13	Perform computer maintenance and preventative maintenance functions. ● Perform physical cleaning (internal and external) of a personal computer. ● Demonstrate how to adjust basic performance settings. ● Perform hard drive file system maintenance. ● Identify anti-virus software and applications
14	Utilize the Internet to download device drivers. Installation of drivers of various devices from the internet. Demonstrate to remove unwanted software applications.

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-142**
Title of the Course: **Multimedia and Web Design**
Number of Credits: **3 (1 T + 2 P)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	NIL	
Course Objectives:	1. To introduce the basic concepts of Multimedia and Web Designing 2. To develop skills and competencies in image, video editing. 3. To acquire and develop skills to create web pages using HTML, CSS, Bootstrap and JavaScript	
Content:		**No of hours**
	Color Theory Color Basics, Color Systems, Color Wheel, Complementary Colors, After Images, Color Combinations, Color & Contrast, Itten's Contrasts, Proportion & Intensity, Contrast & dominance, Shades & Tints, Color Studies, Color Gamut, ICC profiles, Gamma Correction.	03 Hours
	Computer Graphics Difference between Raster and Vector Graphics , Raster graphics : resolution, image compression, file formats, manipulation, Geometrical transformations, Vector graphics – fundamentals, file formats, shapes, transforms and filters.	02 Hours
	Sound : Sound Design, Audio Codec & file formats, processing sound, compression	01 Hour
	Video : Aspect Ratio Frame Size, Frame Rate, Regions, Video Codec & Formats, Processing.	01 Hour
	Web Architecture, HTML : Introduction to internet and web design. Basic concepts of web architecture. Introduction to hypertext mark-up language (html), creating web pages, lists, hyperlinks, tables, web forms, inserting images.	03 Hours
	Cascading style sheet (CSS) : Concept of CSS, creating style sheet, Importing style sheets, CSS properties, CSS styling (background, text format, controlling fonts), CSS rules, Style Types, CSS Selectors, working with block elements and objects, working with lists and tables, CSS id and class, box model.	03 Hours

	Basics of JavaScript : Document object model, data types and variables, functions, methods and events, controlling program flow, built-in objects and operators, validations.	02 Hours
Pedagogy:	PowerPoint presentations, Practical Assignments	
References/ Readings:	a) Nigel Chapman, Jenny Chapman; Digital Multimedia; Wiley India Edition, 2nd Edition b) Roger Parker; One-Minute Designer; Hungry Minds Inc, U.S.; 2nd edition c) Ranjan Parekh, " Principles of Multimedia", McGraw Hill Education; 2 edition d) Tay Vaughan, "Multimedia Making It Work"; Mc Graw Hill, Eighth Edition. e) Laura Lemay , Rafe Colburn , Jennifer Kyrnin, "Mastering HTML, CSS & JavaScript Web Publishing", BPB Publications f) Alex Libby, Gaurav Gupta, Asoj Talesra , "Responsive Web Design with HTML5 and CSS3 Essentials", PACKT Publishing	
Course Outcomes:	On successful completion of this course, the student will be able to: 1. Create and edit images, audio and video 2. Build websites using the elements of HTML. 3. Build interactive and stylish websites using the client-side programming techniques with CSS and JavaScript. 4. Learn to validate client-side data. 5. Define the structure and contents of the website using different features of CSS	

Suggested Practical List: (60 Hours)

Multimedia

i. Image compositing : Remove background and combine images to create a work of art. (GIMP)
ii. Learn to create images for Print, Web and Video
iii. Design a Logo for a company
iv. Design a Brochure for given Product and details. Learn about different file formats(SCRIBUS)
v. Design a poster with given information and learn about image compression(SCRIBUS)
vi. Edit the sound file and Learn about Effects and Filters of sound.(AUDACITY)
vii. Record your voice and learn about Audio Compression(AUDACITY)
viii. Learn Audio mixing and streaming of audio content(AUDACITY)
ix. Learn about Video editing – Prepare video with rough cut.(WINDOWS MOVIE MAKER)

x. Prepare video content with title and special effects. (WINDOWS MOVIE MAKER)
xi. Record video content and learn about video compressions. (WINDOWS MOVIE MAKER)
xii. Prepare Video content for vimeo / youtube. (WINDOWS MOVIE MAKER)

Note : Practical can be done using GIMP, Inkscape, Scribus, Blender, Audacity, Lightworks / Kdenlive

Web Design

HTML

i. Create a basic HTML document structure with the appropriate doctype, <html>, <head>, and <body> elements.
ii. Add a heading (<h1>) and a paragraph (<p>) to your HTML document.
iii. Create a hyperlink (<a>) that navigates to another web page when clicked.
iv. Insert an image (<img>) into your HTML document and provide an appropriate alt text.
v. Construct an ordered list (<ol>) with three list items (<li>).
vi. Design a table (<table>) with two columns and two rows, containing relevant data.
vii. Design table using colspan, rowspan
viii. Build a simple form (<form>) with text input fields (<input type="text">) for name and email.
ix. Implement a checkbox (<input type="checkbox">) and a radio button (<input type="radio">) , lists within a form.
x. Create a navigation menu using semantic HTML tags such as <header>, <nav>, and <ul>.
xi. Embed an audio or video file (<audio> or <video>) into your HTML document.

CSS

Write CSS to ,

i. Apply inline styles to a paragraph (<p>) to change its color and font size.
ii. Link an external CSS file to your HTML document using the <link> tag.
iii. Change the colour of text using CSS
iv. Change the font family and font size of text using CSS
v. Add a background color to an element using CSS
vi. Add padding and margin to elements using CSS
vii. Align text and elements using CSS properties
viii. Change the border color, width, and style of an element using CSS
ix. Style hyperlinks using CSS
x. Apply styles to specific elements using class selectors in CSS
xi. Create and style lists using CSS
xii. Change the display and visibility of elements using CSS
xiii. Control the size and position of elements using CSS properties
xiv. Add shadows and gradients to elements using CSS
xv. Apply styles to images using CSS
xvi. Create and style basic CSS animations and transitions
xvii. Override CSS styles using inline styles

xviii. Include and use external CSS stylesheets in HTML documents
xix. Use CSS pseudo-classes to style elements based on their state
xx. Create and style basic CSS layouts using floats and clear properties
xxi. Style form elements, such as input fields and buttons, using CSS

Bootstrap

i. Include Bootstrap in an HTML document using CDN , local files
ii. Create a responsive grid layout using Bootstrap's grid system
iii. Create and style navigation menus using Bootstrap's navbar component
iv. Create and style buttons using Bootstrap's button classes
v. Incorporate and style Bootstrap's predefined CSS classes for typography
vi. Create and style forms using Bootstrap's form components
vii. Create and style responsive images using Bootstrap's responsive image classes
viii. Incorporate and style Bootstrap's modal dialogs
ix. Use Bootstrap's responsive utilities to control visibility and alignment

JavaScript

i. Validate a user's input in a form using JavaScript
ii. Write a JavaScript function that reverses a given string.
iii. Implement a slideshow or image carousel using JavaScript.
iv. Write a JavaScript program that finds the largest number in an array.
v. Detect and handle browser events like clicks or keyboard input using JavaScript.
vi. Write a JavaScript function that calculates the factorial of a given number.
vii. use JavaScript to manipulate the CSS properties of an HTML element dynamically.

Note : Web design Practical can be done using VS code IDE

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-143**
Title of the Course: **Data analytics using Spreadsheets I**
Number of Credits: **03 (1 T + 2 P)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	Nil	
Course Objectives:	Introduce the basic concepts of data analytics; develop proficiency in students in using spreadsheets to format data, manipulate data using appropriate basic function and formulas; visualize data; filter data and generate basic reports using Pivot tables.	
Content	**Theory**	**No of hours**

	Unit I: Introduction to Data Analytics and Spreadsheet Basics Introduction to Data Analytics using spreadsheet ● Definition of Data Analysis and Data Analytics ● Phases of Data Analysis ● Methods of Data Analysis in Spreadsheets ● Understanding Data: Data and types of data ● Quantitative data – discrete data, continuous data ● Qualitative data - categorical data, ordinal data. ● Understanding operators and functions essential for data analytics. ● Arithmetic operators and order of operations. ● Functions: Parts of a function, arguments to a function, function library and types of functions.	5 hours
	Unit II: Data Collection and Manipulation. Data Collection using online data collection tools. Creating Spreadsheets online and collaboration. Introduction to data cleansing, data modification using data analysis functions. Sorting criteria and types of sorting, Filters and types of filters, Guidelines and examples for sorting and filtering data by colour: Overview of sorting and filtering data by colour and icon set, using colour effectively when analysing data, choosing the best colours.	5 hours
	Unit III: Data Visualization and Summarization Visualizing data: Principles of charting, types of basic charts, Some practicalities in preparing charts. Conditional Formatting and its types. Functions used for data summarization. Pivot tables and its applications.	5 hours
Content	**Practical**	
	Unit I: Spreadsheet Basics: ● Formatting Cells with font formats, alignment, borders etc. ● Number formats, currency formats, formatting dates, custom and special formats. ● Format painter ● Selection techniques ● Advanced paste special techniques: paste value,	20 hours

	paste formulas, paste formats, paste validations, transpose tables ● Formulas and Functions: ● Complex Formulas with arithmetic operators ● Relative, mixed and absolute cell reference ● Basic Functions such as sum, average, max, min, count, counta. ● Customization, Formatting and Protection: ● Customizing the ribbon, Using and customizing autocorrect ● Changing Excel default options ● Page Layout and printing options: Setting up print area, customizing headers and footer, print titles. ● File level protection, workbook, worksheet protection ● Working with named ranges, ● Commonly used shortcut keys **Essential Data Analysis Functions and Methods:** ● Text Functions: Upper, Lower, Proper, Left, Mid, Right, Trim, Len, Exact, Concatenate, Find, Search, Substitute ● Date and time Functions: today, now, day, month, year, date, date if, dateadd, EOMonth, weekday, days, networkdays ● Logical functions: TRUE, FALSE,IF, AND, OR ● Nested if, IF function together with AND, OR function ● Data cleaning and preparation using text functions and text to column.		

<table>
<tr><td></td><td>Unit II
Data collection using online data collection tools such as Google Forms:
● Creating data forms to collect data for different types of scenarios such as surveys, event registration, feedback etc.
● Creating forms with conditional data input workflows based on user choice.
● Online storage of spreadsheets:
● Creating online spreadsheets such as google sheets and online collaboration of the same.
● Working with multiple worksheets & spreadsheets:
● Scenarios which require creating a workbook with multiple sheets and cross referencing.
● Scenarios which require creating multiple workbooks with multiple sheets and cross referencing across workbooks.
● Methods used in data analytics:
● Freezing Rows and Columns
● Sorting Data
● Filtering Data
● Summarizing Data
● Formatting Data as Table</td><td>20 hours</td></tr>
<tr><td></td><td>Unit III
Data Analytics Methods:
● Visualizing data with charts.
● Adding Conditional Formatting.
● Essential advanced Data Analysis Functions: sumif, sumifs, countif, countifs, averageif, averageifs, nested if, iferror statement, and, or, not
● Introduction to simple pivot tables.
● Solving real life problems/scenarios in spreadsheets.</td><td>20 hours</td></tr>
<tr><td>Pedagogy:</td><td colspan="2">● Blended learning: Concept learning through Lab assignments and online video resources followed by application of concept learnt to real life scenario provided.
● Practical skill development through Lab assignments.</td></tr>
</table>

References/ Readings:	M. Alexander, D. Kusleika, Excel 2019 Bible. Indiana: Wiley, 2019. D. Whigham, Business Data Analysis using Excel. New York: Oxford University Press, 2007 https://edu.gcfglobal.org/en/topics/excel/#
Course Outcomes:	**At the end of the course, learner will be able to:** 1. Format a given spreadsheet with various formatting features and use appropriate functions given relevant description of desired output. 2. Sort, filter, summarize data given in a spreadsheet as per given instructions 3. Visualize data using appropriate charts and conditional formatting. 4. Solve basic queries on a given data set by preparing basic pivot tables for a given data set.

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-144**
Title of the Course: **Desktop Publishing**
Number of Credits: **3 (1 T + 2 P)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce the basic concepts of Desktop Publishing and Page Layout. To develop skills and competencies in image editing. To acquire and develop skills for Digital Content Creation for various platforms.	
Content:		**No of hours**
	1. Introduction • Definition of Desktop Publishing and Digital Publishing • Introduction to open source and proprietary software used in DTP • Print Media v/s Digital Media • Benefits of Desktop and Digital Publishing • Examples of Desktop Publishing and Digital Publishing • Digital Publishing Platforms • Branding and Identity	03 hours

	2. Typography and Color • Definition of Typography; Common Types of Fonts; Choosing a Font; Kerning, Leading and Tracking • Color Basics; Hue, Saturation and Value; Color Wheel	04 hours
	3. Layout and Design • Basics of page layout; page layout in pictures measurement units like inch, pica and points; features of good typography; Serif and sans serif fonts. • Basic design principles: Proximity, White Space, Alignment, Contrast and Repetition • Fundamentals of Design: Line, Shape, Forms, Texture and Balance	04 hours
	4. Images • Graphics: Raster v/s Vector • Lossy v/s Lossless Compression • Common Image Formats • Image Manipulation Techniques • Image Usage Rights	04 hours
Pedagogy:	Practical assignments using open source software/platforms such as Gimp, Canva	
References/ Readings:	1: Nigel Chapman, Jenny Chapman; Desktop Multimedia; Wiley India Edition, 2nd Edition • https://edu.gcfglobal.org/en/beginning-graphic-design/ • https://www.copypress.com/kb/content-marketing/everything-you-need-to-know-about-digital-publishing/ • https://www.stateofdigitalpublishing.com/digital-publishing/what-is-digital-publishing/ • https://www.nxtbookmedia.com/blog/everything-you-need-to-know-about-digital-publishing/ • https://www.gimp.org/tutorials/ • https://www.canva.com/	

Course Outcomes:	**At the completion of this course, the learner will be able to:** 1. Explain the basic concepts of Desktop Publishing and its relevance in e-content development. 2. Apply typographic and color schemes used for the layout and designing e-content. 3. Apply the editing features for given images. 4. Develop e-content for a given product for various platforms

. Suggested Practical List:
(at least 10-12 Practicals from the following)
1. Image Editing and Graphic Manipulation
a. Basic Transformation Tools
b. Enhancing images (contrast and brightness changes)
c. Image compression using different file formats
d. Applying special effects and filters on images
2. To create a social media Post for any platform.
3. To create a social media Story for any platform.
4. To create Animated Social Media content such as Instagram Reels.
5. To create social media ads for any platform.
6. To design Covers for any social media platform.
7. To design a Logo for a given product.
8. To design a Poster with the given information.
9. To design a Flyer with the given information.
10. To design a Banner for a given product.
11. To design an Advertisement for a given brand.
12. To develop Infographics content on a given topic.
13. To design a Newsletter covering the given events for your department.
14. To design a Magazine Cover for your college.
15. To design a Brochure for a given product.

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Name of the Programme: **Students from any Programme can opt for this**
Course Code:**CSC-145**
Title of the Course: **Basic Computer Applications**
Number of Credits: **3(1L+2P)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	Nil
Course Objectives:	To Provide An Understanding Of Essentials Of Information Technology, Internet Applications and Emerging Technologies. Includes practical skills in data capture, presentation, report formatting, efficient search techniques and online collaboration tools.

Content:	Description	No.of hours
	Unit I: Information Technology Basics Information : Prerequisites of Information, Need for Information Technology and its advantages;InformationTechnology:Definitionandcomponents;Data:Definition,Types,DataRepresentation,NumbersystemandCodingSchemes(ASCIIandUNICODE);PartsofaComputer: CPU, Memory, Input/ Output Devices, Auxiliary Memory; Software– Definition, relationship between Hardware and Software, Categories of Software, OS - definition & functionsRoleofInformationTechnologyin:Business,MobileComputing,HealthServices,PublicSector,Media, Defense Services, Education and Publication.	10 hours
	Unit II: Internet Applications and Emerging Technologies Internet – role and importance, Web Browser, IP Addressing– Public Vs Private, Static Vs Dynamic; WWW & related protocols; Internet Applications. Cloud Computing: Meaning, Features, & Service models, Advantages and disadvantages, Mobile Computing: Meaning, Business Applications of Mobile computing, Virtual reality & Augmented Reality: Meaning and applications, IoT –Internet of Things: Meaning& Applications.	5 hours
	Practicals	
Lab1	Basic Computer Skills Surfing the Internet, Use of Email and Search Engines Securing your device Installation and Configuration of any free Antivirus Package eg. AVG/Avast etc., Online Sharing and Collaboration Create documents, spreadsheets and presentations online, Share and collaborate in real time, Safely store and organize your work, Control who can see your documents Data capture using Google Forms Create data forms to capture data for Event Registration, Event Feedback, Customer feedback/satisfaction on a product or service and Order Request OS Basic Installation of Operating System, Demonstrate features of any MS Windows based OS or any of the Linux flavor , Identification of Directories , Setting up computer, Add a printer, Check device drivers, Installation of software, Users and administrative rights for installation	10 hours

Lab2	Report Formatting using Word Processing (MS Word or any similar Open Source software) Draft an official letter for job interview invitation/ job appointment/ invitation to a business trade show event, use mail merge to input the recipients list linking with database. Given a project report in PDF format transfer to word processor software and format to include title page, specified Paragraph and Page Formating (page size, orientation, line spacing, font type and font size, Indent, bullets, paragraph formatting) details, Acknowledgement page, Table of contents page, List of figures page, List of Tables page, bibliography, references, distinct headers for each chapter, page numbering in roman for initial pages and normal from first chapter. The document should be checked for spelling errors and corrected appropriately. Create / Upload a document in a collaboration software like Google docs. Share and collaborate in real time, Safely store and organize your work, Control who can see your documents.	30 hours
Lab3	Presentation Software (MS- Powerpoint or any similar Open Source software) Preparing presentation in areas such as Customer satisfaction/ feedback, product analysis, job satisfaction using the data obtained through data capture tool, including appropriate slide animation, sound recording, slide timings, customer feedback video. Export the presentation as video or save as slide show. Prepare handouts for audience.	20 hours
Pedagogy:	MS-Word, MS-Powerpoint or any similar open source software may be used	
References/ Readings:	1. Pradeep K. Sinha and PritiSinha(2022), Computer Fundamentals, BPB Publications 2. ITL Education Solutions Limited(2005), Introduction to Information Technology, Pearson Education 3. M.C.ArvindBabu,Dr. S. Anandamurugan, T.Priyaa(2016), Cloud Computing (First Edition),Laxmi Publications Pvt Ltd 4. ArshdeepBahga, Vijay Madisetti (2014)Internet of Things: A Hands-On Approach, Vijay Madisetti Publications 5. https://www.howstuffworks .com 6.https://www.panola.edu/media/825/download?attachment/itsw1401.pdf	

Course Outcomes:	At the end of the course, learner will be able to: 1. Explain the basic Knowledge and Understanding of Information Technology, Internet Applications and Emerging Technologies. 2. Develop practical skills in Application software. 3. Acquire future technologies through foundational skills learnt. 4. Pursue advanced knowledge and professional development in IT.

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC 146**
Title of the course: **Basics of Python Programming**
Number of Credits:**3 (1T+2P)**
Effective from AY:**2023-24**

Pre-requisites for the Course	Basic working knowledge of Computers and Internet	
Course Objectives:	1. To introduce programming concepts using Python. 2. To introduce object oriented programming concepts.	
Content:	(Theory) 1. Python Interpreter, Python Shell, strings, relational operators, logical operators, precedence of operators, bitwise operators, variables and assignment statements, script mode, functions, modules, command line arguments, control structures- if conditional statements, iteration for and while statements, break, continue and pass statements. 2. Data types- Boolean, numbers, coercing integers to floats and vice versa, numerical operations, lists, creating a list, slicing a list, adding and removing items from a list, searching for values in a list, tuples, immutability property, converting tuples into a list, sets, set operations, dictionaries, strings, Unicode, formatting strings, docString, modules, packages, scope, recursion 3. Object Oriented Concepts- Classes, Objects, Abstract Data types, polymorphism, encapsulation, modifier, accessor methods, static method, adding methods dynamically, composition, inheritance, built-in functions for classes. 4. Files, Exceptions 5. Applications of Python - use of Python libraries such as Matplotlib, Pandas, using databases with python, collecting information from Twitter etc. (at least three applications to be covered).	No.of hours 4L 4L 4L 2L 1L

(Practicals) (15x2=30hrs)

List of Practicals : (at least 8 practicals from the following)

1) a) Write a function that returns the sum of digits of a number, passed to it as an argument.

b)Write a function that returns True or False depending on whether the given number of a palindrome.

c)Take the radius of circle as input from the user, passes it to another function that computes the area and the circumference of the circle and displays the values.

d) Write a function that finds the sum of the n terms of the following series:

1 - x2 / 2! + x4 / 4! - x6 / 6! +. ….. xn/ n!

2) Perform following actions on a list :

a) Print the even-valued elements
b) Print the odd-valued elements
c) Calculate and print the sum and average of the elements of array
d) Print the maximum and minimum element of array.
e) Remove the duplicates from the array
f) Print the array in reverse order

3) a)Define a function which can generate and print a list where the values are square of numbers between 1 and 20 (both included). Then the function needs to print all values except the first 5 elements in the list.

b) Write a program which takes 2 digits, X,Y as input and generates a 2-dimensional array. The element value in the i-th row and j-th column of the array should be i*j.

4) a)Write a program that accepts sequence of lines as input and prints the lines after making all characters in the sentence capitalized.

b) Write a program that accepts a sentence and calculate the number of letters and digits.

c) Given an array of integers, find two numbers such that they add up to a specific target number.

5) a)Write a function that takes a list of values as input parameter and returns another list without any duplicates.

b) Write a program that takes a sentence as input from the user and computes the frequency of each letter. Use a variable of dictionary type to maintain the count.

6) a)Write a recursive function that multiplies two positive numbers a and b and return the result. Multiplication is to be achieved as a+a+a (b times).

b) Write a recursive function that inserts the element x at every n th position in the given list and returns the modified list.

7) a)Given a list of strings, return the count of the number of strings where the string length is 2 or more and the first and last characters of the string are the same

b) Given a list of strings, return a list with the strings in sorted order, except group all the strings that begin with 'x' first. e.g. ['mix', 'xyz', 'apple', 'xanadu', 'aardvark'] yields ['xanadu', 'xyz', 'aardvark', 'apple', mix']

8) Define a class Student that keeps track of academic record of students in a school. The class should contain the following data members:

- rollnum - roll number of the student
- name - name of the student
- marksList - List of marks in 5 subjects
- stream - A: Arts, C: Commerce, S: Science
- percentage - percentage computed using marks
- grade - grade in each subject computed using marks
- division - division computed on the basis of overall percentage

The class should support the following methods:
a. __init__ for initializing the data members
b. setMarks to take marks for five subjects as an input from the user
c. getStream for accessing the stream of the student.
d. Percentage for computing the overall percentage of for the student.
e. gradeGen that generates grades for each student in each course on the basis of marks.

Marks	Grade
>=90	A
<90 and >=80	B
<80 and >=65	C
<65 and >=40	D
<40	E

f. division for computing division on the basis of the following criteria based on overall percentage of marks scored:

Percentage	Division
>=60	I
<60 and >=50	II
<50 and >=35	III

g. __str__ that displays student information.

9) Define a base class Vehicle , having attributes registration number, make, model and color.Also, define classes PassengerVehicle and CommercialVehicle that derive the class Vehicle. The PassengerVehicle class should have additional attribute for maximum passenger capacity. The CommercialVehicle class should have an additional attribute for maximum load capacity. Define __init__ method for all these classes. Also, get and set methods to retrieve and set the value of the data attributes.
10) Define classes Car, Autorickshaw and Bus which derive from the PassengerVehicle class mentioned in the previous question. The Car and Bus should have attributes for storing information about the number of doors, not shared by Autorickshaw. The Bus should have Boolean attribute

	doubleDecker not shared by Car and Autorickshaw. Define __init__ method for all these classes. Also define get and set methods to determine and set the value of the day attributes. 11) Develop a program to sort the employee data on the basis of pay of the employees using i) selection sort ii) bubble sort. iii) insertion sort. Consider a list L containing objects of class Employee having empNum, name and salary. 12) Write a function that takes two file names, file1 and file2 as input. The function should read the contents of the file file1 line by line and should write them to another file file2 after adding a newline at the end of each line. 13) Write a function that reads a file file1 and displays the number of words and the number of vowels in the file. 14) Write a function that reads the contents of the file Peom.txt and counts the number of alphabets, blank spaces, lowercase letters and uppercase letters, the number of words starting with a vowel and the number of occurrences of word ―beautiful‖ in the file. 15) Write a function that takes two files of equal size as an input from the user. The first file contains weights of items and the second file contains corresponding prices. Create another file that should contain price per unit weight for each item. Note : Testing and Debugging tools to be used during the practical sessions.
Pedagogy:	• Powerpoint presentations • Group Discussions
References/ Readings:	Text book : 1) Taneja Sheetal, Kumar Naveen, ―Python Programming - A modular approach‖, Pearson Reference book: 1) Guttag John V., ―Introduction to Computation and Programming using Python‖, MIT Press, 2nd Edition.
Course Outcomes:	At the end of the course, learner will be able to: 1) Use the basic programming syntax with Python programming language, Python Interpreter and Command Line Arguments. 2) Describe the data types, various Control Structures, Packages, Recursion and File Handling concepts available in Python. 3) Explain and use Object Oriented Programming (OOPs) Concept and its features. 4) Develop simple Python Applications using various Python Libraries.

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Name of the Programme: **Students from any Programme can opt for this**
Course Code:**CSC-147**
Title of the Course: **Graphical User Interface Design**
Number of Credits: **03 (1 T + 2 P)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	None	
Course Objectives:	This course is aims to: - teach basic concepts of interface design. - train to create interface prototypes to test usability. - explain user personas and experiences. - teach to create user engaging interfaces	
Content:		Total Contact hours: 15 Hours
	I.Introduction to UI/UX UI and UX An overview of the user interface's history User experience (UX) Similarities and Differences between UX and UI The job of the user experience designer The UI designer's job description	01 hour
	II.User Persona for UX Design User Flow in UX Design User flow in UX Tools to make a user experience flow UX Design Prototypes Creating a user experience prototype Test designs prototypes Wireframes in UX Design Benefits and use of wireframes	02 hours
	III.Basic visual design principles in UI Design Creating attractive and functional interfaces Definition of Design thinking Design Thinking Phases The Science of Creativity in the Brain Advantages of intuition Importance of Intuitive Design Advantages and disadvantages of intuitive design Characteristics and Benefits of Using User-Friendly Software	03 hours

	IV. Common tools for UI Designs Using Balsamiq Wireframes Creating Wireframes with Axure Use Axure RP to Create Wireframes Tips to achieve a good user interface and Experience	03 hours
	V. Understanding what Typography is Understanding typefaces, fonts, and font selection Obey the laws of typography A glossary of typographic terms	02 hours
	VI. Way to test contrast in UI design Design alignment Significance of alignment in design Visual Hierarchy's Building Blocks Creating an Effective Visual Hierarchy UI and its relation with readability Advice on Improving Readability and Legibility	02 hours
	VII. Font pairing Basics of Font Pairing Adding Meta information in UI/UX design SEO and UI Design Responsive Website Design SEO and UX Design	02 hours
Pedagogy:	• Lectures to be conducted using computer and projector • Hands on practice of all concepts covered in theory sessions	
References/ Readings:	Textbooks: 1) Modular Design Frameworks : A Projects-based Guide for UI/UX Designers, Cabrera & James 2) UX for Developers: How to Integrate User-Centered Design Principles Into Your Day-to-Day Development Work, Westley Knight 3) UX for Lean Startups: Faster, Smarter User Experience Research and Design, Laura Klein 4) Smashing UX Design: Foundations for Designing Online User Experiences, Jesmond Allen & James Chudley 5) UX Fundamentals for Non-UX Professionals: User Experience Principles for Managers, Writers, Edward Stull	

Course Outcomes:	At the end of the Course, learner will be able to : - Explain the principles and concepts of Interface design - Create intuitive interfaces - Explain UX - Create better interfaces for effective UX

Practical Work

Sr. No	Topic	Total Hours :60
1	Exercises to Identify interface connectivity and establish interface connectivity between two different program modules. ● Choose any of the programming languages (like HTML, JavaScript, Bootstrap etc.), do create two separate programming files and establish the interface connectivity between both.	08 hours
2	Exercisesthat will facilitate Understanding frontend and backend interface and implementation of both interfacing. ● Front –end and back-end interfacing languages used for interface design. ● HTML: HTML stands for Hypertext Markup Language. It is used to design the front-end portion of web pages using a markup language.	16 hours
3	Exercises to create wireframes designs:- ● Modelling wireframes designs ● Implementing wireframes	14 hours
4	Exercises using font, color matching and typography:- ● Use of colors and contrasts ● Font suitability ● Matching content to target users	10 hours
5	Exercises using responsive design on :- ● Web pages ● Desktop software screens ● Smartphones/ Tabs and other handheld devices	12 hours

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Std. Com.X AC-6 15 & 22.05.2023

Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC-148**
Title of the Course: **Data analytics using Spreadsheets II**
Number of Credits: **03 (1 T + 2 P)**
Effective from AY: **2023-24**

<table>
<tr><td>Pre-requisites for the Course:</td><td colspan="2">Basic knowledge of Spreadsheets.</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">Develop ability to use spreadsheets for conditional data summarization, financial calculations, advanced data visualization. Work with pivot tables and charts to obtain insights, use lookup functions for data manipulation, perform what-if analysis. Create a dashboard in Excel. Obtain basic descriptive statistics using analysis tools.</td></tr>
<tr><td>Content:</td><td>Theory</td><td>No of hours</td></tr>
<tr><td></td><td>Unit I : Financial Data Analysis and Advanced data Visualization:
Data Analysis financial functions
● Financial arithmetic basics and Investment Appraisal functions- modeling financial data in Spreadsheets.
Data Analytics advanced visualization methods
● Data Visualization with charts such as tree map, waterfall, sunburst, box and whisker, power maps.</td><td>5</td></tr>
<tr><td></td><td>Unit II: Steps in data analytics:
● Preparation of data: Data collection, data cleansing and data validation
● Elementary data modeling – linear functions in business, expressions and functions involving logical tests, vertical lookup functions, combining conditional statements with lookup functions.</td><td>5</td></tr>
<tr><td></td><td>Unit III: Statistical analysis of data using Spreadsheets:
● Collating and categorizing data, data description-central tendency and dispersion, descriptive statistics using Analysis Tool Pak.</td><td>5</td></tr>
<tr><td></td><td>Practical</td><td></td></tr>
</table>

	Unit I:Data Analysis advanced functions and methods ● Financial Functions: FV, PV, NPV, IRR, PMT (loan amortization schedule) ● Scenarios for visualizing data using charts such as tree map, waterfall, sunburst, box and whisker, combo charts, power maps and 3D Maps ● Advanced Sorting option and Advanced Filters	20
	Unit II ● Data Validation: Number, Date and Time Validation, Text and List Validation, Custom validation based on formula for a cell, Dynamic dropdown list creation using data validation-dependency list. ● What-if Analysis: Goal Seek, scenario analysis, data tables using PMT function, Solver tool ● Lookup Functions: Vlookup and Hlookup functions, Index and Match, Reverse Lookup using choose function.	20
	Unit III ● Pivot Tables and Pivot Charts: Creating advanced pivot tables with advanced value field settings, filtering pivot tables, modifying pivot table data, grouping based, Pivot Charts and Slicers. Filter data with slicers, manage primary and secondary axis ● Creating Interactive Dashboard: Planning a Dashboard, Adding Tables and charts to dashboard, adding dynamic content to dashboard. ● Descriptive statistics using Analysis ToolPak. ● Introduction to Excel macros and VBA Basics.	20
Pedagogy:	· Blended learning: Concept learning through Lab assignments and online video resources followed by application of concept learnt to real life scenario provided. Practical skill development through Lab assignments.	
References/ Readings:	M. Alexander, D. Kusleika, Excel 2019 Bible. Indiana: Wiley, 2019. D. Whigham, Business Data Analysis using Excel. New York: Oxford University Press, 2007 How to use excel by Kevin Stratvert https://www.youtube.com/playlist?list=PLlKpQrBME6xLYoubjOqowzcCCd0ivQVLY	

Course Outcomes:	At the end of the course, learner will be able to: 1. Use conditional arithmetic functions to summarize data and use financial functions, given a spreadsheet with data and relevant description of desired output. 2. Perform what-if analysis and data validation on given data for a given scenario. 3. Summarize and analyze data using Pivot Tables and Pivot Charts. 4. Present and visualize data using Dashboard for given data and given scenarios. 5. Obtain descriptive statistics for given data using Analysis ToolPak.

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC 149**
Title of the Course: **Data and Business Analytics**
Number of Credits: **3(1L+2P)**
Effective from AY: **2022-23**

Pre-requisites for the Course:	Nil	
Course Objectives:	To understand data processing, data analysis, business analytics concepts, computer networking basics, e-commerce technologyand business applications; To develop practical skills in data analytics and business analytics.	
Content:	**Description**	**No of hours**
	Unit I:Data processing, Data Analysis and Business Analytics Data Processing – Steps involved in data processing, advantages of computers in data processing Data analysis and forecasting - importance of data analysis in business, Data forecasting, its need, benefits of data forecasting, Data Integration: concept and how it works Introduction to Business analytics – meaning and basic concepts,Visualization/ Data Issues: Organization/sources of data, Importance of data quality, Dealing with missing or incomplete data, Data Classification	4

	Unit II:E-Commerce Definition, E-commerce and Trade Cycle, Electronic Markets, Electronic Data Interchange andInternetCommerce,TypesofE-commerce:BusinesstoBusinessE-Commerce,BusinesstoConsumerE-Commerce.ConsumertoConsumer, Government to Consumer, Business to Government, ElectronicPaymentSystems:SmartCards–Credit Cards – Wallets, Safe practices, Risks, E-Retail, Concept and Examples, Onlineshopping–Introduction, Safety measures (Encryption ofdata authentication, SSL, Digital signatures, Digital Certificates), E-Banking, Features and services,M-Commerce,Productsand services	5
	Unit III : Basics of Computer Networking Networking basics, Need for computer networks, Types of networks-LAN, MAN, WAN, Network Components–H/W, Software, Communication channels, Network Devices, Network topologies.	6
	Practicals	

Lab1	Spreadsheet (MS-Excel or any similar open source software) ● Working with worksheets -Entering data, Formatting, Editing, and Printing a worksheet, ● Formulas and Functions in Excel, operators in formula ● Generally used Spreadsheet functions - Mathematical, Statistical, Financial, Logical, Date and Time, Database and Text functions ● Introduction to some more useful functions such as the IF, nested IF, VLOOKUP and HLOOKUP ● Data Sorting and Filtering ● Result representation of data using spreadsheet ● What-if analysis, Logical tests(nested if functions), Goal seek, ● Representing results graphically ● Filtering, advanced filters, sorting and conditional formatting data ● Data validation techniques, Hyperlinks ● Pivot table, Scenarios ● Summing through the sheets ● Getting external data files into Excel ● Macros - creation, editing and deletion of macros Assignments to be given on the following topics: to prepare and analyse Loan and Lease statement; Ratio Analysis; Payroll statements; Capital Budgeting; Depreciation Accounting; Graphical representation of data; Frequency distribution and its statistical parameters; Correlation and Regression	36
Lab2	Data Analytics ● Assignments to analyse data available from IndiaStat.com such as Analysis of demographic data, environment data, public expenditure ● Analyse data from annual reports of Companies and banks	8
Lab3	E-commerce Website review Write a review of an E-Commerce Site visited include: Site description, Site Design, ease in navigation , process for purchasing items, security, privacy, customer service, best features of site, Target Audience, Revenue model, Marketing Strategies	8

Lab4	Computer Networking Basic Networking Setup of PC, Network commands like ipconfig, ping, traceroute, nslookup etc, Setup of Home Router / Wifi Hotspot, Understanding of Firewall and Basic Firewall Setup, File and Printer Sharing, connecting to share, Finding out public address, connection speeds etc.	8
Pedagogy:	MS-Excel or any similar open source software may be used Field visits may be conducted to banks, corporate offices employing relevant software for business applications.	
References/ Readings:	1. ITL Education Solutions Limited(2005), Introduction to Information Technology, Pearson Education 2. Ravi Kalakota& Andrew B. Whinston(2009), Frontiers of Electronic Commerce (Ninth Impression) , Pearson Education. 3. David Whiteley(2000),E-Commerce: Strategy, Technologies And Applications McGraw-Hill Education, ISBN-10 : 0077095529 4. Thomas H. Davenport, Jeanne G. Harris(2010), Competing on Analytics-The New Science of Winning , Harvard Business Review Press. 5. LaValle et al.(2005), Analytics: The New Path to Value, Taxmann Publishers. 6. Davenport and Harris(2007), The Dark Side of Customer Analytics, Harvard Business Review Press. 7. Bartlett, R.(2013) , A Practitioner's Guide to Business Analytics. McGraw-Hill, New York. 8. Bruice Schneier, Applied Cryptography-Protocols, Algorithms and Source code in C (Second Edition), , Wiley India Pvt Ltd, ISBN 978-81-265-1368-0 9. https://www.analyticsvidhya.com/blog/2021/11/a-comprehensive-guide-on-microsoft-excel-for-data-analysis/ 10. https://www.tutorialspoint.com/excel_data_analysis/excel_data_analysis_tutorial.pdf	
Course Outcomes:	At the end of the course, learner will be able to: 1. Explain the concepts of data processing, data analysis, business analytics, computer networking, e-commerce technology and its applications in business. 2. Develop skills of data analysis and business analytics using relevant Application software. 3. Apply the Spreadsheet tools to solve business problems. 4. Review an E-commerce Website	

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Name of the Programme: **Students from any Programme can opt for this**
Course Code: **CSC 150**
Title of the Course: **Database Management and Analysis**
Number of Credits: **3 (1L+2P)**
Effective from AY: **2023-24**

Pre-requisites for the Course:	Nil	
Course Objectives:	To familiarize the student with various applications of Information and Communication technologies in business and to familiarize with the mechanism for conducting business transactions through electronic means.	
Content:	**Unit I : Database Management System** ● Database Designs for Accounting and Business Applications: Reality- Expressing the Application; Creating Initial design in Entity Relationship(ER) Model; Transforming ER Model to Relational data model concepts; Implementing RDM design using an appropriate DBMS. ● SQL and Retrieval of Information: Basic Queries in SQL; Embedded Queries in SQL; Insert, Delete and Update statements in SQL ● DBMS Software: Environment; Tables; Forms; Queries; Reports; Modules; ● Applying DBMS in the areas of Accounting, Inventory, HRM and its accounting, Managing the data records of Employees, Suppliers and Customers.	10 hours
	Unit II: Enterprise Resource Planning ● Introduction: Traditional information model, Introduction to an enterprise, What is ERP?, Reasons for growth of ERP market, Advantages and Disadvantages of ERP , Introduction to business modules: finance, manufacturing, Human resource, materials management, sales and distribution, Limitations of ERP, ERP and eCommerce	5 hours
	Practicals	

Lab1	Database Management System Creating Database and Tables, Changing Table Contents, Adding and Editing Records, Changing Table Properties, Creating Relationships between Tables, Importing and Exporting Data with other Programs. Creating Queries: Using the Query Window, Using Criteria and Saving Queries, Criteria Expressions and Operators, Changing a Query and Totaling, Creating a Query to the above-made Databases Creating Forms: Putting List Box on the Form, Selecting and Redesigning Labels and Data, Moving Label and Data, Adding Data and using Data Validation Creating Reports: Creating a single Column Report, Creating a Grouped Data Report, Adding Graphs to Reports. Use of Macros for search and navigation filters.	50 hours
Lab2	ERP Mini Project Case study – Studying ERP implementation in any business firm Report preparation and submission – report shall include ERP introduction, life cycle as followed by the Business firm under study – pre-evaluation screening, package evaluation, project planning phase, gap analysis, reengineering, configuration, implementation team training, testing, going live, end user training, post implementation.	10 hours
Pedagogy:	MS-Access or any similar open source software Field visits may be conducted to understand and demonstrate ERP Software.	
References/ Readings:	1. Database systems – Bipin Desai 2. MS-Access manual 3. S Sadagopan, "ERP a Management Prospective" Tata McGraw Hill Publishing Company Limited, New Delhi 1999 4. Alexis Leon , "ERP Demystified", Tata McGraw Hill Publishing Company Limited, New Delhi 2000	
Course Outcomes:	At the end of the course, learner will be able to: 1. Describe database designing in DBMS software, Query language and understand its applications. 2. Creation and management of Database tables, queries, forms, reports and also macros in DBMS. 3. Explain the application of Enterprise Resource Planning in Business 4. Explain Implementation of ERP as a case study in any business firm. (Back to Index) (Back to Agenda)	

Annexure II

Computer Applications Programme

Semester	Major - Core (3T + 1P)	Minor (4 T)	MC (3 T)	AEC	SEC (1 T + 2 P)	I	D	VAC	Total Credits	Exit
I	Major- 1 CSA-100 (Problem Solving and Programming)	Minor -1 CSA -111 (Computer System Fundamentals)	MC-1 CSA -131 (E-Commerce) **OR** CSA-132 (Mathematical Foundations - I)		SEC-1 CSA - 141 (Office Automation and PC Troubleshooting) **OR** CSA-142 (Python Programming)					
II	Major- 2 CSA-101 (Data Modelling)	Minor-2 CSA-112 (Open Source Software)	MC-2 CSA -133 (Green Computing) **OR** CSA-134 (Mathematical Foundations - II)		SEC-2 CSA - 143 (Data Analytics using Spreadsheets) **OR** CSA-144 (2D Annimation)					

Computer Applications Major Courses			
First Year			
Semester No.	Course Code	Name of Course	Credits
I	CSA-100	Problem Solving and Programming	3T + 1P
II	CSA-101	Data Modelling	3T + 1P
Second Year			
III	CSA-200	Programming using C++	3T + 1P
III	CSA-201	Database Management Systems	3T + 1P
IV	CSA-202	Web App Development	3P + 1 Tutorial
IV	CSA-203	Agile Methodologies	3T + 1P
IV	CSA-204	Object Oriented Concepts	3T + 1P

IV	CSA-205	Web Technology	2T
Third Year			
V	CSA-300	UI- UX Design	3T + 1P
V	CSA-301	Full Stack Development	3P + 1Tutorial
V	CSA-302	Internet Technologies	3T + 1P
V	CSA-303	Introduction to Functional Programming	2P
VI	CSA-304	Lambda Calculus	4T
VI	CSA-305	Mobile App Development	3P + 1 Tutorial
VI	CSA-306	Data Science	3T + 1P
VI	CSA-307	Project	4
Fourth Year			
VII	CSA-400	Cyber Security	3T + 1P
VII	CSA-401	DevOps	3P + 1 Tutorial
VII	CSA-402	Software Design Patterns	3T + 1P
VII	CSA-403	NLP Applications	3T + 1P
VIII	CSA-404	Educational Technology	3T + 1P
VIII	CSA-405	Information Systems Audit	3T + 1 Tutorial
VIII	CSA-406	IoT	3T + 1P
VIII	CSA-407	Seminar	4T
Computer Applications Minor Courses			
First Year			
Semester No.	Course Code	Name of Course	Credits
I	CSA-110	Computer System Fundamentals	4T
II	CSA-111	Open Source Software	4T
Second Year			
III	CSA-210	Reasoning Techniques	3T + 1 Tutorial
III	CSA-211	Techpreunership Development	3T + 1 Tutorial
IV	CSA-212	Digital Marketing Fundamentals	3T + 1P

IV	CSA-213	Data Analysis	3T + 1P
Third Year			
V	CSA-310	JavaScript	3T + 1P
V	CSA-311	Dashboard Development	3T + 1P
VI	CSA-313	Social Media Marketing & Analytics	3T + 1P
VI	CSA-314	E-Commerce Applications	3T + 1P
VI	CSA-315	Modern Frameworks	3T + 1P
Fourth Year			
VII	CSA-410	Project Management	3T + 1P
VII	CSA-411	Cloud Computing	3T + 1P
VII	CSA-412	Research Methodology	3T + 1P
VIII	CSA-413	Interactive Media	3T + 1P
VIII	CSA-414	Game Design	3T + 1P
VIII	CSA-415	Statistical Tools	3T + 1P
VIII	CSA-416	Blockchain Technology	3T + 1P

Computer Applications Multidisciplinary Courses(MC)

Semester No.	Course Code	Name of Course	Credits
I	**CSA-131**	E-Commerce	3T
I	**CSA-132**	Mathematical Foundations - I	3T
II	**CSA-133**	Mathematical Foundations - II	3T
II	**CSA-134**	Green Computing	3T
III	**CSA-231**	Cyber Law and Ethics	3T
III	**CSA-232**	Digital Ecosystem	3T
III	**CSA-233**	Website Design	2T+1P
III	**CSA-234**	ERP	2T+1P
III	**CSA-235**	Latex	2T+1P
III	**CSA-236**	Multimedia Essentials	2T+1P

Computer Applications Skill Enhancement Courses(SEC)			
Semester No.	Course Code	Name of Course	Credits
I	**CSA-141**	Office Automation and PC Troubleshooting	1T + 2P
I	**CSA-142**	Python Programming	1T + 2P
II	**CSA-143**	Data Analytics using spreadsheets	1T + 2P
II	**CSA-144**	2D Animation	1T + 2P
III	**CSA-241**	Multimedia Applications	1T + 2P
III	**CSA-242**	Search Engine Optimization	1T + 2P
III	**CSA-243**	3D Animation	1T + 2P

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Name of the Programme: UG Honors with Computer Applications
Course Code: CSA-100 **Title of the Course:** Problem Solving and Programming
Number of Credits: 4 (3 Theory + 1 Practical)
Effective from AY: 2023-24

Pre-requisites for the Course:	None	
Course Objectives:	5. To understand the concepts and techniques of problems solving. 6. To analyse, understand and build logic to solve basic problems. 7. To design Algorithms and flowcharts for better understanding and documentation for accurate implementation of the problem. 8. To code and implement a well-structured, robust programming logic using a suitable programming language.	
Units	**Content**	**No of hours 75 (45 T + 30 P)**
I.	**Introduction to Problem Solving** 4. Problem Solving Life Cycle – Understanding the Problem Statement, Analyzing the problem, Planning Program design using Hierarchy charts, Expressing Program logic using flowcharts / Pseudocode. 5. Structured Programming concept 6. Modular Programming - Top-Down design, Bottom-up design, Stepwise Refinement	**04**
II	**Understanding basic problem Solving Tools** 4. Algorithms: Definition & its attributes, algorithm	**06**

	constructs, Statements: Input-Output, Decision-Making, &Looping, Examples 5. Flowchart: Definition & its attributes, symbols, Statements: Input-Output, Decision-Making & Looping, Module representation, Drawing conventions and standards, Examples. 6. Pseudo-code: Definition & its attributes, constructs, and Examples	
III	**Basic Program Structures** Data & its types (Integer, Floating-point, Character, String), Constants & Variables, scope, Instructions & its types, how computer stores data, Operators (Arithmetic, Assignment, Relational, Logical, etc), Expressions and Equations, Evaluation of expressions, Keywords. Local and Global Variables, Parameters, Return Values, naming conventions & standards, Understanding literals, syntax and semantics, functions and modules.	**06**
IV	**Basic Sequential Instructions** Sequential statements using operators, constants, variables, operands, expressions and equations. ***Activity:*** *Design algorithms of at-least 3 basic problems to apply the concept learned in the unit. Represent it using flowchart and pseudo-code.*	**06**
V	**Problem Solving with Decisions** The Decision Logic Structure, Multiple If/Then/Else Instructions, Using Straight-Through Logic, Using Positive & Negative Logic, Logic Conversion, Decision Tables, Case Logic Structure ***Activity:*** *Design algorithms of at-least 3 basic problems to apply the concept learned in the unit. Represent it using flowchart.*	**06**
VI	**Problem Solving with Loops** The Loop Logic Structure, Incrementing, Accumulating, While/While End, Repeat/Until, Automatic-Counter Loop, Nested Loops, Indicators (flags). ***Activity:*** *Design algorithms of at-least 3 basic problems to apply the concept learned in the unit. Represent it using flowchart.*	**06**
VII	**Understanding functions** Functions: Definition and its need & constructs, designing simpler functions, function communication using arguments & return statements. scope of functions, function declaration and prototype, call by Value and Call by reference. Concept of Recursive functions: why, when and how. Designing recursive functions and recursive call. Base case and recursive case.	**06**

	Activity: *Design algorithms of at-least 3 basic problems to apply the concept learned in the unit. Represent it using flowchart.*	
VIII	**Problem Solving with Arrays** Arrays Concepts: One dimensional Arrays, Creating, iterating, accessing and modifying array elements. Concept of Strings, String as array of characters. ***Activity:*** *Design algorithms of at-least 3 basic problems to apply the concept learned in the unit. Represent it using flowchart.*	**03**
IX	**Debugging & Documentation** Definition, Types, Need and how to do it.	**02**
Practical Work	Using any suitable programming language (eg C, C++, etc.), the concepts learnt in the units from I to IX are required to implemented practically. The broad area of practical problems are mentioned / suggested below.	**Practical Hours (30)**
Week 1 & 2 [These practicals should be done using pen & paper and using buddy learning strategy]	1. For each of the following tasks, write a set of numbered, step-by-step instructions (a solution) so complete that another person could perform the task without asking questions. Define the knowledge base of this person by listing what you expect the person to know in order to follow your directions. For example, for task "a" (below), make a cup of cocoa, the knowledge base might include such things as knowledge of milk or water, a refrigerator, pan, spoon, cocoa, cup, range top or microwave, and so forth. a. Make a cup of cocoa. b. Sharpen a pencil. c. Walk from the classroom to the student lounge, your dorm, or the cafeteria. d. Start a car (include directions regarding what to do if the car doesn't start). e. Get a glass of water from your kitchen. f. Start your computer. 2. Test your solution in problem 1 by giving your instructions to another person to see whether he or she can accomplish the task without your help. If they can't, modify your solution so that the person can accomplish the task. Check the solution again by giving the instructions to another person.	**04 Hours**
Week 3 & 4	3. Basic Program Structures • At-least 10 basic programming problems related to Unit III to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	**04 Hours**

Week 5 & 6	4. Basic Sequential Instructions • At-least 08 programming problems related to Unit IV to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	**04 Hours**
Week 7 & 8	5. Problem Solving with Decisions • At-least 08 programming problems related to Unit V to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	**04 Hours**
Week 9 & 10	6. Problem Solving with Loops • At-least 06 programming problems related to Unit VI to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	**04 Hours**
Week 11 & 12	7. Understanding functions • At-least 08 programming problems related to Unit VII to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	**04 Hours**
Week 13 & 14	8. Problem Solving with Arrays • At-least 06 programming problems related to Unit VIII to be completed during the practical sessions. • More programs may be given to the learners to complete and practice as part of their Practice Work.	**04 Hours**
Week 15	9. Debugging & Documentation • Debug & Document at-least 06 problems which you have programmed from week 07 onwards. • More programs may be given to the learners to complete and practice as part of their Practice Work.	**02 Hours**
Pedagogy:	**Suggested strategies for use to accelerate the attainment of the various course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use a. Video/Animation to explain various concepts. b. Collaborative, Peer, Flipped Learning etc. 2. Ask at least three HOT (Higher-Order Thinking) questions in the class, which promotes critical thinking. 3. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. 4. Introduce Topics in manifold representations. 5. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 6. Discuss how every concept can be applied to the real world - and when	

	that's possible, it helps improve the students' understanding 7. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations.
References/ Readings:	1. Maureen Sprankle and Jim Hubbard, Problem Solving and Programming Concepts, Pearson Education India 9th edition (2013) 2. S.Kuppuswamy, S.Malliga, C.S.Kanimozhi Selvi, K.Kousalya. Problem Solving and Programming. 2019, Tata McGraw Hill. 3. A Structured Programming Approach Using C, Behrouz A. Forouzan, Richard F. Gilberg ISBN:9788131500941, Cengage Learning India 4. Introduction to algorithms – Cormen, Leiserson, Rivest, Stein Ritchie,ISBN:9788120305960, PHI Learning 5. How to Solve it by Computer, R.G. Dromey, ISBN: 9788131705629, Pearson Education **Article in Online Encyclopedia** 3. https://code.world/ [Accessed: April 15, 2023]. 4. https://raptor.martincarlisle.com/ [Accessed: April 15, 2023].
Course Outcomes:	**On completion of the course, students will be able to –** **1.** Understand the ways and stages of Problem Solving. **2.** Understand basic computing concepts, algorithm design, flowchart design, programming constructs and debugging. **3.** Apply the problem solving & programming concepts in designing solution to simpler problems. **4.** Code and implement a well-structured programming logic using a suitable programming language.

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Name of the Programme: UG Honors with Computer Applications
Course Code: CSA-101 **Title of the Course:** Data Modelling
Number of Credits: 4 (3 Theory & 1 Practical)
Effective from AY: 2023-24

Pre-requisites for the Course:	None	
Course Objectives:	1. To understand the basic concept of data and its types 2. To understand different data levels and data model. 3. To understand Relational Data Model at conceptual & logical Level 4. To understand basic data storage.	
Units	**Content**	**No of hours 45L + 30P**
I	**Data Model Introduction** • Definition, Importance, Levels (Conceptual, Logical and Physical), Data Types (Textual & Non-Textual) • Career Path of a Data Modeler	**05**

	• Data Modeling Development Life Cycle • Data Model Standards: Naming conventions, information security, compliance	
II	**Data Model Levels** • Conceptual Data Model - Definition, Characteristics, Need of conceptual model, Steps to design a conceptual data model, Representation, Application • Logical Data Model **-** Definition, Characteristics, Need of logical model, Steps to design a logical data model, Representation, Application • Physical Data Model - Definition, Characteristics, Need of physical model, Steps to design a physical data model, Representation, Application • Comparison of Data Model Levels	**10**
III	**Aspects & Types of Data Model:** • Single /Multi-valued, Homogeneous / Heterogeneous, Dimensions • Types: Network, Hierarchical, Object Oriented, Relational, Dimensional. Comparison of Data Models	**05**
IV	**Relational Data Model** • Conceptual Data Models for Database Design • Entity Types, Entity Sets, Attributes • Strong & Weak Entity Types • Relationship Types, Relationship Sets, Roles, and Structural Constraints • ER Diagrams, Naming Conventions, and Design Issues • Cardinality and Multiplicity - Maximum & Minimum • Mapping Conceptual model into relational schema • Concepts of keys, Entity integrity, Unique Requirement and Fundamental integrity rules: entity & referential integrity	**15**
V	**Data Storage** • Meta-data • Proprietary & Open Source formats • Basic storage format: Sequential files, Tabular Data, JSON, XML, XSV (X - Comma, Tab, etc.)	**5**
VI	Introduction to • Big Data • Data Warehousing • Data Mining	**5**
Practical Work	**Content**	**Practical Hours (30)**
Week 1	• Identify any 5 entities from your surroundings. Identify attributes for each of the entities. Examine if each of these entities are related to each other? If yes why and if no why not?	**02 Hours**

Week 2 & 3	• Study and critically examine at-least 2 case studies on each of the data models levels mentioned in Unit II. • A few case studies may be given to the learners to practice at Home.	**04 Hours**
Week 4 & 5	• Critically study at least 1 case study under Network, Hierarchical, Object Oriented, and Dimensional data model type at conceptual level.	**04 Hours**
Week 6 to 9	• Design and Model Data of at-least 04 real life business problems using Relational Data Model at Conceptual Level using ERD. Also, carry out the tasks step by step while designing ERD. • Some real life business problems are Library, Attendance of School, Grocery Store, etc.	**08 Hours**
Week 10 & 11	• Design physical data model of any 02 real life business problems using suitable tool, for which you have designed the logical model in week 6 to week 9.	**04 Hours**
Week 12 to 15	• Using any open source database management designer tool (eg. DB DESIGNER, SqlDBM, DbWrench, and similar tools), design and create databases of real life business problems for which you have designed the physical data model in week 10 and week 11. • Use concepts of primary key & foreign keys	**08 Hours**
Pedagogy:	**Suggested strategies to use to accelerate the attainment of the various course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use a. Video/Animation to explain various concepts. b. Collaborative, Peer, Flipped Learning etc. 2. Ask at least three HOT (Higher-order Thinking) questions in the class, which promotes critical thinking. 3. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. 4. Introduce Topics in manifold representations. 5. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 6. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding 7. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations.	
References/ Readings:	1. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, Pearson Education, 7th Edition	

	2. Graeme C. Simsion and Graham C. Witt, Data Modeling Essentials, Morgan Kaufmann Publishers, Third Edition, 2005 3. Abraham Silberschatz, Henry Korth, S. Sudarshan, Data Base System Concepts, McGraw Hill, 6th Edition
Course Outcomes:	**On completion of the course, students will be able to –** 1. Understand the basics of data, data levels and data models. 2. Design Relational Data Model. 3. Understand different data storage formats. 4. Create a simple Relational Database for data storage.

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Name of the Programme: **Any Discipline**
Course Code: CSA-110 **Title of the Course:** Computer System Fundamentals
Number of Credits: 4
Effective from AY: 2023-24

Pre-requisites for the Course:	None
Course Objectives:	1. To understand the basic concepts of Operating System and Computer Architecture 2. To understand the concepts of organization and functioning of Computer System. 3. To design Algorithms and flowcharts for better understanding and documentation for accurate implementation of the problem. 4. To learn and use efficient programming constructs.

	Content	**No of hours (60)**
Unit	**Topic**	
I	**Fundamentals of Computer** **Evolution of Computer** – Operating Systems – Definition, Introduction to Major Functions/Services, OS Structure, Relationship between Kernel, OS, Hardware, Block Diagram of computer, Generations of Computer, Von Neumann Architecture. **Computer Components and Functions –** Instruction Cycle with and without interrupts, Multiple interrupts, Bus Interconnections. Number System –Conversion (Binary, Decimal, Octal, Hexa-Decimal)	**10**
II	**Central Processing Unit** Computer Arithmetic ALU, Integer representation, Integer Representation, Addition, subtraction. Instruction sets, characteristics & Functions, Addressing modes and formats. CPU structure and function. Processor Generation-8086,Pentium I-IV,i1-i7	**05**

III	**Processes & Process Management** Process- Definition, Process Control Block, Process States, Operations on Process. Threads and Microkernels – Definition, Multithreading, Model Process Scheduling - Introduction to the Concept, Scheduling Criteria Scheduling Algorithms. Concurrency/ Process Coordination – Synchronization Principles, Mutual Exclusion, The Critical-Section Problem, Peterson's Solution Deadlock – Principles, Deadlock Handling Methods, Prevention, Avoidance, Detection, Recovery from Deadlock	**15**
IV	**Memory Management** Memory Management Concepts – Swapping, Contiguous Memory Allocation, Paging, Page Table, Segmentation. Virtual Memory – Introduction, Demand Paging, Page Replacement Frames Allocation, Thrashing Cache Memory, Internal Memory (Semiconductor, Main Memory, RAM), External Memory (Magnetic Disk, RAID, Optical memory)	**10**
V	**Input/ Output and File System** File System Concepts, File Organization and Access Methods, Directory Structure, File Sharing I/O Management - I/O devices, I/O Hardware, Organization of I/O, I/O Buffering, Disk Scheduling- Algorithms, I/O Modules, I/O techniques (programmed, interrupt driven and DMA), Operating System Support.	**14**
VI	**Control Unit** Structure of the Control Unit, Functioning of the Control Unit, Micro programmed control	**6**
Pedagogy:	**Suggested strategies to use to accelerate the attainment of the various course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use a. Video/Animation to explain various concepts. b. Collaborative, Peer, Flipped Learning etc. 2. Ask at least three HOT (Higher-order Thinking) questions in the class, which promotes critical thinking. 3. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. 4. Introduce Topics in manifold representations. 5. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 6. Discuss how every concept can be applied to the real world - and when	

	that's possible,it helps improve the students' understanding 7. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations.
References/ Readings:	1. PradipSinha and PritiSinha, "Computer Fundamentals", 6th Edition, BPB Publications, 2016 2. Abraham Silberschatz and Peter Baer Galvin, "Operating System Concepts", 7th Edition, Pearson Education, 2007. 3. William Stallings, "Operating Systems", 6th Edition, Pearson Education, 2010 4. Computer Organization and Architecture (7th Edition): William Stalling, Prentice-Hall. 5. Computer System Architecture: Morris Mano, Prentice-Hall. E-Books: 6. Operating Systems Guide: by Tim Bower 7. Operating Systems Course Notes: by Dr. John T. Bell 8. Schaum's Outline of Operating Systems (Schaum's Outline Series) [Kindle Edition] by J. Archer Harris. 9. Computer Organization: TMH, Ace series. 10. Computer Organization and Architecture by William Stallings, 8th Edition, Prentice-Hall.
Course Outcomes:	**On completion of the course, students will** 1. Understand the basic structure and functioning of the Computer 2. Get the understanding of various functions and characteristics of operating systems. 3. Understand basic concepts of Computer Organisation& Architecture. 4. Understand basic understanding of resource allocation,functioning of the I/O modules, primary and secondary memory, and Control Unit.

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Programme: Any Discipline
Course Code: CSA-111 **Title of the Course:** Open Source Software
Number of Credits: 04
Effective from AY: 2023-24

Prerequisite for the Course :	None		
Course Objectives :	1. Explain the benefits of Open Source software 2. Understand the social impact of Open Source software 3. Understanding tools and techniques for creating and managing open source communities of practice 4. Understanding Open Source software ecosystem		
Unit	**Title**	**Content**	**No of Hours (60)**
	Introduction to Open source	**Introduction** • Open Source, Free Software, Free Software vs. Open Source software, Public Domain Software, FOSS does	

I	Software	not mean no cost. History: BSD, The Free Software Foundation and the GNU Project. **Methodologies** • Open Source History, Initiatives, Principle and methodologies. Philosophy: Software Freedom, Open Source Development Model Licenses and Patents: What Is A License, Important FOSS Licenses (Apache, BSD, GPL, LGPL), copyrights and copy lefts, Patents Economics of FOSS: Zero Marginal Cost, Income-generation opportunities, Problems with traditional commercial software, Internationalization **Social Impact** • Open source vs. closed source, Open source government, Open source ethics. Social and Financial impacts of open source technology, Shared software, Shared source, Open Source in Government.	**20**
II	Contribution to Open Source Projects	**Case Studies** • Example Projects: Apache web server, GNU/Linux, Android, Mozilla (Firefox), Wikipedia, Drupal, wordpress, GCC, GDB, github, Open Office. Study: Understanding the developmental models, licensings, mode of funding, commercial/non-commercial use. Open Source Hardware, Open Source Design, Open source Teaching. Open source media. **Collaboration, Community and Communication Contributing to Open Source Projects** • Introduction to github, interacting with the community on github, Communication and etiquette, testing open source code, reporting issues, contributing code. • Introduction to wikipedia, contributing to Wikipedia Or contributing to any prominent open source project of student's choice. • Starting and Maintaining own Open Source Project	**20**
III	Open Source Ecosystem	**Understanding Open Source Ecosystem** • Open Source Operating Systems: GNU/Linux, Android, Free BSD, Open Solaris. Open Source Hardware, Virtualization Technologies, Containerization Technologies: Docker, Development tools, IDEs, debuggers, Programming languages, LAMP, Open Source database technologies	**20**

Pedagogy:	**Suggested strategies to use to accelerate the attainment of the various course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternativeeffective teaching methods could be adopted to attain the outcomes. You may use a. Video/Animation to explain various concepts.

	b. Collaborative, Peer, Flipped Learning etc. 1. Ask at least three HOT (Higher-order Thinking) questions in the class, whichpromotes critical thinking. 2. Adopt ProblemBased Learning (PBL), which fosters students' Analytical skills,develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. 3. Introduce Topics in manifold representations. 4. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 5. Discuss how every concept can be applied to the real world - and when that's possible,it helps improve the students' understanding 6. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations.
References/ Readings:	**Text book:** 1. Unix Concepts and Applications by Sumitabha Das, Tata McGraw Hill Education, 2006 2. The official Ubuntu Book, 8th Edition **Article in Online Encyclopedia** [All accessed on: April 15, 2023] 3. The Linux Documentation Project: http://www.tldp.org/ 4. Docker Project Home: http://www.docker.com 5. Linux kernel Home: http://kernel.org 6. Open Source Initiative: https://opensource.org/ 7. Linux Documentation Project: http://www.tldp.org/ 8. Wikipedia: https://en.wikipedia.org/ 9. https://en.wikipedia.org/wiki/Wikipedia:Contributing_to_Wikipedia 10. Github: https://help.github.com/ 11. The Linux Foundation: http://www.linuxfoundation.org/
Course Outcomes:	At the end of the course, the student will be able to - 1. Understand the significance of Open Source software practices and guidelines 2. Understand knowledge of Open Source ecosystem, its use, impact and importance. 3. Use Open Source methodologies, case studies in real life applications. 4. Collaborate and contribute to Open Source Projects

Note: Above Syllabus referred from **University of Mumbai Institute of Open and Distance Learning**

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Course Code: CSC-131
Title of the Course: E-Commerce
Number of Credits: 3 (3 Theory)
Effective from AY: 2023-24

Pre-requisite for the Course:	**None**	
Course Objectives:	1. To give fundamental understanding of e-commerce 2. To instill idea of convergence of business relationship through technologies. 3. To understand the application of e-commerce in B2B and B2C modal. 4. To identify, define and differentiate the various modes and risks of electronic commerce.	
Units	**Content**	**No of hours 45**
1	**Introduction to Electronic Commerce** Meaning, Nature and scope of e-commerce,History of e-commerce, Business applications of e-commerce, E-Commerce Models:-(B2B,B2C,C2C,B2G), Advantages and Disadvantages of e-commerce, Applications of M-Commerce	5 hours
2	**E-Commerce Web-sites** Websites as marketplace, Role of website in B2C e-commerce, Website design principles, Alternative methods of customer communication such as e-mail, Email etiquette and e-mail security	5 hours
3	**Online Marketing** Online marketing and advertising, Push and pull approaches, Web counters, Web advertisements, Content marketing, Need of Digital Marketing for an e-commerce Business, Search Engine Optimization(SEO), Search Engine Marketing(SEM), Social Media Marketing(SMM), Web Analytics	10 hours
4	**Applications of E-commerce** Applications of e-commerce to Supply chain management Applications of e-commerce to Customer Relationship Management, Product and service digitization, Remote servicing	5 hours
5	**Business to Consumer E-Commerce** Cataloguing,Order planning and order generation,Cost estimation and pricing,Order receipt and accounting,Order selection and prioritization,Order scheduling,Order fulfilling,Order delivery,Order billing,Post sales service	4 hours

6	**Business to Business E-Commerce** Need and Models of B2B e-commerce,Using public and private computer networks for B2B trading; EDI and paperless trading, Characteristic features of EDI service arrangement, EDI architecture and standards	7 hours
7	**Electronic Payment System** Types of payment systems, credit cards, debit cards, mobile, etc, Electronic Fund Transfer(EFT), Operational credit and legal risk of e-payment, Risk management options for e-payment systems	5 hours
8	**Security Issues in E-Commerce** Risks of e-commerce,Types and sources of threats; Security tools, Risk management approaches	4 hours
Pedagogy:	**Suggested strategies for use to accelerate the attainment of the various course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use a. Video/Animation to explain various concepts. b. Collaborative, Peer, Flipped Learning etc. 1. Ask at least three HOT (Higher-Order Thinking) questions in the class, which promotes critical thinking. 2. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. 3. Introduce Topics in manifold representations. 4. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 5. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding 6. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations.	

<table>
<tr><td>References/

Readings:</td><td>Reference Books:
1. P. T. Joseph, E-Commerce: An Indian Perspective Paperback, PHI Learning, 5th Edition, 2015
2. V. Rajaraman, Essentials of E-Commerce Technology, PHI Learning, 2015 Revised Edition
3. Kalakota, Ravi and Andrew.Whinston, Frontiers of Electronic Commerce, Pearson Education, 2015 Revised Edition
4. Kamlesh N. Agarwala, Amit Lal and Deeksha Agarwala, Business on the Net: An Introduction to the Whats and Hows of E Commerce, Macmillan India Ltd, 2000
5. Diwan, Pragand Sunil Sharma, Electronic Commerce- A Manager's Guide to E Business,Vanity Books International, Delhi.
6. Fitzgerald, Business Data Communication Network, McGrawHill, 1998.
7. Dishek J. Mankad,Understanding Digital Marketing: Strategies for online success, 2019
NPTELResources:
https://nptel.ac.in/content/storage2/courses/106108103/pdf/PPTs/mod13.pdf</td></tr>
<tr><td>Course Outcomes:</td><td>On completion of the course students will be able to
1. Understand the foundation of e-commerce and e-commerce websites.
2. Explain the basics of online marketing and e-commerce applications.
3. Compare B2B and B2C e-commerce models.
4. Explain electronic payment system, the security issues, and security mechanism in e-commerce applications.</td></tr>
</table>

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Name of the Programme: Any Discipline
Course Code: CSA-132 **Title of the Course:** Mathematical Foundation - I
Numbe rof Credits: 3 (3T)
Effective from AY:2023-24

<table>
<tr><td>Pre-requisites fortheCourse:</td><td colspan="2">None</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">1. To learn higher secondary level mathematical concepts.
2. To understand basic mathematical concepts and build logic to solve problems.</td></tr>
<tr><td>Units</td><td>Content</td><td>No of hours 45</td></tr>
<tr><td>I.</td><td>Complex Numbers
• A Introduction
• Operations on Complex numbers: Addition, subtraction, multiplication, division, conjugate, modulus, reciprocal
• Representation: graphical, polar, vector
• De Moiveor’s Theorem
• Nth roots of complex number: Basic properties, Square roots, Cube roots of unity</td><td>7</td></tr>
<tr><td>II</td><td>Matrices and Determinants
• A Definition, Types of matrices: Row, column, square,</td><td>9</td></tr>
</table>

	diagonal, scalar, unit, null, upper and lower • Properties of matrix • Algebra of matrices: negative, transpose, equality, addition and subtraction, scalar multiplication, Matrix multiplication, Adjoint, Inverse • Solving non homogeneous equations by Matrix inverse method **Determinants** • Determinants: Definition and order, Types • fundamental concepts: minor, co-factors, expansion value, properties, • Cramer's rule	
III	**Sequence and Series** • Arithmetic Progression • Geometric Progression • Harmonic Progression	**5**
IV	**Coordinate Geometry** • Cartesian System: Coordinate of a point, Distance between points, Section formula, Area of triangle • Straight Lines: Slope of a line, Parallel and Perpendicular lines, Angle between two intersecting lines, Equation of a straight lines (Through origin, Point slope form, two point form) • Circle: Standard form of a circle, circle with given radius and center	**8**
V	**Trigonometry** • Introduction, Relation between degree and radian, Unit Circle definition • Trigonometric function: Periodicity of trigonometric function • Trigonometric identities	**5**
VI	**Limits & Continuity** • Introduction, Ordered pairs, Cartesian product, Relation, Function • Real function and types, Domain and Range of function, Composition of function • limit of a function, Algebra of limits • Continuity of a function	**7**
VII	**Vectors** • Vectors in plane Cartesian coordinates, Vectors in space • Dot products • Cross products	**4**
Pedagogy:	**Suggested strategies to use to accelerate the attainment of the various course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the	

	outcomes. You may use c. Video/Animation to explain various concepts. d. Collaborative, Peer, Flipped Learning etc. 1. Ask at least three HOT (Higher-order Thinking) questions in the class, which promotes critical thinking. 2. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. 3. Introduce Topics in manifold representations. 4. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 5. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding ~~6.~~ To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations.
References/ Readings:	1. Elementary Engineering Mathematics -B S Grewal 2. Calculus – Thomas Finney,14e 3. Mathematical Techniques – Maria Ester Rebelo Abranches 4. Mathematics for computer- Neeta Mazumdar 5. Parmanand Gupta, Comprehensive Algebra (for BA, BSc-I), Laxmi Publication,2008
Course Outcomes:	**On completion of the course, students will be able to** 1. Identify and understand different operations on the complex numbers. 2. Understand concept of matrices and determinants and use Cramer's rule. 3. Understand the concept of straight lines and its properties. 4. Understand the limit &continuity of thefunction 5. Understand dot and cross product of vectors.

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Name of the Programme: Any Discipline
Course Code: CSA-133 **Title of the Course:** Mathematical Foundation - II
Number of Credits: 3 (3T)
Effective from AY: 2023-24

Prerequisite for the Course :		None	
Course Objectives :		To introduce basic fundamentals of applied mathematics and understand its applications to solve real world problems	
Unit	**Title**	**Content**	**No of Hours (45)**
I	Mathematical Logic	• Introduction to Logic • Logical Connectives • Well-formed formulas (WFF) • Tautology and Contradiction statements • Converse and Contra positive statements	**5**

		• Equivalence Formulas	
II	Mathematical Induction	• Principle of Induction	**2**
III	Boolean Algebra and Circuits	**Boolean Algebra** • Introduction • Representation of Logic Variables: 0 and1; Low and High; Off and On; No and Yes; Closed and Open Switch **Truth table** • Unary Operations: Logical Identity, Logical Negation • Binary Operations: Conjunction, Disjunction, Implication, Equality, Exclusive Disjunction, Logical NAND, Logical NOR • Applications: Logical Equivalences **Boolean functions** • Commutative Law • Associative Law • Distributive Law • Identity Law • Negation Law • De-Morgan's theorem **Logic gates** • AND, OR, NOT, NAND, NOR, XOR, XNOR • Logic Gate Diagram and Truth Table Circuit Diagrams	**12**
IV	Set Theory	• Introduction to Sets **Set Operations** • Union • Intersection • Complement • Differences • Algebraic Properties of Sets and De Morgan's Laws • Venn diagrams	**5**
V	Relations	• Cartesian Product • Introduction to Relations **Properties of Relations** • Reflexive • Symmetric • Asymmetric • Anti-symmetric • Transitive • Equivalence Relation	**5**
		• Introduction to functions	

VI	Functions	**Types of Functions** • Identity function • Composite function • Injection (One-to-One) • Surjection (Onto) • Bijection (One-to-One and Onto) • Invertible • Composition of functions (fog, gof)	**5**
VII	Permutations and Combinations	• Principle of counting • Factorial Notation **Permutations** • Permutations with and without repetition • Circular Permutations • Combinations • The Pigeonhole Principle • The Inclusion-Exclusion Principle	**9**
VIII	Binomial Theorem	• Binomial Theorem	**2**

Pedagogy:	**Suggested strategies to use to accelerate the attainment of the various course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use a. Video/Animation to explain various concepts. b. Collaborative, Peer, Flipped Learning etc. 2. Ask at least three HOT (Higher-order Thinking) questions in the class, which promotes critical thinking. 3. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. 4. Introduce Topics in manifold representations. 5. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 6. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding 7. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations.
References:	1. Parmanand Gupta, Comprehensive Discrete Mathematics (for BA/BSc III, BCA, MCA), Laxmi Publications 2. Trembly J.P and Manohar R, Discrete Mathematical Structures with 3. Applications to Computer Science, McGraw Hill Education 4. Kenneth H. Rosen, Discrete Mathematics and its Applications(5e), McGraw Hill Education

	5. Swapan Kumar Sarkar, A Textbook of Discrete Mathematics, S.Chand Publication (9e) 6. B. Kolman, R.C. Busby, and S.C. Ross, Discrete Mathematical Structures, PHI 7. Mathematical Foundation of Computer Science, Bhavanari Satyanarayana, T,V. Pradeep Kumar, Shaik Mohiddin Shaw, 2019
Course Outcome:	1. Understand the various connectives used in logic reasoning. 2. Apply the principle of mathematical induction, Boolean operation laws, and basic concepts of sets, relations and functions. 3. Apply permutations and combinations in solving problems.

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Name of the Programme: Any Discipline
Course Code: CSA-134 **Title of the Course:** Green Computing
Number of Credits: 3 (3 Theory)
Effective from AY: 2023-24

Prerequisite for the Course :		None	
Course Objectives :		1. To understand Green IT concepts and meeting standards set for Green Computing 2. To comprehend Green IT from the perspective of hardware, software, storage, and networking at the enterprise level. 3. To understand Green Initiatives and future of Green IT	
Unit	**Title**	**Content**	**No of Hours (45)**
I	Trends and Reasons to Go Green	• Overview and Issues • Current Initiatives and Standards • Consumption Issues - Minimizing Power Usage, Cooling	**05**
II	Introduction to Green IT	**Green IT** • Holistic Approach to Greening IT • Awareness to Implementation Green IT Trends Green Engineering **Greening by IT** • Using RFID for Environmental • Sustainability • Smart Grids • Smart Buildings and Homes • Green Supply Chain and Logistics • Enterprise-Wide Environmental Sustainability	**08**
III	Green Hardware and Software	**Green Hardware** • Introduction • Life Cycle of a Device or Hardware • Reuse, Recycle, and Dispose **Green Software**	**08**

		• Introduction • Energy-Saving Software Techniques **Changing the way we work** • Going Paperless	
IV	Green Data Centres and Storage	**Green Data Centres** • Data Centre IT Infrastructure • Data Centre Facility Infrastructure: Implications for Energy Efficiency • IT Infrastructure Management • Green Data Centre Metrics **Green Data Storage** • Introduction • Storage Media Power Characteristics • Energy Management Techniques for Hard Disks • System-Level Energy Management **Green Networks and Communications** • Introduction • Objectives of Green Network Protocols • Green Network Protocols and Standards	**08**
V	Enterprise Green IT Strategy	• Introduction • Approaching green IT strategies • Business Drivers of Green IT Strategy • Business Dimensions for Green IT Transformation • Organizational Considerations in a Green IT Strategy • Steps in Developing a Green IT Strategy • Metrics and Measurements in Green Strategies • Organizational and Enterprise Greening • Greening the Enterprise: IT Usage and Hardware	**6**

<table>
<tr><td>VI</td><td>Managing and Regulating Green IT</td><td>Managing Green IT
Introduction
Strategizing Green Initiatives
Implementation of Green IT
Information Assurance
Communication and Social Media
Regulating Green IT
Introduction
The Regulatory Environment and IT Manufacturers
Non-regulatory Government Initiatives
Industry Associations and Standards Bodies
Green Building Standards
Green Data Centres
Social Movements and Greenpeace
The Future of Green IT
Green Computing and the Future
Megatrends for Green Computing
Tele-presence Instead of Travel
Tele-commuting Instead of Commuting
Deep Green Approach</td><td>10</td></tr>
<tr><td colspan="2">Pedagogy:</td><td colspan="2">Suggested strategies to use to accelerate the attainment of the various course outcomes.
1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use
a) Video/Animation to explain various concepts.
b) Collaborative, Peer, Flipped Learning etc.
1. Ask at least three HOT (Higher-order Thinking) questions in the class, which promotes critical thinking.
2. Adopt Problem Based Learning (PBL), which fosters students’ Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it.
3. Introduce Topics in manifold representations.
4. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
5. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding
6. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations.</td></tr>
<tr><td colspan="2">References:</td><td colspan="2">1. Toby Velte, Anthony Velte,Green IT: Reduce Your Information System's Environmental Impact While Adding to the Bottom Line,</td></tr>
</table>

	McGraw Hill Education, 2008 2. San Murugesan, G. R. Gangadharan, Harnessing Green IT: Principles and Practices, Wiley, 2013 3. Bud E. Smith, Green Computing-Tools and Techniques for saving energy, money and resources, Auerbach Publications 4. Mark G. O'Neill, Green IT for Sustainable Business Practice, BCS, The Chartered Institute for IT 5. Jason Harris, Green Computing and Green IT Best Practices, Emereo Pty Ltd
Course Outcome:	At the end of the course, the students will be able to 1. Understand Green Computing & Green IT fundamentals. 2. Acquire knowledge on Green Hardware and Software, Green Data Centres and Green IT Strategies 3. Understand the concept of green compliance 4. Express the understanding of green initiatives.

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Programme: Any discipline
Course Code: CSA-141
Title of the Course: Office Automation and PC troubleshooting
Number of Credits: 1T + 2P **Effective from AY**: 2023-24

Prerequisite for the Course :	None
Course Objectives :	1. Understand the basics of office automation software and its applications. 2. Develop proficiency in using word processing, spreadsheet, and presentation software. 3. Identify common hardware and software issues in a PC. 4. Diagnose and troubleshoot common PC issues. 5. Develop skills in maintaining and optimizing the performance of a PC.

#	Title	Content	No of Hours
	THEORY		**15**
1.	Introduction to Office Automation	Understanding office automation software and its applications Types of office automation software Microsoft Office Suite Google Workspace	**1**
2.	Word Processing	Introduction to Microsoft Word Creating and formatting documents Working with templates Mail merge and labels Collaboration tools	**3**
3.	Spreadsheets	Introduction to Microsoft Excel Creating and formatting spreadsheets Working with formulas and functions	**3**

		Charts and graphs Collaboration tools	
4.	Presentation Software	Introduction to Microsoft PowerPoint Creating and formatting presentations Working with images, videos, and animations Collaboration tools	**2**
5.	Email Management	Introduction to Email Setting up and configuring email accounts Composing and sending emails Managing Email Accounts	**1**
6.	Internet and Web Browsers	Introduction to the Internet Web Browsers Searching the Internet Configuring web browser settings	**1**
7.	PC Troubleshooting	Hardware Troubleshooting: Basic hardware components of a PC, Common hardware issues and their solutions, Maintenance and optimization of hardware Software Troubleshooting: Common software issues and their solutions, Malware and virus removal, System recovery and backups Network Troubleshooting	**4**
	PRACTICAL		**60**

1. Practical on Google Workspace
2. Practical on Word Processing
   - Bulleted and numbered list, headers and footers, page numbering.
   - Creation of tables
   - Mail Merge
3. Practical on Spreadsheet
   - Formatting of cells, rows and columns
   - Presenting data with charts
   - Working with formulae
4. Practical on Presentation software
   - Usage of text, images and animation for presentation
   - Adding slide transition, custom animation, set up show.
   - Creating graphs in presentation.
5. Practical on Internet browsing, downloading files, knowing secure browsing.
6. Practical on Email account creation, sending emails, attachments.
7. Practical on PC troubleshooting
   – Understanding PC components and PC assembling, formatting, fragmentation and installation of Operating system and configurationof different types of software.

	- Installation of different hardware devices, configuring Printers - Identifying issues with hardware devices and troubleshooting. - Network setup of two or more PCs. - System protection, antivirus and firewall

Pedagogy:	**Suggested strategies to use to accelerate the attainment of the various course outcomes**. 1. . Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use c. Video/Animation to explain various concepts. d. Collaborative, Peer, Flipped Learning etc. **1.** Ask at least three HOT (Higher-order Thinking) questions in the class, which promotes creative thinking. **2.** Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. **3.** Introduce Topics in manifold representations. **4.** Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. **5.** Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding **6.** To promote self-learning give at least one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations. **7.** Activity/ Practical Based Learning (Suggested Activities in Class) a. Real world problem solving using group discussion. E.g., designing poster for road safety etc., b. Demonstration of solution to a problem through design. 10. Demonstration of simple project and motivating the students to develop similar type of projects.
References/Readings:	1. Discovering Computers 2022: Digital Technology, Data, and Devices by Misty E. Vermaat 2. A+ Guide to IT Technical Support (MindTap Course List) by Jean Andrews 3. Shelly, G. B., &Vermaat, M. E. (2017). Microsoft Office 365 & Office 2016: Introductory. Cengage Learning. 4. Russel, C., & Hoque, M. R. (2018). Google Workspace for Dummies. John Wiley & Sons. 5. Meyers, M. (2017). CompTIA A+ Certification All-in-One Exam Guide, Ninth Edition (Exams 220-901 & 220-902). McGraw Hill Professional.
Course Outcomes:	**On completion of the course, students will be able to** 1. To create and format documents, create and format tables and

	mail 2. merge. 3. Understand the use and various functions of spreadsheets 4. To apply the knowledge of tools to create effective presentations. 5. Understand PC assembling and troubleshooting

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Programme: **Any Discipline**
Course Code: CSA-142
Title of the Course: Python Programming
Number of Credits: 1T +2P **Effective from AY**: 2023-24

Prerequisite for the Course :	None
Course Objectives :	1. To understand simple Python programs. 2. To develop Python programs with conditionals and loops. 3. To define Python functions. 4. To use Python data structures –- lists, tuples, dictionaries. 5. To deal with input/ output files in Python. 6. To understand application areas of Python.

#	Title	Content	No of Hours (75)
	THEORY		**15**
I	Introduction to Python	• Data values and types: int, float, Boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; modules and functions, function definition and use, flow of execution, parameters and arguments.	**4**
II	Program Flow Control	• Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays.	**4**
III	List, Tuple and Dictionary	• Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension.	**3**
IV	Files, Modules,	Files and exception: text files, reading and writing files, format operator; command line	**3**

	Packages	arguments, errors and exceptions, handling exceptions, modules, packages.	
V	Application Areas	• Google Translate, Sentiment Analysis: Analyse Facebook data, Image processing, Page rank.	**1**
	PRACTICAL		**60**
	1. Installation & IDE 2. Program to understand variables & different data types 3. Program to perform basic Input and Output operations 4. Program to demonstrate operations (Arithmetic, assignment, comparison) 5. Math, Strings, and Variables 6. Program to demonstrate Conditional Statements 7. Program to demonstrate setting precedence 8. Program to perform casting data types. 9. Program to demonstrate Control Structures 10. Repetition Structures- Program to demonstrate while loop and forloop 11. Program to demonstrate Break and Continue statements 12. Program to create custom Functions 13. Program to demonstrate local and global variables 14. Program to demonstrate arguments and return values 15. Program to perform list manipulation 16. Program to demonstrate Sets and its methods 17. Write a Tuple and perform sequence unpacking 18. Program to demonstrate key value pairs in dictionaries 19. Program to demonstrate recursive function 20. Program to perform File Input and Output 21. Program to demonstrate exception handling		

Pedagogy:	**Suggested strategies to use to accelerate the attainment of the various course outcomes:** 1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use 2. Video/Animation to explain various concepts. 3. Collaborative, Peer, Flipped Learning etc. 4. Ask at least three HOT (Higher-order Thinking) questions in the class, which promotes critical thinking. 5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it. 6. Introduce Topics in manifold representations. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding

	9. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations. 10. One internal practical exam will be conducted as a part of internal evaluation. 11. Practical shall be performed in the laboratory as indicated in the syllabus. 12. A softcopy of e-journal shall be maintained clearly mentioning the name of the experiment and other required information.
References:	1. John V Guttag, Introduction to Computation and Programming Using Python'', Revised and expanded Edition, MIT Press , 2013 2. Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016, 1st Edition 3. Timothy A. Budd, Exploring Python, Mc-Graw Hill Education (India) Private Ltd., 2015. 4. Kenneth A. Lambert, Fundamentals of Python: First Programs, CENGAGE Learning, 2012, New Edition 5. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, Updated for Python 3, Shroff/O'Reilly Publishers, 2016 (http://greenteapress.com/wp/thinkpython/) 6. Guido van Rossum and Fred L. Drake Jr, An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011.
Course Outcomes:	At the end of the course, the students will be able to - 1. Describe the datatypes, various Control Structures used in Python. 2. Decompose a Python program into functions and recursive functions. 3. Represent compound data using Python lists, tuples, and dictionaries. 4. Understanding use of files and packages in Python Programs.

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Name of the Programme: Any Discipline
Course Code: CSA-143
Title of the Course: Data Analytics using spreadsheets
Number of Credits: 1T + 2P **Effective from AY:** 2023-24

Pre-requisites fortheCourse:	None
Course Objectives:	• To be familiar and understand spreadsheet software. • To be familiar and learn basic and advanced functions in any spreadsheet. • To learn data analysis and data visualization with charts and pivot tables. • To be familiar with power query in spreadsheets and learning joins. • To understand data analysis tools and the functions used.

Sr. No.	Title	Content	No. of Hours
THEORY			**15 hours**
I	Introduction to	Introduction to spreadsheets,	1

	spreadsheets	understanding spreadsheet environment, cell addressing, cell references, absolute and relative cell references, named ranges, formatting using paste special, Data filters and sorting, worksheet and workbook protection	
II	Formulas and Functions	Sum, Average, Min, Max, count, IF, nested IF, using IF with AND OR formulas, COUNTIF, SUMIF, AVERAGEIF formulas, TEXT functions	2
III	Advanced Functions	Vlookup function, match function, index function, date and time functions, maths functions, financial functions	2
IV	Data Analysis	Conditional formatting, What if analysis using data table, Goal seek, scenario manager, Linear regression	2
V	Charts and Visualization	Data storytelling tips, Introduction to charts, types of charts, uses and benefits, Understanding Pivot tables, Pivot table tips and tricks	2
VI	DAX and Power Query	Power query tips, Introduction to power pivot, Apply DAX in power pivot for analysis, introduction to types of joins in power query, full outer join and inner join in power query, left outer join and right outer join in power query, Left anti join and right anti join in power query	3
VII	Dashboard reporting in spreadsheets	Understanding how to create dashboard in spreadsheets, Sales Analytical Dashboard using Data Analysis Expressions (DAX) & Visualization, creating a simplified GANTT chart with AND function	2
VIII	Data Analysis tools	ANOVA, Correlation, Covariance, regression, sampling, t-test, z-test and histograms	1
PRACTICAL			**60 hours**
1	Practical on introduction to spreadsheet using simple tabular data and formatting using paste special, absolute and relative cell references, calculating sum, average, min, max, count and percentage.		4
2	Practical using IF, NESTED IF, SUMFIF, AVERAGEIF, COUNTIF		4
3	Practical on advanced functions		8

4	Practical on conditional formatting, what if analysis using Goal seek, scenario manager and linear regression	4
5	Practical on different types of charts and pivot table with suitable examples	8
6	Practical on Power query, DAX and different types of joins with suitable data.	12
7	Creating dashboard and gantt chart in spreadsheet using suitable examples	8
8	Excel data analysis Toolpak add-in covering ANOVA, Correlation, Covariance, Descriptive Statistical analysis, random number generation analysis, rank and percentile analysis, regression analysis, T-test, Z-test, Histogram	12
Pedagogy	**Suggested strategies to use to accelerate the attainment of thevarious course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternativeeffective teaching methods could be adopted to attain the outcomes. You may use a. Video/Animation to explain various concepts. b. Collaborative, Peer, Flipped Learning etc. 2. Ask at least three HOT (Higher-order Thinking) questions in the class, whichpromotes critical thinking. 3. Adopt ProblemBased Learning (PBL), which fosters students' Analytical skills,develop design thinking skills such as the ability to design, evaluate, generalize, andanalyse information rather than simply recall it. 4. Introduce Topics in manifold representations. 5. Show the different ways to solve the same problem and encourage the students tocome up with their own creative ways to solve them. 6. Discuss how every concept can be applied to the real world - and when that's possible,it helps improve the students' understanding 7. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. Test their understanding through quizzes or presentations. 8. One assignment in the form of mini-project collecting data and using analytic tools may be given to the students.	
References/Readings	i) Kenneth N Berk, Data Analysis with Microsoft Excel ii) Microsoft Excel 2019 Data Analysis And Business	

	Modeling, Sixth Edition, Microsoft.	
Course Outcomes	**On completion of the course learners will be able to:-** 1. Understand the basics of spreadsheets and advanced functions 2. Apply data analysis and data visualization using charts and pivot tables. 3. Apply the knowledge of power query and DAX in spreadsheets. 4. Apply data analysis tools and solve simple real life data analysis applications.	

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Programme: **Any Discipline**
Course Code: CSA-144
Title of the Course: 2D Animation
Number of Credits: 03 (1T + 2P) **Effective from AY**: 2023-24

Prerequisite for the Course :	• Basic concepts of graphics design.
Course Objectives :	1. Familiarize with various approaches, methods and techniques of Animation Technology. 2. Study the basics of color theory and graphics. 3. Master traditional & digital tools to produce stills and moving images. 4. Develop expertise in life-drawing and related techniques. 5. Apply laws of human motion and psychology in 2-D characters. 6. Apply Audio and Video Production Techniques to an Animation Project.

#	Title	Content	No of Hours (75)
	THEORY		**15**
I	Introduction to Animation	• Introduction to Animation, Terms used in Animation • Types of Animation- Cel (Celluloid) Animation, 2D Animation, 3D Animation, • Motion Graphics, Stop Motion. • Animation Techniques- Hand-drawn animation, Cut-out animation, Model animation or Stop motion animation, Computer animation or computer generated imagery. • Equipment required for animation- Pen tablet, Graphic tablet, Artist glove, Ergo stand, Flex arm.	**3**
II	Principles of Animation	• Disney's twelve basic principles of animation- Squash Principles of Animation and stretch, Anticipation, Staging, Straight ahead action and	**3**

		pose to pose, Follow through and overlapping action, Slow in and slow out, Arc, Secondary action, Timing, Exaggeration, Solid drawing, Appeal string slices, immutability, string functions and methods, string module; Lists as arrays.	
III	Fundamentals of Drawing and Design	• Basic Drawing techniques, Concepts of Visualization- Perspective drawing, Illustration and Sketching techniques, Basic Shapes and Sketching Techniques, Modelling digital objects that one can find reference for in the real world, Modelling hard surface, Developing Animation Character, shading objects and techniques.	**2**
IV	Color Theory and Graphics	• Color fundamentals- primary colors, secondary colors, Tertiary Colors, Color balance, Properties of color-Hue, Reflective Value, Tints and Shades, Saturation, • Color tone – Intensity • Color swatches, Color Charts, Safety Colors & Industrial Identification - Additive • Color System (RGB) - Subtractive Color System (CMYK). • Vector and Raster graphics - Overlapping shapes, Reshaping lines and shape • outlines - Snapping (object snapping, pixel snapping, snap alignment), • Working with color, strokes and fills.	**3**
V	2D Animation	**2D Animation tools processing** 1. 2D animation software paradigms-Scripting & Storyboarding, Usage of tools for Digital Painting and vector drawings, How to develop a character and background creation, Usage of timeline and its purpose, Creation of symbols, Onion skinning. **Basics of 2D Animation** 2. Introduction to 2D Animation, 2D motion graphics, Incorporating images into 2D animation, Incorporating sound into 2D animation Exporting your work to various formats-Still image, GIF, Video, Flash.	**3**
VI	Motion Data Processing	**3.** History of motion capture, recording actions of human actors, and using that information to animate digital character models in 2D computer animation	**1**
	PRACTICAL		**60**

	List of suggested Practical: 1. Flip Book Drawing simple flip book with minimum 10 pages 2. Frame by frame animation Creating simple frame by frame animation for a short animation (maximum 20 sec with color drawings and background. 3. Tween Creating simple animation with shape, classic & motion tweening. 4. Ball animation Drawing the ball with gradient color, Creating key frames for the animation sequence, Creating stretch and squash for the ball animation, Giving tween to the sequence of ball animation. 5. Character drawing Drawing simple character with pen tool or shape tool, Preparing the character for animation, dividing each body parts into symbol and creating motion 6. Human/ Animal walk cycle Drawing cycle sheet for an animal walk cycle, Creating four different types of walk cycle (jump, run, tip toe, crawl) 7. Mini project Creating a short animation film	

Pedagogy:	**Suggested strategies to use to accelerate the attainment of the various course outcomes.** 1. Lecture method need not be only a traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes. You may use a. Video/Animation to explain various concepts. b. Collaborative, Peer, Flipped Learning etc. 2. Introduce Topics in manifold representations. 3. Show the different ways to solve the same problem and encourage the students tocome up with their own creative ways to solve them. 4. Discuss how every concept can be applied to the real world - and when that's possible,it helps improve the students' understanding 5. To promote self-learning give atleast one assignment (equivalent to 50% assignment weightage) where they can complete atleast one MOOCs (certificate or equivalent) course out of lecture hour. 6. Course delivery pattern, evaluation scheme, prerequisite shall be discussed at the beginning. 7. Lectures preferably to be conducted with the aid of multi-media projector, black board, group activities, cases, etc. 8. One internal written/practical exam would be conducted as a part of internal theory evaluation. 9. One assignment based on the course content may be given to the students to evaluate how learning of objectives was achieved.

	10. The course has a separate laboratory, where students have an opportunity to build an appreciation for the concepts being taught in this course. 11. Mini-Project may be given as part of assessment 12. Suggestive software's for 2d animation: pencil 2d, adobe flash/animate, synfig
References:	1. Mary Murphy, Beginner's Guide to Animation: Everything you need to know to get started, Watson-Guptill 2. Chris Patmore, The Complete Animation course, Barons Educational Series (New York) 3. Stephen cavalier, The world history of animation, Disney animation, Disney editions 1, 9 Sep 2011. 4. Richard Williams,The Animator's Survival Kit : A Manual of Methods, Principles and Formulas for Classical, Computer, Games, Stop Motion and Internet Animators. Expanded Edition 5. Alberto Menache, Understanding Motion Capture for Computer Animation, The Morgan Kaufmann Series in Computer Graphics Second Edition
NPTEL	1. Introduction to Computer Graphics : https://nptel.ac.in/courses/106/102/106102065/
Course Outcome:	**On completion of the course learners will be able to:-** 1. Define terminologies and aspects of computer animations. 2. Use different tools and techniques of animating graphics. 3. Implement the concepts of colors, shapes and digital imagery. 4. Design and develop 2D and 3D animations using different tools.

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Annexure III

M.Sc Integrated (Data Science) Programme Structure Semester VI onwards subjects specific to Data Science only

Semester I	Credits	Semester II	Credits
DSTC 101: Management Concepts and Organisation Behaviour	4	DSTC 108: Business Analytics	2
DSTC 102: Environmental Studies	4	DSTC 109: Microeconomics	4
DSTC 103: Probability and Statistics - I	4	DSTC 110: Linear Algebra	4
DSTC 104: Programming in Python	4	DSTC 111: Algorithms and Data structures	4
DSTC 105: Soft Skills - I (Oral Communication)	2	DSTC 112: Probability and Statistics - II	4
DSTC 106: Perspective Building Course - I (Film Appreciation)	2	DSTC 113: Soft Skills - II (Written Communication)	2
DSPC 107: Programming in Python Lab	2	DSPC 114: Algorithms and Data structures Lab	2
	22		22
Semester III	**Credits**	**Semester IV**	**Credits**
DSTC 201: Marketing Analysis	4	DSTC 208: Machine Learning	4
DSTC 202: Deductive and Inferential Mathematics	4	DSTC 209: Data Modeling and Visualization	2
DSTC 203: Macroeconomics	4	DSTC 210: Linear Programming & Optimization	4
DSTC 204: Database Management Systems	4	DSTC 211: Econometrics I	4
DSTC 205: Soft Skills - III (Interview Facing Skills and Mock Interviews)	2	DSTC 212: Soft Skills IV (Public Speaking Skills)	2
DSTC 206: Perspective Building course - II (Character Development)	2	DSTC 213: Perspective Building Course - III (Music Appreciation)	2

DSPC 207: Database Management Systems Lab	2	DSPC 214: Machine Learning Lab	2
		DSPC 215: Data Modeling and Visualization Lab	2
	22		22
Semester V	**Credits**	**Semester VI ***	**Credits**
DSTC 301: Computer Organization & Operating Systems	4	DSTC 310: Introduction to Data Science	4
DSTC 302: Programming in C++	4	DSTC 311: Big Data Framework	4
DSTC 303: Data Science Toolkit	2	DSPC 312: Introduction to Data Science Lab	2
DSTC 304: Strategic Management	4	DSPC 313: Big Data Framework Lab	2
DSTC 305: Econometrics II	4	DSTE 314: Elective 1	4
DSTC 306: Perspective Building Course - IV (Leadership)	2	DSTE 315: Elective 2	4
DSPC 307: Computer Organization & Operating Systems Lab	2	Project/Dissertation/Internship	6
DSPC 308: Programming in C++ Lab	2		
DSPC 309: Data Science Toolkit Lab	2		
	26		26
Semester VII (Discipline)	**Credits**	**Semester VIII (Discipline)**	**Credits**
DSTC 401: AI - Search Methods and Problem Solving	4	DSTC 408: Reinforcement Learning	4
DSTC 402: Research methodology and IP	4	DSTC 409: Optimization Techniques for Analytics	4
DSTC 403: Deep Learning	4	DSTC 410: MLOps at scale	4
DSTC 404: Design thinking for Data Driven App development	4	DSPC 411: Optimization Techniques for Analytics Lab	2

DSPC 405: AI- search methods and Problem Solving Lab	2	DSPC 412: MLOps at scale Lab	2
DSPC 406: Deep Learning Lab	2	DSTE 413: Elective 4	4
DSTE 407: Elective 3	4	DSTE 414: Elective 5	4
	24		24
Semester IX * (Discipline)	**Credits**	**Semester X**	**Credits**
DSTE 501: Elective 6	6		
DSTE 502: Elective 7	6		
DSTE 503: Elective 8	4		
	16	Project/Dissertation	16
* Semester includes an audited Project/Dissertation/Internship. Total Credits (5 years) = *220*			

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Programme: MSc Integrated
Course Code: DSTC 101
Title of the Course: Management Concepts and Organisational Behaviour
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48hours (48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites.	
Objective:	At the end of the course, the student should have the ability to understand managerial processes and have the competence to deal with people at work-place	
Content:	Management Science: basic concepts and its role in decision making: Planning, organizing, staffing, leading and controlling. Organization Structure and Design: Role in Individual and Interpersonal behavior at work-place Introduction to Determinants of Individual Behaviour: Perception, Personality, Attitudes, , learning, Self- Concepts ; Theories/ Models for understanding these determinants Fundamentals of Interpersonal Behaviour: Group Dynamics, Tools for Interpersonal Analysis, Fundamentals of Leadership and Motivation and their application, Theories/ Models/	8 hours 4 hours 15 hours 15 hours 6 hours

	Styles Organizational Change and Development; Models of Change; Organizational Climate and Culture; Conflict, and Negotiations. Power and Politics in Organization.	
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/ assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. Weihrich, Heinz and Harold Koontz; 'Essentials of Management: An International Perspective'; McGraw–Hill, Inc.; 10th edition, 2015 2. Robbins, Stephen and Mary Coulter; 'Fundamentals of Management'; Prentice Hall of India Pvt. Ltd.; New Delhi; 9th edition, 2018 3. Luthans, Fred; 'Organizational Behavior'; McGraw– Hill, Inc, 12th edition, 2017 4. Robbins, Stephen P; 'Essentials of Organizational Behavior'; Pearson Education India, 18th edition, 2018.	
Learning Outcomes	The participant will be able to understand people's behavior at work-place, and take managerial decisions.	

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Programme: MSc Integrated
Course Code: DSTC 102
Title of the Course: Environmental Studies
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)
Effective from AY: 2020-21
Common Prescribed Syllabus …

Programme: MSc Integrated
Course Code: DSTC 103
Title of the Course: Probability and Statistics - I
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours (48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites	
Objectives:	This course aims to introduce the basic concepts of probability theory	
Content:	**Module** 1. Experiments and sample spaces, events, algebra of events, probability axioms, conditional probability, independence of events, mutually exclusive events. Bayes theorem. 2. One dimensional random variable: discrete and continuous random variable, characteristics of distributions, cumulative distribution function, functions of one random variable. 3. Two dimensional random variable: marginal and conditional distributions, conditional expectation	12 hours 12 hours 12 hours 5 hours 7 hours

	independence. 4. Covariance and correlation. Understanding linkages, visualizing 5. Discrete distributions: Bernoulli, Binomial, Poisson	
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. William W. Hines and Douglas C. Montgomery, Probability and Statistics in Engineering and Management Science, Wiley India Pvt. Ltd., 2003 2. T.Veerarajan, Probability, Statistics and Random Processes, Tata McGraw Hill Pub. Co. Ltd., 2009	
Learning Outcomes	Upon successful completion of this course, students will have a good understanding of elementary probability ,One dimensional random variable,Two dimensional random variable,Covariance and correlation and Discrete distributions	

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Programme: MSc Integrated
Course Code: DSTC 104 **Title of the Course:** Programming in Python
Number of Credits: 4(4L-0T-0P) **Contact Hours:** 48 hours(48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites	
Objectives:	The aim of the course is to provide an exposure to solve common computing problems through programming using Python language. The course is designed with a lab component to give the student hands-on experience of the basic concepts of programming.	
Content:	Introduction to computer systems and data representation: Functional units of a Computer, Characteristics of a Computer, Data representation and Storage,Evolution of Programming Languages, Compilation and Interpretation, Structured and Procedural Programming languages	3 hours
	The Problem Solving Process: – Requirement Analysis, Algorithmic Construction, Identifying Test Cases, Desk Checking, Implementation, Testing and maintenance issues, Data verification and validation.	4 hours
	Python Programming Environment: Python overview, Structure of Python program, character Set, variable declarations and data types, Program Statements, Types of Instructions, Expression Evaluation rules, Type Conversions. Managing I/O operations	4 hours
	Selection and Iterative Constructs :Writing conditions, IF-ELSE constructs Conditional operators, SWITCH ,WHILE and FOR loops, Use of BREAK and CONTINUE statements. Nested Loops	9 hours

	Advance Data types: Lists, Tuples, Set, Dictionaries, Strings, Unicode, formatting strings, docString. Searching and sorting algorithms without using library functions. Modular Programming: Importance of User Defined Functions, Hierarchy charts, fan-in/out, cohesion and coupling and loosely coupled modules. Fan-in – Fan-out concepts.	6 hours 5 hours
	User Defined Functions: Local and Global Variables, Scoping Rules, Parameters & arguments. Function with variable arguments. Modules, packages, scope. Recursion & Recursive Functions. Recursive v/s Iterative Functions. Custom Data Types and File Management: Object of a Class and basic concept of classes & OOP, Files, Exceptions in file handling. Introduction to Packages: Python packages for plotting, mathematical computation & linear regression.	7 hours 4 hours 6 hours
Pedagogy:	Lectures/Practical/ tutorials/assignments/self-study.	
References/ Readings	1. Taneja Sheetal, Kumar Naveen , —Python Programming - A modular approach, Pearson 2017 2. Guttag John V., —Introduction to Computation and Programming using Python, MIT Press, 2nd Edition 2016. 3. Maureen Sprankle, Jim Hubbard — Problem Solving and Programming Concepts, Pearson, 9th Edition 2012	
Learning Outcomes	Upon successful completion of the course, a student will be able to: ● Analyze a given problem and develop a Python program to solve it. ● Identify test cases for a given problem. ● Understand, test, trace programs written in Python language. ● Working with python Standard Libraries,User Defined Functions,Custom Data Types and File Management and Packages	

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Programme: MSc Integrated
Course Code: DSTC 105 **Title of the Course:** Soft Skills - I (Oral Communication)
Number of Credits: 2(2L-0T-0P) **Contact Hours:** 24 hours (24L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites	
Objective:	To introduce the essentials of effective communication in different contexts	
Content:	Difference between formal and informal communication; Communication process, types, Effectiveness in communication – the Roles of Sender, Receiver and the medium; Role of culture in communication; cross cultural communication; Non Verbal Communication – aspects and	12 hours

	importance. Oral Communication: Skills required for effective interpersonal and group communication, Effective Public speaking. Noise in communication and its prevention. Barriers and Gateways in Communication;	12 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Learning Outcomes	The participant will be able to facilitate interpersonal Communication, Effectiveness in communication, Role of culture in communication, Oral Communication Skills, participate in group discussions, and to write effectively.	
References/ Readings	1. Business and Professional Communication by Kelly M. Quintanilla and Shawn T. Wahl, 2018, Sage Publications 2. Effective Business Communication by Anjanee Sethi ,Bhavna Adhikari, 2009; Tata MacGraw Hill Education, India. 3. How to be a Great Communicator in Person, On Paper, and on Podiumby Nido Qubein, 2008; Viva Books, India.	

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Programme: M.Sc Integrated
Course Code: DSTC 106
Title of the Course: Perspective Building Course-I (Film Appreciation)
Number of Credits: 2(2L-0T-0P)
Contact Hours: 24 hours (24L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course	Same as programme pre-requisites	
Objective:	To help the participants appreciate cinema (national and international) as having its own distinct language and philosophy, the way it stimulates people, and helps in making sense of the world.	
Content:	**Approaches to Films** Document, Documentary and Narratives; Thought Orientation in Films; Text, Context and Non-Text **Film and Other Art Forms** Photography and Representation; Symbolism and Metaphors; Music, Dance and Drama; Presenting Reality and Fiction **Films and our Minds** Films and Emotions; Imagination; Identifying the Audience (Spectatorship); Communication and Persuasion **Films and Morality** Lessons from Films; Authorship and Copyright; Film Criticism; Evils and Issues – Pornography, Free Will, Laws and Artistic	6 hours 6 hours 6 hours 6 hours

	License	
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Learning Outcomes	After completion of the course, students will develop the ability to 1. Appreciate films as works of art 2. Recognize the impact of films on society 3. Critique films	
References/ Readings	1. Jim Piper (2014) The Film Appreciation Book, 1st Edition; Allworth Publishers, USA 2. Satyajit Ray (2006) Speaking of Films, International Edition Penguin, India 3. Gregory Currie (1995) Image and Mind, Film, Philosophy and Cognitive Science; Cambridge University Press.	

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Programme: MScIntegrated
Course Code: DSPC 107 **Title of the Course:** Programming in Python Lab
Number of Credits: 2(0L-0T-4P) **Total Contact Hours:** 48hours(0L-0T-48P)
Effective from AY: 2020-21

Prerequisites for the course:	Python programming	
Objective:	How to write a program in python and learn the fundamentals of python programming for data science.	
Content	Suggested Lab Assignments: minimum 16 assignments and duration of carrying out each assignment 3 hrs. 1. Introduction to UNIX environment- Introduction to Fedora/Ubuntu, Basic directory and file handling commands, Editor (vi editor), man pages, installation of Python and Jupyter notebook. Programs using decision control, branch and loop control structure 1. Program to find the largest of three numbers 2. Program to print the reverse of a given number. 3. Program to check whether a given number is Armstrong or not 4. Program to print the prime numbers from 2 to n, where n is an input given by the user. 5. Program to print the patterns. Programs using List, Set, Tuple, Dictionary & Strings 6. Program to find the largest and smallest number in a list of integers (without using library function). 7. Program to sort a given integer list in ascending order(without using library function). 8. Program to print	12 hours 12 hours

	the sum and average of the elements of the list(without using library function). 8. Program to find the duplicate elements in the list(without using library function). 9. Program to reverse a given string and check whether it is palindrome (without using library function). 10. Program to read a string and count the number of vowels in it. 11. Program to concatenate two strings without using library functions 12. Program to arrange the list of names in alphabetical order. 13. Program to find the union, interaction and difference between two sets. 15. Program to take a sentence as an input from the user and compute the frequency of each letter. Make use of dictionary type to maintain the count. 14. Programs using functions & Recursion. 15. Write functions for addition, subtraction and multiplication of two matrices. Each function has two matrices as parameters and returns the result. 16. Program to print the Fibonacci series using recursion. 17. Program to find the GCD of two numbers using recursion. 18. Program to solve Tower of Hanoi 19. Programs user-defined data types & file handling 20. Program to store the item number, name, rate and quantity of 'n' items in a custom data type, where n is given as input by the user. Display the total value inventory items. 21. Program to store employee details in a Custom data type. The data should include employee ID, name, salary, and date of joining. The date of joining should be stored in a structure. The program should perform the following operations based on a menu selection a) Display the details of the employees who have more than 5 years of experience with the company. b) Increase the salaries according to the pay scale rules 1. Program to create a custom data type of Student with fields Roll No, Name, course, and Total_Marks. Read the data from the user and store them in a file. Write a function to display the Roll No, name of the student who has secured the highest marks. 23. Program to count the number of characters in a file. 2. Program to search for a particular word in a file. 3. Program to handle various file exceptions. 4. Program to implement linear regression method. 5. Program to plot graphs.	12 hours 12 hours
Pedagogy:	Lab assignments	
Learning	After completion of the course, students will be able to write	

Outcomes	Programs using decision control, branch and loop control structure and Programs user-defined data types & file handling.	

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Programme: M.Sc. Integrated
Course Code: DSTC 108
Title of the Course: Business Analytics
Number of Credits: 2(2L-0T-0P)
Contact Hours: 24 hours(24L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course	Nil	
Objective	To introduce fundamentals of financial management	
Content	Reading of Annual Report, Balance Sheet, Profit and Loss Account, Vertical Form, Cash Flow statements, Comparative statements, Common Size Statements, Profitability Ratios. Basic Accounting Standards. Directors‟ Report, Auditor‟s Report, Notes to Accounts, Understanding Annual Reports of Companies with Ratio Analyses and making basic performance decisions. Time Value of Money, Forecasting cash flows, Estimation of Project Cost, Techniques of Capital Budgeting, N. P. V., I. R. R., Discounted Payback, profitability Index.	8 hours 8 hours 8 hours
Pedagogy	Lectures/tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Learning Outcomes	1. The Students will be able to analyze financial information that facilitates long term and short term financial decisions. 2. The Students will be able to make primary basic assessment of making capital investment decisions.	
References/ Readings	1. N. Ramchandran, Ram Kumar Kakani: „How to Read A Balance Sheet‟, Tata McGraw-Hill Professional: Finance Made Easy Series,2009. 2. N. Ramchandran, Ram Kumar Kakani: „How to Read A Profit and Loss Account‟, Tata McGraw-Hill Professional: Finance Made Easy Series, 2017 3. N. Ramchandran, Ram Kumar Kakani: „How to Read A Cash Flow Statement‟, Tata McGraw-Hill Professional: Finance Made Easy Series, 2017	

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Programme: M.Sc. Integrated
Course Code: DSTC 109
Title of the Course: Microeconomics
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48hour (48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the Course:	Nil	
Objective:	Equip the students to understand consumer and firm behavior under profit and non-profit maximizing framework.	
Content:	**Module 1: Introduction and Basic Concepts** Nature and scope of micro economics – concept of equilibrium – static, dynamic and neutral equilibrium – Partial Vs. General equilibrium – role and limitations of price mechanisms in a free market economy **Module 2: Theory of Demand** Theory of Consumer Behavior- Utility, indifference curve, [income and substitution effects, Slutsky‟s theorem, compensated demand]; Revealed preference; consumer surplus; **Module 3: Theory of production and costs** Production function –short period and long period; law of variable proportions and returns to scale; Isoquants – least cost combination of inputs; Returns of factors; Economies of scale; Elasticity of substitution; Euler‟s Theorem; Cobb-Douglas, CES, VES and Translog. Cost functions, cost curves, Elasticity of supply. **Module 4: price and output determination** Demand and supply equilibrium; Cobweb theorem. Market forms – perfect and imperfect forms – equilibrium under perfect, monopoly, monopolistic, duopoly and oligopoly – importance of time element in price theory – price discrimination and measure of monopoly power – control and regulation of monopoly.	10 hours 14 hours 14 hours 10 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Reference/ Readings:	1. Varian, Hal R., *Intermediate Microeconomics*, Current Edition, W.W. Norton and Company 2. Andreu Mas-colell, Michael D. Whinston and Jerry R. Green John, *Microeconomic Theory*, Oxford University Press, Current Edition.	
Learning Outcomes:	Students will be able to understand the factors that determine consumption and production decisions under different market structures.	

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Programme: M.Sc. Integrated
Course Code: DSTC 110
Title of the Course: Linear Algebra
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48hours (48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Standard XII mathematics	

Objectives:	The aim of this course is to provide students an introduction to vectors and matrices and their use in Data Sciences.	
Content:	Linear Equations in Linear Algebra: Systems of linear equations, row reduction, and echelon forms, Vector equations, matrix equation, solution sets of linear systems, linear independence, Matrix of linear transformation. Matrix Algebra: characteristics of invertible matrices, Partitioned matrices, matrix factorizations, application to computer graphics, dimension and rank. Determinants: Properties, Cramer‟s rule, volume and linear transformations. Vector Spaces: vector spaces and subspaces, linear transformations, Bases, coordinate systems, Dimension of a vector space, rank, change of bases Eigenvalues and eigenvectors: Characteristics equation, diagonalization, eigenvectors and linear transformations, discrete dynamical systems Orthogonality: inner product, length, and orthogonality, orthogonal sets, orthogonal projections, Gram-Schmidt process, inner product spaces Symmetric matrices and quadratic forms: diagonalization of symmetric matrices, quadratic forms, constrained optimization, Singular Value Decomposition (SVD).	8 hours 4 hours 4 hours 8 hours 8 hours 8 hours 8 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings:	1. David C. Lay, Linear Algebra and its Applications, Pearson. 2. Jim DeFranza and Daniel Gagliardi, Introduction to Linear Algebra with Application, McGraw Hill Education (India) 3. Steven J. Leon, Linear Algebra with Applications 8th Edition, Pearson. 4. Gilbert Strang, Introduction to Linear Algebra 4th Ed. South Asian Edition, Wellesley-Cambridge Press	
Learning Outcomes:	Students will be able to understand Linear Equations in Linear Algebra, Matrix Algebra, Determinants, Vector Spaces, Eigenvalues and eigenvectors, Orthogonality, Symmetric matrices and quadratic forms.	

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Programme: M.Sc. Integrated
Course Code: DSTC 111
Title of the Course: Algorithms and Data Structures
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48L(48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Programming in Python	
Objectives:	The aim of the course is to introduce the fundamental concept of data structures and to emphasize the importance of data	

	structures in developing and implementing efficient algorithms. It provides an exposure to various data structures and algorithm analysis including lists, stacks, queues, trees, and various sorting and searching algorithms.	
Content:	Introduction: Three level Approach - Application/User level, Abstract/Logical level, Physical/Implementation level; Concept of Abstract Data Types (ADTs), Data Structure definition, Data type vs. data structure, Applications of data structures, Algorithms analysis and its complexity, Best case, worst case , and Average case performance, time-space tradeoff, Asymptotic Analysis, Big-O notation. Linear Data Structures: Array and its application: Polynomials, Sparse matrices, String-pattern Matching. Linked Lists, Doubly linked list, Circular linked list, Stack and Queues. Nonlinear Data Structures: Trees: Binary tree representation, Binary Search Trees, AVL Trees, M-way Search Trees, B-trees. B tree algorithms, Heap Structures. Graphs: Graph representations; Graph Traversals Complexity of Searching & Sorting algorithms: Bubble sort, Quick sort, Selection sort, Insertion sort, Merge sort and Heap sort. An Empirical Comparison of Sorting Algorithms, Lower bounds for Sorting. Linear search, binary search. Dynamic programming and Greedy algorithms: Assembly line scheduling, Matrix-chain multiplication; Prim"s Algorithm, Kruskal"s Algorithm	4 hours 4 hours 10 hours 10 hours 2 hours 12 hours 6 hours
Pedagogy:	lectures/Practical/ tutorials/assignments/self-study	
References/ Readings:	1. Horowitz, Ellis, Sartaj Sahni, and Susan Anderson-Freed. Fundamentals of data structures in C. WH Freeman & Co., 1992. 2. Benjamin Baka, Basant Agarwal, "Hands on Data Structure and Algorithms with Python", Second Edition, O"Reilly, 2018 3. Cormen Thomas, L. Charles, R. Ronald, S. Clifford, "Introduction to Algorithms", Second Edition,EEE, PHI. 4. Allen, Weiss Mark. Data structures and algorithm analysis in C. Pearson Education India, 2011. 5. Algorithms, by Dasgupta, Papadimitriou, and Vazirani, McGraw-Hill.	
Learning Outcomes:	Upon successful completion of the course, a student will be able to ● Implement common data structures such as lists, stacks, queues, graphs, and binary trees for solving programming problems. ● Identify and use appropriate data structures in the context of a solution to a given problem.	

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Programme: M.Sc Integrated
Course Code: DSTC 112 **Title of the Course:** Probability & Statistics - II
Number of Credits: 4(4L-0T-0P) **Contact Hours:** 48 hours(48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Nil	
Objectives:	This course aims to introduce the basic concepts of probability theory and statistical analysis. Students will get exposure to fundamental theory of distribution of random variables, the basic theory and techniques of parameter estimation and tests of hypotheses.	
Content:	**Module 1:** Continuous distributions: Uniform, exponential, normal, standard normal, T-distribution, Chi-Square and F distribution **Module 2:** Sampling distributions, Parameter Estimation of mean and proportion. **Module 3:** Hypothesis tests about mean and proportion, Chi square tests, analysis of variance, least squares curve fitting, the coefficient of Determination, Confidence Intervals **Module 4:** Non parametric tests: sign test, Rank test, Median test	12 hours 12 hours 12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. T.Veerarajan, Probability, Statistics and Random Processes, Tata McGraw Hill Pub. Co. Ltd. 2. P.S.Mann, Introductory Statistics, Wiley Student edition	
Learning Outcomes:	Upon successful completion of this course, students will be able to: ● Apply the central limit theorem to sampling distribution ● Perform and analyze hypothesis testing	

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Programme: M.Sc Integrated
Course Code: DSTC 113 **Title of the Course:** Soft Skills - II (Written Communication)
Number of Credits: 2(2L-0T-0P) **Contact Hours:** 24 hours(24L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Nil	
Objective:	To introduce the essentials of effective communication in different contexts	
Content:	Written Communication: Fundamentals of effective writing; different forms of written communication; report writing, creative writing; Structure and content of various types of reports; Creativity in Communication Competitive versus collaborative communication, types of	12 hours 12 hours

	negotiation, barriers in effective negotiation, interests versus positions in negotiation;	
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Learning Outcomes:	The participant will be able to facilitate interpersonal Communication, participate in group discussions, and to write effectively.	
References/ Readings:	1. Business and Professional Communication by Kelly M. Quintanilla and Shawn T. Wahl, latest Edition, Sage Publications 2. Effective Business Communication by Anjanee Sethi ,Bhavna Adhikari, Tata MacGraw Hill Education, India. 3. How to be a Great Communicator in Person, On Paper, and on Podiumby Nido Qubein, Viva Books, India.	

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Programme: M.Sc Integrated
Course Code: DSPC 114
Title of the Course: Algorithms and Data Structures Lab
Number of Credits: 2(0L-0T-4P)
Contact Hours: 48 hours(0L-0T-48P)
Effective from AY: 2020-21

Prerequisites for the course:	Python programming	
Objective:	Aimed at teaching implementation of data structure using python	
Content:	**Suggested Lab Assignments: minimum of 16 assignments with duration of 3 hrs for each assignment** Object-Oriented Design Goals, Object-Oriented Design Principles. 1. The programming assignment should introduce and enforce the concepts of encapsulation, polymorphism and Inheritance. ADT Specifications and Implementation of following basic data structures 2. Singly Linked Linear Lists 3. Singly Linked Circular Lists 4. Doubly Linked Linear Lists 5. Doubly Linked circular Lists 6. Stack using linked list 7. Queue using linked list 8. ADT Specifications and Implementation of following non-linear data structures 8. Binary Trees 9. Binary Search Trees 10. AVL Trees 11. B-Trees and its variants	

	12. Application of stack 13. Program to convert the given infix expression to postfix expression using stack. 13. Program to evaluate a postfix expression using stack. 14. Program to traverse a binary tree in the following way: Pre-order, In-order, Post-order 15. Applications of Binary Trees 16. Write a program to implement Huffman encoding using Binary tree. 17. Write a program to create a binary tree for the given infix expression. Applications of AVL Trees 18. Write a program that reads a list of names and telephone number from a text file and inserts them into an AVL tree. Write a function to allow the user to search the tree. Searching and sorting 19. Program to implement Binary search technique using Iterative method and Recursive methods. 20. Programs to implement following sorting algorithm- Bubble sort, Selection sort, Insertion sort, Quicksort, Merge sort and Heap sort 21. Implementation of Dynamic programming 22. Assembly line scheduling 23. Matrix-chain multiplication 24. Implementation of Greedy algorithms 25. Prim‟s Algorithm 26. Kruskal‟s Algorithm	
Pedagogy:	Lab assignments	
Learning Outcomes	Students should be able to implement data structure using python.	

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Programme: M.Sc Integrated
Course Code: DSTC 201
Title of the Course: Marketing Analysis
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme prerequisites	
Objective:	At the end of the course, the students would have competence in understanding and using Marketing Frameworks, Theories and analytical tools for analysing and decision making in the area of Marketing.	
Content:	Role of Marketing, Core Concepts of Needs, Wants and Demands, Marketing Orientation of Companies. Strategic Planning and Marketing Management Process. External Environment including Customers and Suppliers.	12 hours

	Consumer Behaviour and Consumer markets, Theories of Consumption Behaviour, Buying Process and decision making process. Types of Buying behavior. Organisational Buying behavior, Industrial Market, Reseller Markets, Government Markets. Marketing Information Systems, concepts and components, Market Measurement and Forecasting techniques, Demand Estimation, Segmentation, Targeting and Positioning, Types of segmentation, Basis for Segmentation. Marketing Plan, Process and evaluation, New Product Development Process, Product Life Cycle concept, different strategies of different stages of PLC, Strategies for Leaders, Followers, Challengers and Nichers. Product Concept and hierarchy, Product decesions, Branding and Packaging Decisions, Pricing and setting of Price, Methods of Pricing and initiating responses to Price Cuts. Channels of Distribution, Role and Types of Channel, Distribution Channel design and management and modification. Retailing and Wholesaling. Advertising and Integrated Marketing Communication. Advertising decisions, Media decisions, Sales promotion concept and designing. Sales Management and Personal Selling. Digital Marketing and Social Media Marketing. Marketing Plan, Audits and Control of Marketing Decisions. Annual Plan Control, Profitability Control, Efficiency Control and Strategic Control.	6 hours 6 hours 6 hours 6 hours 6 hours 6 hours
Pedagogy:	Pedagogy includes interactive sessions involving lectures, case studies, presentations, debates and field based work.	
Learning Outcomes	At the end of the course, the students would have competence in understanding and using Marketing Frameworks, Theories and analytical tools for analysing and decision making in the area of Marketing.	
References/ Readings	1. Majarao, Simon; 'The Essence of Marketing'; Prentice Hall of India Limited; New Delhi; Latest edition. 2. Brand Equity and News Items of Economic Times, Articles from Popular Business Periodicals, etc. 3. Kotler, Philip., Keller Kevin., Koshy Abraham., and Jha Mithileshawar; 'Marketing Management: A South Asian Perspective'; Pearson Education India, Latest edition. 4. Ramaswami., Namkumari; Marketing Management, McMilan IndiaLtd. New Delhi. Latest Edition 5. Baines, Paul; Chris, Fill; Kelly, Page; Sinha, Piyush Kumar:	

	Marketing Management; Oxford Press, India. Latest Edition.	

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Programme: M.Sc. Integrated
Course Code: DSTC 202
Title of the Course: Deductive and Inferential Mathematics
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the Course:	XII Mathematics	
Objective:	On completion of this course, the learner should be able to successfully explore, conjecture and reason logically to arrive at a solution to a given problem using appropriate mathematical methods and will learn to estimate the impact of a policy/decision in the presence of uncertainty	
Content:	**unit -1 :Mathematical Logic-**An open sentence, a closed sentence, Definition of proposition or a Statement. Strong emphasis on the Distinction between Inclusive OR and Exclusive OR. -In Logic, Mathematics and in Computer Science theory, **only inclusive OR** is used unless otherwise stated.-Logical Connectives - **NOT(negation** ¬ ~)-**AND (conjunction** ⋀**)**, **OR (disjunction** ⋁**), IF…THEN**(one way implication ⇒ →) and **IF, AND ONLY IF** (two ways implication ⇔ ↔) Truth tables for each one of the above.-Compound Proposition.Technique of determining the Truth value of a compound proposition using the truth tables and without using the truth tables.-Equivalent statements (≡.). Examples and important logical results. De Morgan Laws for negation.Converse, Inverse and Contrapositive of conditional proposition. Tautology and Contradiction. Definition and Examples.Functionally complete set of connectives.Other Connectives such as XOR($Exclusive\ OR :\ \nabla$ **),** NAND (Not and : ↑**)** and NOR (Not or :↓)Both NAND and NOR singly form a functionally complete set of connectives by deriving that all other connectives can be expressed exclusively in terms of only NAND or NOR. How the proof by contradiction works : $p \Rightarrow q \ \equiv \sim q \ \Rightarrow \sim p$ -Meaning of some as at least one. **unit 2-Well-formed-formulae** . Equivalence of formulae. Various laws governing the well-formed formulae. Duality law. Normal Form. Disjunctive normal form, conjunctive normal form, Principal disjunctive normal form, Principal conjunctive normal form. Propositional Calculus. Predicate Calculus. Predicate Formula.	5 hours 5 hours

	Equivalence of Predicate Formulae. Inference Theory. **unit -3 :SET THEORY:** (Quick revision and recapturing) Definition. Different ways of expressing a set such as Set Builder Method, Venn Diagram, Roster Method. Equality of two sets. Different types of sets. Empty set, Universal set, Finite Sets, Infinite Sets, Universal Sets etc. Proper emphasis on explaining the Universal Set. Set Operations such as Union, Intersection, Complementation, Set Theoretical Difference. Their properties. De Morgan Laws for the complementation. Comparison of sets through subset, super set. Properties. Set Identities. Sets of Natural Numbers, Integers, Rational Numbers, Real Numbers and relation among them. Mathematical Induction. Functions: Relation on sets. Definition of a function as a relation. Domain, Co-domain and the range of a function. One-to-one (injective), Onto (surjective) One-to-one and Onto (bijective) functions. Composition of functions. Various properties of composition of functions with composition as an operator on the set of all functions with common domain and co-domain. Inverse of a function. Condition for existence of an inverse of a function. Uniqueness of the inverse. Properties of inverses of functions. **unit 4 :- Counting Principle**. **Principle of Inclusion and Exclusion:** Counting the number of elements in the union of finitely many finite sets in terms of the number of the elements of the individual sets and the number of elements of possible intersections of the sets involved. Principle of inclusion and exclusion for finitely many finite sets.	5 hours
	unit - 5:- Inferential Statistics Introduction to Probability Theory using Kolmogorov Technique: Definition of an experiment. Outcomes of an experiment. Outcomes which are not **decomposable**. Sample space as the set of all **non-decomposable** outcomes of an experiment. Event as any subset of the sample space of an experiment under consideration. Probability of an event. Laws of probability. Exclusive events and Independent events. Conditional Probability. Extension of conditional probability. Revision of Permutations and Combinations. Stress on solving problems in obtaining permutations and combinations when the elements are repeated.	5 hours

	(For the topic of combination of repeated elements, refer Discrete Mathematics by Kenneth Rosen) Idea of variations. Standard deviation as the root mean square deviation with respect to the mean. Mathematical Expectation and Expected Values.	8 hours
	Random Variables: Idea of Distribution of a Function. Some standard Distributions such as Binomial., Normal, Poisson and Exponential. Their standard properties with the stress on Normal Distribution. Use of Normal Distribution Table to solve problems. **unit - 6 :- Sampling Techniques** Testing Statistical Hypothesis. Parameters are statistical constants such as Mean, Variance etc. In sampling techniques, **Statistics** are the parameters estimated (of the population) from the samples drawn from the population. Clear distinction to be made between the **parameters** and **statistics.**	5 hours
	Standard Error is the standard deviation of the sampling distribution of the statistics. Null Hypothesis and Alternate Hypothesis. Critical Region and Intervals of confidence, the Level of Significance. Errors in Sampling: Type I and Type II errors. One tailed and two tailed tests. **unit - 7 :- Tests of Significance for the large Samples:**	5 hours
	(i) Testing Significance of single proportion (ii) Testing Significance of for the difference of proportions of two large samples (ii) Test of Significance for single Mean (iv) Test of Significance for Difference of Means of two large samples Tests of Significance for the small Samples (using Student t-test)	5 hours
	Concept of t-distribution. Degree of freedom. **unit -8 :-Tests of Significance of Large Samples:** (i)Testing Significance of single proportion (ii) Testing Significance of for the difference of proportions of two small samples (ii) Test of Significance for single Mean (iv) Test of Significance for Difference of Means of two small samples. **unit-9 :- Resampling Techniques:** Resampling. Need for carrying out resampling. Advantages. Some selected methods of resampling: (a) Bootstrapping and Normal Resampling, (b) Permutation Resampling (c) Cross Validation	5 hours
Pedagogy	Assignments/Presentations	

Reference/ Readings	1. A textbook of Discrete Mathematics by Dr. S. K. Sarkar S, Chand & Company, New Delhi. 2. Discrete Mathematics and its Applications by Kenneth Rosen, Tata McGraw Hill. 3. Discrete Mathematics for Computer Scientists by John Truss, Addison Wesley (Pearson Education). 4. Discrete Mathematics and Graph Theory by Purna Chandra Biswal, Prentice Hall of India. 5. Statistics for Management by Richard Levin and David Rubin, Prentice Hall of India. 6. Statistics for Business and Economics by Anderson, Sweeney and Williams, Thomson South Western. 7. Statistics for Management by Anand Sharma, Himalaya Publishing House, Mumbai. 8. Engineering Mathematics Volume II by Kandasamy, Tilagavathy and Gunavanthy S. Chand & Company, New Delhi.	
Learning Outcomes	1. Learner will understand how to explore, conjecture and reason logically to model/arrive at a solution to a given problem 2. Learner will be able to use a variety of mathematical methods effectively to solve problems 3. Learner will learn decision making in the presence of uncertainty and will learn to quantify the uncertainty in estimation /the decision	

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Programme: M.Sc. Integrated
Course Code: DSTC 203
Title of the Course: Macroeconomics
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites	
Objectives:	Provide a basic understanding of how aggregate variables like national income, aggregate prices, employment, and exchange rates get determined by interaction of public policy and individual agents	
Content:	**Module 1: Introduction to Macroeconomics : What is it about.** Aggregate Income and its Dimensions, Measuring output, Real and Nominal Incomes, Savings, Balance of Payments and the Money supply. The sources and Use of Savings, The Balance of Payments, The Money supply **Module 2: Consumption & Investment.** Keynes on Consumption, Consumption Smoothing, Temporary and Permanent Shocks, Stochastic Income Expectations, Effect of Interest Rates, Aggregating Across Individuals, Savings and	10 hours

	Portfolio Choice, Profit Maximization and the Optimal Capital Stock, Adjustment Costs and Investment Decisions, Financial Structure and Investment, Residential and Inventory Investment, Irreversibility and Investment, Investment in Developing Countries, Investment in India **Module 3: Trade Balance and Exchange rates, Demand for Money, Labour market.** The Real Exchange Rate, Other Approaches to the Trade Balance, Exchange Rates and Assets, Purchasing Power Parity, Choice of Exchange Rate Regimes, Money, Bonds, and Private Wealth, Nominal and Real Interest Rates, Financial Assets and the Budget Constraint, Money as a store of value, Seigniorage, Profit Maximization and Labour Demand, Utility and Labour Supply, Aggregate Supply with / without Money illusion, Introducing Unemployment, Cyclical Unemployment and the Output Gap, The Static Phillips Curve, The Dynamic Phillips Curve **Module 4: IS-LM model :** Walras Law, Nominal Versus Real Rate of Interest, The IS Curve, The LM Curve, IS and LM - Fiscal and Monetary Policy, IS - LM in India, Ricardian Equivalence– determination of equilibrium income and interest rates – fiscal and monetary policy.	14 hours 14 hours 10 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings	*Essential Reading* 1. Macroeconomics by Errol D'Souza, Pearson Education, Delhi Second Edition 2012 *Additional Reading* 2. Macroeconomics: Theories and Policies, by Richard T. Froyen, Pearson Education, 10th Edition or later, 2013	
Learning Outcomes	Understand the factors that determine consumption and production decisions under different market structures.	

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Programme: M.Sc. Integrated
Course Code: DSTC 204
Title of the Course: Database Management Systems
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Operating Systems, Data and File Structures, A programming language	
Objectives:	To Provide students with theoretical knowledge and practical skills to effectively design , implement and query a relational	

	database application	
Content:	**Basic concepts** Database & Database Users, Characteristics of the Database Approach, Database Systems, Concepts & Architecture Data Models, Schemes & Instances, DBMS Architecture of Data Independence, Data Base languages & Interfaces **Relational Model** The Relational Model, Overview of Design Process, Data Modelling using the Entity – Relationship approach , Structure of Relational Databases, Relational Algebra **SQL-A Relational Database Language Data** Data Definition in SQL, structure of SQL queries, Set operations, aggregate functions, Nested Subqueries, Modification of the database, Views Specifying Integrity Constraints & Indexes in SQL. A Relational Database Management System Relational DataBase Design Features of a Good Relational design, Function Dependencies & Normalization , Normal forms based on primary keys (1NF, 2NF, 3NF, BCNF) Covers of Functional Dependencies, Canonical covers. Loss less join and Dependency preserving decomposition algorithms. **Transactions** Concept and states of transactions, Properties of Transactions, issues in Concurrent execution of transactions, concept of serializability, Recovery techniques	6 hours 10 hours 12 hours 10 hours 10 hours
Pedagogy:	Lectures/ tutorials/assignments/class presentations and debates/peer reviews/workshops/self-study	
References/Readings	1. Korth, Silberchartz, " Database System Concepts" McGrawhill Publication. 2. Elmasri and Navathe, " Fundamentals of Database Systems", Addison Wesley, New Delhi. 3. Database Management Systems –R. Ramakrishnan, J.Gehrke – T.McGraw Hill 4. Desai B., " An Introduction to Database Concepts", Galgotia Publications, New Delhi. 5. Rob,Coronel, "Database Systems (Design, Implementation	

	and Management)" 6. Date C. J. , " An Introduction to Database Systems", Publication House, New Delhi.	
Learning Outcomes	1. Understand and evaluate the role of database management systems in information technology applications within organizations; 2. Recognise and use logical design methods and tools for databases; 3. Implement a database solution to an information technology problem; 4. Understand the SQL data definition and SQL query languages; 5. Develop sophisticated queries to extract information from databases. 6. Understand how the database manages and recovers from concurrent and multiple transactions	

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Programme: M.Sc. Integrated
Course Code: DSTC 205
Title of the Course: Soft Skills - III (Interview Facing Skills and Mock Interviews)
Number of Credits: 2(2L-0T-0P)
Contact Hours: 24 hours(24L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme prerequisites	
Objective:	To introduce the basics of writing resumes and preparatory skills required to face interviews	
Content:	Fundamentals of Resume Writing, Writing effective Cover letters and emails to organizations. Group Discussions – different types, Different types of interviews and basic competencies required in facing interviews. Preparation required prior to facing an interview – industry and firm analysis. SWOT analysis; Frequently asked questions in interviews Mock interviews to assess conceptual clarity, domain knowledge, soft skills, and perspectives held, etc.	4 hours 4 hours 4 hours 12 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ selfstudy/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning	
Learning	An ability to face interviews	

Outcomes		
References/Readings	1.Prasad, Hari Mohan,How to prepare for Group Discussion and Interview, Tata McGraw Hill, Latest Edition 2. Patnaik, Priyadarshini, Group Discussion and Interview Skills, Cambridge University Press, Latest Edition	

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Programme: M.Sc. Integrated
Course Code: DSTC 206
Title of the Course: Perspective Building course - II (Character Development)
Number of Credits: 2(2L-0T-0P)
Contact Hours: 24 hours(24L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course	Same as programme prerequisites	
Objective:	Have a holistic outlook towards life, to face and solve the challenges in their day to day life by strengthening their Emotional intelligence. Using their Talents to develop their personality and using this to bring happiness in their life and career. Changing their behaviour by becoming passionate and positively energized in doing their studies, job and life.Help them to become productive, proactive and persevere in all that they do in their lives and to become good Managers and professionals	
Content:	Talents you are born with, using Talents to enhance your personality and succeed. Using the E – Enthusiasm. Using this to build your passion and positive Energy. E - Efforts – Persevere and reach your goals. In Efficiency - un Productive and not planned or not Pro active . Dealing with their negative Self Awareness, Self Regulation, Motivation, Empathy and Social Skill. E - Positive Emotional Intelligence to reach your goals. Negative Attitude with regards to oneself, family and Friends. Positive Attitude	4 hours 4 hours 4 hours 4 hours 4 hours 4 hours
Pedagogy:	Use of Presentations, Activities, Discussions	
Learning Outcomes	Students will be able to ● To face and solve the challenges in their day to day life by strengthening their Emotional intelligence. ● Using their Talents to develop their personality and using this to bring happiness in their life and career. ● Change their behaviour by becoming passionate and positively energized in doing their studies, job and life.	
References/Readings	1. Rich Dad Poor Dad – Robert Kiyosaki . Warner books 2. Think and grow Rich – Napoleon Hill. The Ralston Society 3. The Power of now- Eckhart Tolle. Namaste Publishing	

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Std. Com.X AC-6
15 & 22.05.2023

Programme: M.Sc. Integrated
Course Code: DSPC 207 **Title of the Course:** Database Management Systems (Lab)
Number of Credits: 2(0L-0T-4P) **Contact Hours:** 48 hours(0L-0T-48P)
Effective from AY: 2020-21

Prerequisites for the course:	Database management system concepts and programming	
Objective:	The objective of the course is to present an introduction to database management systems, with an emphasis on how to organize, maintain and retrieve - efficiently, and effectively - information from a DBMS.	
Content:	**Suggested Lab Assignments:** **A. Installation of DBMS Software** **B. Data Definition Language(DDL) Statements** 1. Creating tables, with or without constraints. 2. Understanding Data types. 3. Creating User Defined data Types 4. Altering the structure of the table 5. Dropping tables. 6. CreatingSequences **C. Query in Data Dictionary** 1. To view the structure of the table created by the user. 2. To view user information. 3. To view integrity constraints. **D. Data Manipulation Language(DML) Statements** 1. Inserting Data into the table. 2. Updating Data into the table. 3. Deleting Data from the table. **E. Simple SQL statements** 1. Displaying all the attributes and tuples from the table. 2. Displaying selected attributes/tuples from the table. 3. Using Logical and comparison operators. 4. Ordering data **F. Complex SQL Statements** 1. Using aggregate functions (using Group by and having clauses). 2. Creating SQL Aliases and View. 3. Joins and Nested queries. 4. Creating temporary tables in SQL statements	

	G. Transaction Control Language(TCL) statements **H. Embedded SQL statements** 1. Procedures with and without cursors	
Pedagogy:	Lab Assignments	
Learning Outcomes	Upon successful completion of this course, students should be able to: • Describe the fundamental elements of relational database management systems • Explain the basic concepts of relational data model, entity-relationship model, relational database design, relational algebra and SQL. • Design ER-models to represent simple database application scenarios • Convert the ER-model to relational tables, populate relational database and formulate SQL queries on data. • Improve the database design by normalization.	

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Programme: M.Sc. Integrated
Course Code: DSTC 208
Title of the Course: Machine Learning
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the course:	Familiarity with linear algebra, statistics & probability theory	
Objectives:	This course provides students with an in-depth introduction to three main areas of Machine Learning: supervised and unsupervised and reinforcement learning.this course will cover some of the main models and algorithms for regression, classification, clustering and Markov decision processes. Topics will include linear and logistic regression, regularisation, SVMs and kernel methods, ANNs, clustering, and dimensionality reduction ,sequential learning Like HMM and deep learning CNN and RNN	
Content:	**1. Introduction:** well posed learning problem, designing a learning system, perspectives and issues in machine learning-types of learning - supervised, unsupervised and reinforcement learning	3 hours
	2. Concept learning: concept learning task , notation, inductive learning hypothesis, concept learning as search, version space and candidate elimination algorithm, decision tree, random forest.	5 hours
	3. Linear regression: logistic regression - Support vector machine kernel, Model selection and feature selection-Ensemble methods: Bagging, boosting, Evaluating and debugging learning algorithms.	5 hours

	4. Continuous Latent Variables: Principal Component Analysis, Maximum variance formulation, Minimum error formulation, Applications of PCA, PCA for high-dimensional data.	5 hours
	5. Neural Networks: -Feed-forward Network, Functions, perceptron, -Weight-space symmetries, Network Training, Parameter optimization, Local quadratic approximation, Use of gradient information, Gradient descent optimization, Error Backpropagation, Evaluation of error-function derivatives, Efficiency of backpropagation.	10 hours
	6. Deep learning: Deep Feedforward Networks, Gradient-Based Learning, Hidden Units, -Architecture Design, CNN and RNN (simple RNN and LSTM).	5 hours
	7. Unsupervised learning; Clustering, K-means, EM.Mixture of Gaussians.	5 hours
	8. Sequential Data: Markov Models, Hidden Markov Models, Maximum likelihood for the HMM, The forward-backward algorithm, The sum-product algorithm for the HMM, Scaling factors, -The Viterbi algorithm.	5 hours
	9. Reinforcement learning: introduction- learning task-Q learning, non deterministic rewards and actions-temporal difference learning.	5 hours
Pedagogy:	lectures/ tutorials/assignments/self-study/lab assignment/ project work	
References/ Readings	Main Reading :- 1. James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013. 2. Alpaydin, Ethem. Introduction to machine learning. MIT press, 2020. 3. Hart, Peter E., David G. Stork, and Richard O. Duda. Pattern classification. Hoboken: Wiley, 2000. 4. Flach, Peter. Machine learning: the art and science of algorithms that make sense of data. Cambridge University Press, 2012. 5. Bishop, Christopher M. "Pattern recognition and machine learning: springer New York." (2006). 6. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016. 7. Mitchell, Tom, and Machine Learning McGraw-Hill. "Edition." (1997). 8. machine learning and AI online google course by cassie	

	kozyrkov	
Learning Outcomes	By the end of the course, students will be able to: ▪ develop an appreciation for what is involved in learning from data. ▪ understand a wide variety of learning algorithms. ▪ understand how to apply a variety of learning algorithms to data. ▪ understand how to perform evaluation of learning algorithms and model selection. ▪ Equips them with a general understanding of deep learning.	

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Programme: M.Sc. Integrated
Course Code: DSTC 209 **Title of the Course:** Data modeling and visualization
Number of Credits: 4(4L-0T-0P) **Contact Hours:** 48 hours(48L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the course:	A basic understanding of data management concepts and knowledge of relationship database tables	
Objective:	1. Learn to understand practical techniques to analyze and model data as part of the overall data management lifecycle 2. to expose students to visual representation methods and techniques that increase the understanding of complex data. 3. Learn to design good design practices for visualization, tools for visualization of data from a variety of fields and visualization software like Processing, GapMinder and Tableau.	
Content:	Data modeling fundamentals : The purpose and role of data modelling- basic data modeling concepts and terminology, data modeling building blocks- hierarchies for the entities, data model constraints for your attributes: specify cross-entity dependencies through strong and weak entities -summary of real-world entity and attributes complexities real-world complexities to relationships why relationship cardinality and complexities matter - build real-world complexities into data model relationships-define the maximum cardinality of a relationship -define the minimum cardinality of relationship -use crow's foot notation for minimum and maximum cardinality -summary of cardinality and complex relationships. move across the different levels of data model: Harmonize	9 hours 4 hours 6 hours 4 hours 4 hours 4 hours

	different levels of data model - brief look a relational database normalization -forward-engineering your conceptual data model - more data model forward engineering - reverse engineer a physical model back into conceptual model - summary - how to work with different levels of data model Software for data modeling : The importance of data modeling software -build a data model with a drawing program - build model with data modeling software tool Visualization : Right graph for right data, Components of a Data Visualisation-Different Types of Graphs, Deadly Sins of Graph Design,How to Avoid Being Mislead with GraphsSession The Value of Visualization Sessions - Effective Use of Form and Space Fundamentals of Graphs - Integrity in Visualization-Visual Perception and Quantitative Communication Reading - Effective Use of Form and Space Detailed Design of Tables and Graphs Readings: Summary at a Glance: Table Design Summary at a Glance: Graph Design Session Additional Constructs and Multivariate Analysis- Escaping 2 Dimensions: Animated Scatter-Plots-Introduction to Information Design summary -data modelling and visualization	4 hours 3 hours 4 hours 4 hours 2 hours
Pedagogy:	lab assignments/ theory assignments /mini case study/capstone project	
References/ Readings	1. Hoberman, Steve. Data modeling made simple: a practical guide for business and IT professionals. Technics Publications, 2015. 2. Edward Tufte, The Visual Display of Quantitative Information 3. Tufte, Edward R., Nora Hillman Goeler, and Richard Benson. Envisioning information. Vol. 2. Cheshire, CT: Graphics press, 1990. 4. Fry, Ben. Visualizing data: Exploring and explaining data with the processing environment. " O'Reilly Media, Inc.", 2008.	
Learning Outcomes	1. Learning to build data model by carrying out mini project 2. The use of a data visualization software for investigating a substantial data-set .	

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Programme: M.Sc. Integrated
Course Code: DSTC 210 **Title of the Course:** Linear Programming & Optimization
Number of Credits: 4(4L-0T-0P) **Contact Hours:** 48 hours(48L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the course:	Linear Algebra	
Objective:	To provide students the theoretical knowledge to effectively formulate linear programming problem and optimization.	
Content:	**Introduction to Operational Research (OR):** Origin & Development, Different Phases of OR study, Methodology of OR, Scope and Limitations of OR, Applications of OR. **Linear Programming:** Linearly independent / dependent vectors, Basis, Convex sets, Extreme points. Graphical method. **Simplex method and its variant:** Simplex method, Artificial variable techniques- Two Phase Method; M-Charnes Method, Special cases in LPP. **Duality:** Definition of the dual problem, Primal-dual relationships, Economic Interpretation of Duality, Dual simplex Method. **Sensitivity analysis:** Changes in cost and resource vector **Special Cases of Optimization Problems:** Assignment Problems, Transportation Problem	4 hours 10 hours 12 hours 12 hours 4 hours 6 hours
Pedagogy:	Lectures/ tutorials/assignments/class presentations and debates/peer reviews/workshops/self-study	
References/ Readings	1. G. Hadley: Linear Programming. Narosa, 2002 (reprint). 2. A. Ravindran, D. T. Phillips and James J. Solberg: Operations Research-Principles and Practice, John Wiley & Sons, 2005. 3. Hamdy A. Taha: Operations Research-An Introduction, Prentice Hall, 8th Edition, 2008. 4. F.S. Hillier. G.J. Lieberman: Introduction to Operations Research- Concepts and Cases, 9th Edition, Tata McGraw Hill. 2010.	
Learning Outcomes	1. Understand applications of OR 2. Formulation of Linear programming problem 3. Understanding primal dual relationship	

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Programme: M.Sc. Integrated
Course Code: DSTC 211 **Title of the Course:** Econometrics I
Number of Credits: 4(4L-0T-0P) **Contact Hours:** 48(48L-0T-0P)

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15 & 22.05.2023

Effective from AY: 2021-22

Prerequisites for the Course:	Understanding of probability and statistics	
Objective:	Equip the students to make sense of empirical data using multiple variables and analytical approaches	
Content:	**Module 1:** The Nature of Econometrics and Economic; Regression Analysis with Cross-Sectional Data; The Simple Regression Model	12 hours
	Module 2: Multiple Regression Analysis: Estimation and Inference; OLS Asymptotics	12 hours
	Module 3: Multiple Regression Analysis with Qualitative Information: Binary (or Dummy) Variables; Heteroskedasticity; Other Specification and Data Issues	12 hours
	Module 4: Regression Analysis with Time Series: Basic Regression Analysis with Time Series Data; Serial Correlation and Heteroskedasticity in Time Series Regressions	12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Reference/ Readings:	Essential Reading Wooldridge, J. (2018). *Introductory econometrics: A modern approach* (7th edition). Cengage Learning. Additional Reading Angrist, J. D., & Pischke, J.-S. (2009). Mostly harmless econometrics: An empiricist's companion. Princeton University Press. Heiss, F. (2020). *Using R for introductory econometrics*. https://elopage.com/s/florian-heiss/using-r-for-introductory-econometrics	
Learning Outcomes:	Understand causality among variables and draw inferences based on data relations	

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Programme: M.Sc. Integrated
Course Code: DSTC 212
Title of the Course: Soft Skills IV (Public Speaking Skills)
Number of Credits: 2(2L-0T-0P)
Contact Hours: 24 hours(24L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the course:	Nil	
Objective:	To provide students with an ability to address larger audien!1+1ces confidently.	
Content:	**Preparation for delivering a speech: S**election of topic, Relevant data collection, Draft preparation etc. **Listening to famous speeches.:** The faculty will choose some famous public speeches and make them listen to the students. The students then will have to analyse them. **Making speeches:** The students will be asked to make public speeches by implementing the learning.	8 hours 8 hours 8 hours
Pedagogy:	Lectures/ tutorials/assignments/class presentations/Role plays and debates/peer reviews/workshops/self-study	
References/ Readings	1. Dale Carnegie with J. Berg Eisenwen: The art of public speaking, Rupa publications India Pvt. Ltd., Latest edition. 2. Topher Morrison: The Book on Public Speaking, MJ Publishers, Latest Edition.. 3. Chris Anderson et.al: HBR's 10 Must Reads on Public Speaking and Presenting, HBR, Latest Edition	
Learning Outcomes	At the end of the course, the participant will be able to make a public speech with confidence.	

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Programme: M.Sc. Integrated
Course Code: DSTC 213
Title of the Course: Perspective Building Course - III (Music Appreciation)
Number of Credits: 2(2L-0T-0P)
Contact Hours: 24 hours(24L-0T-0P)
Effective from AY: 2021-22

Prerequisites the for course:	Nil	
Objective:	To make the participants appreciate different genres of music.	
Content:	• What is Sound/Music?, Facets of Music, Art of listening to Music. • How Music works, Elements of Music. • Fundamentals of Music. Rhythm, Melody, Harmony, Timbre. • Music instruments genres- Strings, Wood wind, Percussion, Brass EDM. • Different Musical Eras, History of Music, Genres of Music. • Appreciating forms, styles and genres of Classical Music: Film music, fusion music	4 hours 4 hours 4 hours 4 hours 4 hours 4 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/	

	term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Learning Outcomes :	Students will be able to ● Develop the ability to distinguish different genres of music, Indian & Western; and appreciate the works of some famous artistes	
References/ Readings:	1. Music Videos from Dave Conservatoire. 2. Music Videos from Stephen Titra. 3. Baugh's Music Theory videos from YouTube. 4. The Young Person's Guide to the Orchestra. Harcourt Childrens Books, 1996 or later edition 5. How Music Works series by Howard Goodall, Channel 4 Network; 2010 or latest edition	

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Programme: M.Sc. Integrated
Course Code: DSPC 214
Title of the Course: Machine Learning Lab
Number of Credits: 2(0L-0T-4P)
Contact Hours: 48 hours(0L-0T-48P)
Effective from AY: 2021-22

Prerequisites for the course:	Machine learning theory and programming in python	
Objective:	Aimed at imparting implementation of machine learning algorithms using python and its APIs	
Content:	**Suggested Lab assignments/work with respect to the following using python (scikit /keras libraries) /amazon sage maker/matlab toolbox - each assignment with duration of 4 hrs and 8 hrs for project work** 1. Write a program to implement version space. 2. Write a program to implement a decision tree for given data. 3. Write a program to implement linear regression for given data. 4. Write a program to implement logistic regression. 5. Write a program to implement SVM. 6. Write a program to implement perceptron. 7. Write a program to implement a multilayer perceptron. 8. Write a program to implement RNN. 9. Write a program to implement CNN. 10. Write a program to implement HMM. Capstone mini project work is given to assess the overall learning.	
Pedagogy:	Lab Assignments	
Learning	Students should be able to write program in python for	

Outcomes	implementing Machine learning algorithms using different libraries like scikit learn, keras and pytorch	

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Programme: M.Sc Integrated
Course Code: DSTC 301
Title of the Course: Computer Organization & Operating Systems
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course:	Nil	
Objective:	The aim of the course is to provide students the theoretical and conceptual knowledge of Computer System Architecture and Operating systems .	
Content:	**Introduction to digital electronics:** Logic gates, boolean algebra, combinational circuits **Data Representation and Basic Computer Arithmetic:** Number systems, complements, fixed and floating point representation, character representation, addition, subtraction **Basic Computer Organization and Design:** Computer registers, instruction set, instruction cycle, input-output and interrupt, Bus Interconnection design of basic computer. **Central Processing Unit :** Register organization, arithmetic and logical micro-operations, stack organization, micro programmed control. Instruction formats, addressing modes. **Memory and Input-Output Organization:** Cache memory, Associative memory, mapping, Input / Output: External Devices, I/O Modules, Programmed I/O, Interrupt-Driven I/O, Direct Memory Access. **Introduction to Operating Systems** Basic OS functions, resource abstraction, types of operating systems. **Operating System Organization:** Processor and user modes, kernels, system calls and system programs. **Process Management:** System view of the process and resources, process abstraction, process hierarchy, threads, threading issues, thread libraries; Process Scheduling, non-pre-emptive and preemptive scheduling algorithms; concurrent and	2 hours 2 hours 4 hours 4 hours 3 hours 3 hours 4 hours 12 hours 6 hours 5 hours 3 hours

	processes, critical section, semaphores, methods for inter-process communication; deadlocks. **Memory Management:** Physical and virtual address space; memory allocation strategies -fixedand variable partitions, paging, segmentation, virtual memory **File and I/O Management:** Directory structure, file operations, file allocation methods, device management. **Protection and Security:** Policy mechanism, Authentication, Internal access Authorization..	
Pedagogy:	Lectures/ tutorials/assignments/class presentations and debates/peer reviews/workshops/self-study	
References/ Readings	1. M. Mano, Computer System Architecture, Pearson Education 1992 2. W. Stallings, Computer Organization and Architecture Designing for Performance, 8th 3. Edition, Prentice Hall of India,2009 4. M.M. Mano , Digital Design, Pearson Education Asia,2013 5. A Silberschatz, P.B. Galvin, G. Gagne, Operating Systems Concepts, 8th Edition, John Wiley Publications 2008. 6. A.S. Tanenbaum, Modern Operating Systems, 3rd Edition, Pearson Education 2007. 7. G. Nutt, Operating Systems: A Modern Perspective, 2nd Edition Pearson Education 1997. 8. W. Stallings, Operating Systems, Internals & Design Principles , 5th Edition, Prentice Hall of India. 2008. 9. M. Milenkovic, Operating Systems- Concepts and design, Tata McGraw Hill 1992.	
Learning Outcomes	The students will learn: ● data representation and computer arithmetic. ● organisation of CPU, register, I/O and memory. ● the services provided by and the design of an operating system. ● the structure and organization of the file system. ● what a process is and how processes are synchronized and scheduled. ● different approaches to memory management. ● the implementation and use of system calls for managing processes, memory and the file system.	

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Programme: M.Sc. Integrated
Course Code: DSTC 302
Title of the Course: Programming in C++
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)

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Effective from AY: 2022-23

Prerequisites for the course:	Nil	
Objective:	**The subject aims to provide the student with:** 1. An understanding of the concept of object oriented programming. 2. An understanding of the concepts of data hiding, data abstraction, polymorphism inheritance and exception handling. 3. Ability to understand the generic principles of object oriented programming using "C++". 4. An understanding of the use of templates in "C++". 5. An ability to plan, design, execute and document sophisticated object oriented programs to handle different computing problems.	
Content:	Programming paradigm; procedural to object oriented, Basic concepts of Object-Oriented Programming: Objects, Classes, Data Abstraction and Encapsulation, Inheritance, Polymorphism, Dynamic Binding, Message Passing. Benefits of Object-Oriented Programming. Structure of a C++ program, Data types, Constants, tokens, expressions, control structures, functions, recursion, arrays.	12 hours
	Classes and Objects, Constructors and destructors, Friend functions and friend classes, Concepts of polymorphism: Function overloading, operator overloading. Overloading types, & rules, explicit & implicit type conversion operators, Pointers.	12 hours
	Inheritance: Introduction, Single, Multilevel, Multiple, Hierarchical, Hybrid. Virtual Base Class, Abstract classes. 'this' pointer, pointers to deriver classes Virtual functions, pure virtual functions. I/O streams and classes, managing output with Manipulators, Classes for file streams, file I/O operations and functions. String processing.	12 hours
	Functions Templates and Class Templates, Exception handling: Basics of Exception Handling, Exception Handling mechanism, Throwing Mechanism, Throwing Mechanism, Catching mechanism, Re-throwing mechanism. Introduction to the Standard Template Library: Components of STL, Containers and Adapter: stack, queue, priority queue adapter algorithms, Iterators, Applications.	12 hours
Pedagogy:	Lectures/tutorials/practical assignments/self-study	
References/Readings	1. C++ : from control structures through objects / Tony Gaddis. 2. Timothy Budd, —An Introduction to Object Oriented	

	Programming, Pearson Education, 3rd Edition 3. Paul Deitel and Harrey Dietel; C++, How to Program; seventh edition. 4. E Balaguruswamy; Object oriented programming with C++; Tata McGraw Hill. 6th edition.	
Learning Outcomes	The students will learn: ● The various programming constructs in C++ and their usage ● To write modular and readable code using C++ ● To trace the execution of code fragments. ● Learner will appreciate mapping real-world scenarios in the object-oriented world ● Learner will understand object-oriented principles ● Learner will be able to design object oriented software's ● Learner will be able to analyse	

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Programme: M.Sc. Integrated
Course Code: DSTC 303
Title of the Course: Data Science Toolkit
Number of Credits: 2(2L-0T-0P)
Contact Hours: 24(24L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of data science and data analytics	
Objective:	The aim of this course is to provide an introduction to the main tools and ideas in the data scientist's toolbox.	
Content:	**Excel for Data Visualization**: Predefined, custom number and conditional data format for cells; macros; sorting and filtering data; plotting charts and graphs; working across sheets in excel file; creating interactive dashboards, Pivot table, lookup functions	6 hours
	Numeric and Statistical Computing: Programming and functions; strings, lists, arrays, matrices and data frames; R packages; working with data (e.g. csv, excel, xml, json); plot graphs and charts; R statistical functions and models .	6 hours
	Markdown: Document structure; basic text formatting; paragraphs; headings; lists; links and images; code blocks; escape characters; HTML elements; converting markdown to html web pages	6 hours
	Source Version Control: Version Control; introduction to SVN and Git; Git repositories; Git cloning, forks and branches; Git stash; Git pull requests; resolving Git merge conflicts; maintaining your Git pages	6 hours

Pedagogy:	Lectures/tutorials/practical assignments/self-study	
References/Readings	1. Alexander, Kusleika, Walkenbach, “Excel Bible”, Wiley 2. Wickham, Grolemund, “R for Data Science”, O’Reilly 3. Matt Cone, “The Markdown Guide” 4. Chacon, Straub, “Pro Git”, Apress	
Learning Outcomes	At the end of course students will able to • Create a Github repository • Explain essential study design concepts • Set up R, R-Studio, Github and other useful tools • Understand the data, problems, and tools that data analysts work with.	

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Programme: M.Sc. Integrated
Course Code: DSTC 304
Title of the Course: Strategic Management
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the course:	Nil	
Objective:	To create an awareness of knowledge and tools used for industry and firm analysis in designing organizational strategies and their implementation	
Content:	**Introduction to Strategy** Strategy meaning & importance, Strategy development process, Vision, Mission statements, Objectives of the company. **External and Internal Analysis of Firms** Evaluating company’s external environment (Porter’s 5 Forces Analysis, Political Economic Social Technological Environmental Legal (PESTEL) Analysis), Evaluating company’s internal environment (Strength Weakness Opportunity Threats (SWOT) Analysis), resource capabilities, & competitive environment **Crafting Strategy** Five generic competitive strategies: Low cost, Broad Differentiation, Focussed Differentiation, Focussed Low Cost, Best Cost Strategy.	8 hours 20 hours 20 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Learning	At the end of the course, the participants shall be able to	

Outcomes	analyse the structure of an industry and indicate sustainable strategies for competitive advantage.	
References/ Readings	1. Arthur Thompson Jr., Margaret Petarf, John Gamble, Strickland III &Arun K. Jain, "Crafting and Executing Strategy", MacGraw Hill Publication, Latest Edition. 2. Bowman, Cliff: 'The Essence of Strategic Management'; Prentice Hall of India Private Ltd; New Delhi; Latest Edition. 3. Faulkner, David and Cliff Bowman; 'The Essence of Competitive Strategy'; Prentice Hall of India Private Ltd; New Delhi; Latest Edition. 4. Industry notes and business stories from popular business periodicals, databases.	

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Programme: M.Sc Integrated
Course Code: DSTC 305 **Title of the Course:** Econometrics II
Number of Credits: 4(4L-0T-0P) **Contact Hours:** 48 hours(48L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the Course:	Understanding of probability and statistics and basic Econometrics 1 or equivalent.	
Objective:	Equip the students to make sense of empirical data using multiple variables and analytical approaches	
Content:	**Module 1:** Pooling Cross Sections Across Time: Simple Panel Data Methods; Advanced Panel Data Methods	12 hours
	Module 2: Instrumental Variables Estimation and Two Stage Least Squares; Simultaneous Equations Models	12 hours
	Module 3: Limited Dependent Variable Models and Sample Selection Corrections; Logit and Probit Models for Binary Response; Tobit censored models	12 hours
	Module 4: Advanced Time Series: Distributed Lag Models; Testing for Unit Roots; Spurious Regression; Cointegration; Error Correction Models; Forecasting	12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Reference/Readings:	1. Wooldridge, J. (2018). *Introductory econometrics: A modern approach* (7th edition). Cengage Learning. 2. Angrist, J. D., & Pischke, J.-S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press. 3. Heiss, F. (2020). *Using R for introductory econometrics*. https://elopage.com/s/florian-heiss/using-r-for-introductory-econometrics	

Learning Outcomes:	Advance use of econometric tools along with software handling.	

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Programme: M.Sc. Integrated
Course Code: DSTC 306 **Title of the Course:** Perspective Building Course - IV (Leadership)
Number of Credits: 2(2L-0T-0P) **Contact Hours:** 24(24L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course:	Nil	
Objective	To introduce the concepts of leadership and developing leaders at work-place.	
Contents	**Unit I** **Introduction to Leadership** Leadership and Person, Personality, cultural values and ability, Leadership that gets results, Emotional Intelligence, Models of Leadership, Leadership theories: Traits, Situational, and Functional leadership, Leadership and Power, Leadership and Influence: Interpersonal Conflict and Negotiation, Leadership in Groups and Teams	6 hours
	Unit II **Leadership and Organisation** Organizations as Complex Systems: Strategy, Structure & Environment, Organizational Culture, Leading Teams: Design and Structure, Leadership and Communication, Leading Change	6 hours
	Unit III **Leadership Development** Identifying potential leaders, Leader Development Vs Leadership Development, Process of leadership Development, Developmental Readiness of employees, Tools and interventions for developing leadership	6 hours
	Unit IV **Special Leadership dimensions** Identifying potential dark/ Negative leadership, Corrective measures, Public Leadership, Academic Leadership, Spiritual Leadership, Transformational leadership, Leadership in different types of organisations: Small businesses, Family Businesses, Global Organisations	6 hours
Pedagogy	lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall	

	be interactive in nature to enable peer group learning.	
Learning Outcomes	An ability to be effective leaders and to promote leadership among others at workplace.	
References/ Readings.	1. RL Hughes, RC Ginnett, GJ Curphy; Leadership; Tata McGraw Hill; 2022 or latest edition. 2. James Kouzes, Barry Posner, Jossey-Bass; The Leadership Challenge; 2002 or Latest edition. 3. J Owen, Kogan; The Leadership Skills Handbook; Page Publishing; 2020 or latest edition. 4. WG Rowe, L Guerrero; Cases in Leadership; Sage Publications; 2015 or latest edition. 5. JH Zenger, JR Folkman; The Extraordinary Leader; Tata McGraw Hill; 2002 or latest edition.	

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Programme: M.Sc Integrated

Course Code: DSPC 307

Title of the Course: Computer Organization & Operating Systems Lab

Number of Credits: 2(0L-0T-4P)

Contact Hours: 48(0L-0T-48P)

Effective from AY: 2022-23

Prerequisites for the course:	Computer organization and OS theory and programming background	
Objective:	Aimed at teaching programming to implement concepts learnt in theory.	
Content:	**Suggested Lab Assignments with each assignment with duration of 4 hrs** 1. Sample assignment for introduction to the environment of the Unix program. 2. Sample assignment for introduction to vi editor. 3. Assignment for use of paths: absolute,relative and search. 4. Assignment for use of unix file commands. 5. Assignment for use of unix directory commands. 6. Assignment for use of simple filters: who, sorts, tail, head, etc. 7. Introduction to Command substitution : foreground and background processors. 8. Assignment for use of process management commands. 9. Assignment for sse of redirection commands. 10. Assignment for use of wildcards and regular expressions. 11. Assignment for use of complex commands: pipelining commands. 12. Assignment for use of advanced filters: grep, sed, tr and awk.	
Pedagogy:	Lab Assignments/Presentations	
Learning	should be able to implement any computer organization	

Outcomes	related concepts and appreciate role of OS	

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Programme: M.Sc. Integrated
Course Code: DSPC 308
Title of the Course: Programming in C++
Number of Credits: 2(0L-0T-4P)
Contact Hours: 48(0L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course:	Programming in C++ concepts	
Objective:	Aimed at imparting programming using C++	
Content:	**Suggested Lab Assignments - with minimum duration of 4 hrs for each assignment.** 1. Assignment on Basics of C++ (input /output / control statements / array). 2. Assignment on Classes and objects. 3. Assignment on Function Overloading. 4. Assignment on Operator Overloading. 5. Assignment on Constructors and Destructors. 6. Assignment on Inheritance and Polymorphism. 7. Assignment on Console I/O and Files. 8. Assignment on Templates. 9. Assignment on Exception Handling. 10. Assignment on Standard Template Library. 11. Mini project using OOP paradigm	
Pedagogy:	Lab Assignments	
Learning Outcomes	Should be able to write a program in C++	

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Programme: M.Sc. Integrated
Course Code: DSPC 309
Title of the Course: Data Science Toolkit Lab
Number of Credits: 2(0L-0T-4P)
Contact Hours: 48 hours(0L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of data science and data analytics	
Objective:	The aim of this course is to provide an introduction to the main tools and ideas in the data scientist's toolbox.	
Content:	**Suggested Lab Assignments** (1) Sample Assignments using Excel (a) Using a provided sample dataset excel file (containing office supplies dats, or food sales), format the columns for different currency (currency unit and thousands’	

	delimiter) based on geo location mentioned (2) Sample Assignments using R (3) Sample Assignments using Markdown (4) Sample Assignments using Git	
Pedagogy:	Lab Assignments	
Learning Outcomes	At the end of course students will able to • Create a Github repository • Explain essential study design concepts • Set up R, R-Studio, Github and other useful tools • Understand the data, problems, and tools that data analysts work with.	

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Programme: MSc Integrated
Course Code: DSTC 310 **Title of the Course:** Introduction to Data Science
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Statistics and Probability theory and Python Programming	
Objectives	To get started with basics of Data Science and learn all aspects of Data Science in its entirety	
Content	**Unit-1: Basics of Data Science:** Introduction; Typology of problems-**Data science in a big data world:** Benefits and uses of data science and big data-Facets of data-The data science process-The big data ecosystem and data science-**The data science process:** Overview of the data science process- Defining research goals and creating a project charter-Retrieving data-Cleansing, integrating, and transforming data-Exploratory data analysis-Build the models- Presenting findings and building applications on top of them. **Unit -2: Mathematics for Data science (Revision):** • Importance of linear algebra, statistics and optimization from a data science perspective; Structured thinking for solving data science problems. • Linear Algebra: Matrices and their properties (determinants, traces, rank, nullity, etc.); Eigenvalues and eigenvectors; Matrix factorizations; Inner products; Distance measures; Projections; Notion of hyperplanes; half-planes. • Probability, Statistics and Random Processes: Probability theory and axioms; Random variables; Probability distributions and density functions (univariate and multivariate); Expectations and moments; Covariance and correlation; Statistics and sampling distributions; Hypothesis testing of means, proportions, variances and correlations; Confidence (statistical) intervals; Correlation functions; White-noise process.	6 hours 7 hours 7 hours 7 hours

	Unit -3: Introduction to Data Science Methods: Linear regression as an exemplar function approximation problem; Linear classification problems. **Unit -4: Handling large data on a single computer:** ● The problems you face when handling large data-General techniques for handling large volumes of data-General programming tips for dealing with large data sets-Case study 1: Predicting malicious URLs-**First steps in big data-** Distributing data storage and processing with frameworks **Unit 5: Join the NoSQL movement-Introduction to NoSQL** **Unit 6: The rise of graph databases:** ● Introducing connected data and graph databases ● Introducing Neo4j: a graph database **Unit 7: Data visualization to the end user:** ● Data visualization options ● Crossfilter, the JavaScript MapReduce library ● Creating an interactive dashboard with dc.js ● Dashboard development tools	7 hours 7 hours 7 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Practical Statistics for Data Science by Peter Bruce, Andrew Bruce, Peter Gedeck, May 2017 2. Naked Statistics by Charles Wheelon, 2012 3. Business Data Science by Matt Taddy, McGraw Hill, 2019 4. Elements of statistical learning by Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie,2001 5. Python for Data Analysis by Wes McKinney, 2nd edition, 2017 6. Data Science and Big Data Analytics -EMC2	
Learning Outcomes	Students will be able to understand the basics of data science, Mathematics for Data science, Data science Methods, Handling large data on a single computer, to join the NoSQL movement and understand NoSQL, Graph database and Data visualization.	

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Programme: MSc Integrated
Course Code: DSTC 311 **Title of the Course:** Big Data Frameworks
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Probability and Statistics; Python Programming	
Objectives	● To understand the need of Big Data, challenges and different analytical architectures ● Installation and understanding of Hadoop Architecture and its ecosystems	

	● Processing of Big Data with Advanced architectures like Spark. ● Describe graphs and streaming data in Spark	
Content	**Introduction to Big Data:** Data Storage and Analysis - Characteristics of Big Data – Big Data Analytics - Typical Analytical Architecture – Requirement for new analytical architecture – Challenges in Big Data Analytics – Need of big data frameworks **Hadoop framework:** Hadoop – Requirement of Hadoop Framework - Design principle of Hadoop –Comparison with other system - Hadoop Components – Hadoop 1 vs Hadoop 2 – Hadoop Daemon's – HDFS Commands – Map Reduce Programming: I/O formats, Map side join, Reduce Side Join, Secondary sorting, Pipelining MapReduce jobs - **Hadoop Ecosystem :** Introduction to Hadoop ecosystem technologies: Serialization: AVRO, Co-ordination: Zookeeper, Databases: HBase, Hive, Scripting language: Pig, Streaming: Flink, Storm **Spark framework:** Introduction to GPU Computing, CUDA Programming Model, CUDA API, Simple Matrix, Multiplication in CUDA, CUDA Memory Model, Shared Memory Matrix Multiplication, Additional CUDA API Features. **Data analysis with spark shell:** Writing Spark Application - Spark Programming in Scala, Python, R, Java - Application Execution **Spark SQL and Graph X :** SQL Context – Importing and Saving data – Data frames – using SQL – GraphX overview – Creating Graph – Graph Algorithms. **Spark Streaming:** Overview – Errors and Recovery – Streaming Source – Streaming live data with spark	9 hours 7 hours 7 hours 7 hours 6 hours 6 hours 6 hours
Pedagogy	Assignment / Quiz / Project / Seminar	
References/ Readings	1. Mike Frampton, "Mastering Apache Spark", Packt Publishing, 2015. 2. Tom White, "Hadoop : The Definitive Guide", O'Reilly, 4thEdition, 2015. 3. Nick Pentreath, Machine Learning with Spark, Packt Publishing, 2015. 4. Mohammed Guller, Big Data Analytics with Spark, Apress, 2015. 5. Donald Miner, Adam Shook, "Map Reduce Design Pattern", O'Reilly, 2012.	
Learning Outcomes	Students will be able to understand Big Data, Hadoop Framework, and Ecosystem, Spark framework, Data analysis with spark shell, Spark SQL and Graph X and Spark Streaming.	

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Std. Com.X AC-6
15 & 22.05.2023

Programme: MSc Integrated
Course Code: DSPC 312 **Title of the Course:** Introduction to Data Science Lab
Number of Credits: 2(0L-0T-4P) **Contact hours:** 48 hours (0L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of Python Programming	
Objectives	1. To provide necessary knowledge on how to manipulate data objects, produce graphics, analyze data using common statistical methods and generate reproducible statistical reports with programming in Python 2. Apply the concepts learnt in Data Science.	
Content	**Suggested Lab Assignment:** **Program to understand these concepts**: Numpy Arrays objects, Creating Arrays, basic operations, Indexing, Slicing and iterating, copying arrays, shape manipulation, Identity array, eye function, Universal function **Program to understand these concepts:** Linear algebra with Numpy, eigen values and eigen vectors with Numpy **Program to understand these concepts:** Aggregation and Joining, Pandas Object: Concatenating and appending data frames, index objectsHandling Time series data using pandas **Program to understand these concepts:** Handling missing values using pandas **Program to understand these concepts:** Reading and writing the data including JSON data **Program to understand these concepts:** Web scraping using python, Combining and merging **Program to understand these concepts:** Data transformations Basic matplotlib plots, common plots used in statistical analysis in python **Program to understand these concepts:** Common plots used in statistical analysis in python Data Types **Program to understand these concepts:** Sequence generation, Vector and subscript, Random number generation Data frames and functions-Data manipulation and Data Reshaping using plyr, dplyr, reshape **Program to understand these concepts:** Parametric statistics	15 hours 5 hours 5 hours 5 hours 5 hours 5 hours 4 hours 4 hours

	and Non-parametric statistics- Continuous and Discrete Probability distribution using python Correlation and covariance, contingency tables- Overview of Sampling, different sampling techniques- and database connectivity2.	
Pedagogy	Lab Assignments	
References/ Readings	1. James Payne, "Beginning Python: Using Python 2.6 and Python 3.1" Wrox, Ist Edition, 2010. 2. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, "Data Structures and Algorithms in Python", John Wiley & sons, 2013. 3. Ivan Idris, "Python Data Analysis", Packt Publishing Limited, 2014. 4. Wes McKinney, "Python for Data Analysis Data Wrangling with Pandas, NumPy, and IPython", O'Reilly Media, Ist Edition, 2012. 5. Michael Heydt, "Learning Pandas - Python Data Discovery and Analysis Made Easy", Packt Publishing Limited, 2015. 6. Jacqueline Kazil,Katharine Jarmul, "Data Wrangling with Python: Tips and Tools to MakeYour Life Easier", O'Reilly Media, Ist Edition, 2016. 7. https://docs.scipy.org/doc/numpy-dev/reference/index.html#reference 8. http://www.python-course.eu/numpy.php	
Learning Outcomes	Students will be able: ● To solve the analytical problems using Python ● Develop competency in the Python programming language and a number of data related Python libraries such as Pandas, Numpy, and Scipy ● To communicate results of analysis effectively using visualizations in Python ● Import, export and manipulate data and produce statistical summaries of continuous and categorical data in Python ● To perform exploratory data analysis using Python.	

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Programme: MSc Integrated
Course Code: DSTC 313 **Title of the Course:** Big data frameworks Lab
Number of Credits: 2(0L-0T-4P) **Contact hours:** 48 hours(0L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course	Introduction to Data Science and Python Programming	
Objectives	To appreciate the concepts learnt in Big data analytics	
Content	**Suggested Lab Assignments:** 1. Downloading and installing Hadoop; Understanding different Hadoop modes. Startup scripts, Configuration files.	6 hours

	2. Hadoop Implementation of file management tasks, such as Adding files and directories, Retrieving files and Deleting files 3. Implement of Matrix Multiplication with Hadoop Map Reduce 4. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm. 5. Implementation of K-means clustering using Map Reduce 6. Installation of Hive along with practice examples. 7. Installation of HBase, Installing thrift along with Practice examples 8. Patrice importing and exporting data from various databases	6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours
Pedagogy	Lab Assignments	
References/ Readings	Big Data Analysis with Python By Ivan Marin, Ankit Shukla, Sarang VK, Packt Publishing Limited, 2019	
Learning Outcomes	Students will be able to install all the relevant tools required for big data analytics and write a program in python to appreciate big data concepts.	

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Programme: MSc Integrated
Course Code: DSTC 401 **Title of the Course:** AI-Search Methods for Problem Solving
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programming skills, Data structures, Mathematical Foundations	
Objectives	The Objective of this course is to learn the fundamentals of Artificial Intelligence. The focus is on blind search methods - blind search , heuristic search methods etc and appreciate how formulating the problem as state space representation.	
Content	Introduction and philosophy. The Turing Test. The Winograd Schema Challenge. Placing search in the landscape of AI. Search spaces. Examples. State space search. Depth First, Breadth First, Iterative Deepening. Analysis. Heuristic search. Heuristic functions. Solution space search. Escaping local optima. Stochastic local search. Population based methods. Genetic Algorithms, emergent systems, Ant Colony Optimization. Finding optimal paths. Algorithm A*. Admissibility of A*. The monotone condition. Space saving versions of A*. Sequence alignment. Game playing. Board games. Algorithms Minimax, Alpha-Beta, and SSS*. Automated domain independent planning. Goal Stack Planning, Partial Order Planning. Problem decomposition with goal trees. Algorithm AO*. Pattern directed inference systems. Forward chaining inference engine. The Rete algorithm.Constraint processing. Algorithm	12 hours 12 hours 12 hours 12 hours

	Backtracking. Arc consistency. Combining search and reasoning. Waltz algorithm. Model based diagnosis.	
Pedagogy	Hands-on Assignments / Tutorials / Peer-teaching / Presentations	
References/ Readings	1. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India), 2013. (Chapters 1 – 8, some parts from Chapters 9 and 10)) 2. John Haugeland, Artificial Intelligence: The Very Idea, A Bradford Book, The MIT Press, 1985. 3. Pamela McCorduck, Machines Who Think: A Personal Inquiry into the History and Prospects of Artificial Intelligence, A K Peters/CRC Press; 2nd edition, 2004. 4. Eugene Charniak and Drew McDermott, Introduction to Artificial Intelligence, Addison- Wesley Publ., 1985. 5. Zbigniew Michalewicz and David B. Fogel. How to Solve It: Modern Heuristics. Springer; 2nd edition, 2004. 6. Judea Pearl. Heuristics: Intelligent Search Strategies for Computer Problem Solving, Addison-Wesley, 1984. 7. Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill, 1991. 8. Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall, 2009. 9. Patrick Henry Winston. Artificial Intelligence, Addison-Wesley, 1992. 10. Stefan Edelkamp and Stefan Schroedl. Heuristic Search: Theory and Applications, Morgan Kaufmann, 2011.	
Learning Outcomes	Students will be able to understand: 1. A historical and philosophical perspective on artificial intelligence. 2. The ability to formulate problems in a general problem solving framework. 3. Knowledge of domain independent search based problem solving algorithms. 4. Knowledge of stochastic, local, and population based search algorithms. 5. The foundations of problem decomposition and rule based methods. 6. To implement game playing algorithms. 7. The relation between search methods and other formulations including planning, constraints and logical reasoning.	

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Programme: MSc Integrated
Course Code: DSTC 402 **Title of the Course:** Research Methodology and IP
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48 L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Basics of probability and statistics , Programming skills	
Objectives	● Present research methodology and the technique of defining a research problem. ● Learn the meaning of interpretation, techniques of interpretation, precautions is to be taken in interpretation for research process, ● Application of statistical methods in research ● Learn intellectual property rights and its constituents.	
Content	**Unit 1** Introduction to research, Definitions and characteristics of research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Quantitative vs. Qualitative Approach, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs. Theoretical Research, Importance of reasoning in research. **Unit 2** Problem Formulation, Understanding Modeling & Simulation, Literature Review, Referencing, Information Sources, Information Retrieval, Indexing and abstracting services, Citation indexes, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Interpretation of Results. **Unit 3** Statistics: Probability & Sampling distribution, Estimation, Measures of central Tendency, Arithmetic mean, Median, Mode, Standard deviation, Co-efficient of variation (Discrete serious and continuous serious), Hypothesis testing & application, Correlation & regression analysis, Orthogonal array, ANOVA, Standard error, Concept of point and interval estimation, Level of significance, Degree of freedom, Analysis of variance, One way and two way classified data, 'F' test. **Unit 4** Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents. Intellectual property rights (IPR) patents copyrights Trademarks Industrial design geographical indication. Ethics of Research Scientific Misconduct Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science.	12 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Assignments/Self-study	

References/ Readings	1. K. S. Bordens, and B. B.Abbott, , "Research Design and Methods – A Process Approach", 8th Edition, McGraw Hill, 2011. 2. C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers,2014 3. Douglas C. Montgomary&George C. Runger, Applied Statistics & probabilityfor Engineers, 3rd edition,2007,Wiley. 4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in the New Technological Age". Aspen Law & Business; 6th edition July 2012. 5. A Beginners Guide to Latex, Chetan Shirore, 5 July 2015.	
Learning Outcomes	Students will be able to: ● Design and formulation of research problems. ● Analyze research related information and statistical methods in research. ● Carry out research problem individually in a perfect scientific method ● Understand the filing patent applications processes, Patent search, and various tools of IPR, Copyright, and Trademarks.	

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Programme: MSc Integrated
Course Code: DSTC 403
Title of the Course: Deep Learning
Number of Credits: 4(4L-0T-0P)
Contact hours: 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Machine Learning, Programming,Probability and Statistics, Linear Algebra	
Objectives	To study the basics of Neural Networks and their various variants such as the Convolutional Neural Networks and Recurrent Neural Networks, to study the different ways in which they can be used to solve problems in various domains such as Computer Vision, Speech and NLP.	
Content	Moving beyond Linearity-Non-Linear regression-polynomial and spline-polynomial regression,step function,basis function, regression splines -piecewise polynomials, constraints and splines, the spline basis representation etc - smoothing splines,Generalized additive models History of Deep Learning, McCulloch Pitts Neuron, Thresholding Logic, Perceptron Learning Algorithm and Convergence. Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent. Feedforward Neural Networks, Representation Power of Feedforward Neural Networks, Backpropagation. Gradient Descent(GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Adagrad,	4 hours 8 hours 12 hours

	AdaDelta,RMSProp, Adam,AdaMax,NAdam, learning rate schedulers. Autoencoders and relation to PCA , Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders. Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout Greedy Layer Wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization. Learning Vectorial Representations Of Words, Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet. Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks. Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT. Gated Recurrent Units (GRUs), Long Short Term Memory (LSTM) Cells, Solving the vanishing gradient problem with LSTM. Encoder Decoder Models, Attention Mechanism, Attention over images, Hierarchical Attention, Transformers.	12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. An MIT Press book. 2016. 2. Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019.	
Learning Outcomes	Students will be able to understand: ● A brief history of deep learning and its success stories. ● Perceptrons, Sigmoid neurons and Multi-Layer Perceptrons (MLP) with specific emphasis on their representation power and algorithms used for training them (such as Perceptron Learning Algorithm and Backpropagation). ● Gradient Descent (GD) algorithm and its variants like Momentum based GD,AdaGrad, Adam etc Principal Component Analysis and its relation to modern Autoencoders. ● The bias variance tradeoff and regularisation techniques used in DNNs (such as L2 regularisation, noisy data augmentation, dropout, etc). ● Different activation functions and weight initialization strategies ● Convolutional Neural Networks (CNNs) such as AlexNet, ZFNet, VGGNet, InceptionNet and ResNet. ● Recurrent Neural Network (RNNs) and their variants such as LSTMs and GRUs (in particular, understanding the vanishing/exploding gradient problem and how LSTMs overcome the vanishing gradient problem)	

	• Applications of CNN and RNN models for various computer vision and Natural Language Processing (NLP) problems.	

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Programme: MSc Integrated
Course Code: DSTC 404
Title of the Course: Design Thinking for Data-Driven App Development
Number of Credits: 4(4L-0T-0P)
Contact hours: 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	None	
Objectives	This course helps you learn the basics of Design Thinking in an experiential way. This course aims at an empathy-led data-driven app development approach for data scientists. The learners will launch a fully functioning app in a real app store at the end of the course.	
Content	Introduction to Design Thinking – Course outline and projects,Intro to the Design of Everyday Things, Intro to Design Thinking in software apps, Project management. Empathize phase (Iteration #1)-- Emotional and intellectual map of the user stories from interviews, User story creation and Customer Journey Mapping Analyze phase (Iteration #1) - Stated needs and unsaid/latent needs, Root cause analysis, Multiple perspectives of customers and manufacturers, Frame conflicts from popular movies. Solve phase (Iteration #1)Structured and unstructured creativity, Dynamics of group thinking, Optimal conditions of creativity, Natural creativity, Concept creation via group activities, Silent brainstorming, inventive principles and concept consolidation Test phase (Iteration #1)/ Empathize phase (Iteration #2) - Basics of prototyping, Assumptions in creation of new concepts, Features rather than ideas. Basics of Digital Marketing, User Experience Design, Website Development Analyze phase (Iteration #2) Solve phase (Iteration #2) - Introduced problems via the solution from iteration #1, the subsequent ideation process in iteration #2, apply solutioning and analysis tools in iteration #2, subsequent testing and field trial skills required for iteration #3, analytical tools and data oriented tools on iteration #3. Test (Iteration #2) / Empathize (Iteration #3) - Basics of obtaining insights from feedback from a live audience. Analyze (Iteration #3). Test phase (Iteration #3) - Launch of the App.	12 hours 12 hours 12 hours 12 hours
Pedagogy	Hands-on assignments / Tutorials / Peer-teaching /Presentations	
References/	1. Design of everyday things by Don A. Norman, 2013.	

Readings	2. This is Service Design thinking- basics , tools and cases by Marc Stickdorn, 1st edition,John Wiley & Sons Inc,2012.	
Learning Outcomes	Students will be able to: ● Recall the basics of Design Thinking ● Apply Agile method to developing software ● Design an App using the principles of Design Thinking ● Develop an App for Android ● Collaborate with other developers using git version control method ● Learn the basics of marketing and customer support through their website	

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Programme: MSc Integrated
Course Code: DSPC 405
Title of the Course: AI-Search Methods for Problem Solving Lab
Number of Credits: 2(0L-0T-4P)
Contact hours: 48 hours(0L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course	Programming Knowledge, Basic AI concepts	
Objectives	Learn to write a program to appreciate the concepts of AI	
Content	Implementation of Toy problems Developing Agent programs for real world problems Implementation of constraints satisfaction problems Implementation and Analysis of DFS and BFS for an application Developing Best First search and A* Algorithm for real world problems Implementation of minimax algorithm for an application Implementation of unification and resolution for real world problems Implementation of knowledge representation schemes-use cases Implementation of uncertain methods for an application Implementation of block world problem Implementation of learning algorithm for an application Development of ensemble model for an application	4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours
Pedagogy	Hands-on assignments / tutorials / presentations	
References/ Readings	● Artificial programming in Python (zero to zero)By Perry Xiao, 2022 ● AI and Machine Learning for coders by Lawrence, O'Reilly Publication,2020	
Learning Outcomes	Students will be able to write a program to implement AI Techniques.	

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Programme: MSc Integrated
Course Code: DSPC 406
Title of the Course: Deep Learning Lab
Number of Credits: 2(0L-0T-4P)
Contact hours: 48 hours(0L-0T-48 P)
Effective from AY: 2022-23

Prerequisites for the course	Programming in Python, Machine learning and Deep learning concepts	
Objectives	To study the basics of Neural Networks and their various variants such as the Convolutional Neural Networks and Recurrent Neural Networks, to study the different ways in which they can be used to solve problems in various domains such as Computer Vision, Speech and NLP.	
Content	**Suggested lab assignments** 1. Data representation for neural networks . 2. The gears of neural networks -Tensor operations. 3. Engine of neural network – implementation of gradient -based optimization algorithm. 4. Getting started with keras- setting up a deep learning workstation . 5. Writing program to classify movie reviews-binary classification example. 6. Classifying newswires -multi classification example 7. Predicting house prices-regression example 8. Program to understand the effect of underfitting and overfitting . 9. Training a Convnet on a small dataset. 10. Learning to use predefined convnet. 11. Sequencing processing example using recurrent network and LSTM 12. Generative deep learning assignment-Text generations with LSTM	 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours 4 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	• Deep Learning with Python by Francois Chollet, 2017 • Deep Learning from scratch by Acth Eidman, O'Reilly Publication , 2019. • Deep learning with PyTorch by Eli Stevens, Luca Antiga, Thomas,2020.	
Learning Outcomes	Students will be able to write a program in python to implement deep learning algorithms.	

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Programme: MSc Integrated
Course Code: DSTC 408
Title of the Course: Reinforcement Learning
Number of Credits: 4(4L-0T-0P)
Contact hours:48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites	Programme prerequisites, Machine Learning	

for the course		
Objectives	To enable the student to understand the reinforcement learning paradigm, to be able to identify when an RL formulation is appropriate, to understand the basic solution approaches in RL, to implement and evaluate various RL algorithms.	
Content	Review of ML fundamentals – Classification, Regression. Review of probability theory and optimization concepts. RL Framework; Supervised learning vs. RL; Explore-Exploit Dilemma; Examples. MAB: Definition, Uses, Algorithms, Contextual Bandits, Transition to full RL, Intro to full RL problem Intro to MDPs: Definitions, Returns, Value function, Q-function. Bellman Equation, DP, Value Iteration, Policy Iteration, Generalized Policy Iteration. Evaluation and Control: TD learning, SARSA, Q-learning, Monte Carlo, TD Lambda, Eligibility Traces. Maximization-Bias & Representations: Double Q learning, Tabular learning vs. Parameterized, Q-learning with NNs Function approximation: Semi-gradient methods, SGD, DQNs, Replay Buffer. Policy Gradients: Introduction, Motivation, REINFORCE, PG theorem, Introduction to AC methods Actor-Critic Methods, Baselines, Advantage AC, A3C Advanced Value-Based Methods: Double DQN, Prioritized Experience Replay, Dueling Architectures, Expected SARSA. Advanced PG/A-C methods: Deterministic PG and DDPG, Soft Actor-Critic (SAC) HRL: Introduction to hierarchies, types of optimality, SMDPs, Options, HRL algorithms POMDPS: Intro, Definitions, Belief states, Solution Methods; History-based methods, LSTMS, Q-MDPs, Direct Solutions, PSR. Model-Based RL: Introduction, Motivation, Connections to Planning, Types of MBRL, Benefits, RL with a Learnt Model, Dyna-style models, Latent variable models, Examples, Implicit MBRL. Case study on design of RL solution for real-world problems.	12 hours 12 hours 12 hours 12 hours
Pedagogy	Hands-on assignments / Tutorials / Peer-teaching / Presentations	
References/ Readings	1. Reinforcement learning - Introduction by Richard Sutton and Andrew barto,1992. 2. Algorithms for reinforcement learning by Csaba Szepesvari, Ronald Brachman, et al, 2010	
Learning Outcomes	Students will be able to understand the fundamentals of reinforcement learning and its role in building gaming applications and in turn helps to understand the challenges of	

	real world problems , and how RL will help them.	

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Programme: M.Sc. Integrated
Course Code: DSTC 409
Title of the Course: Optimization Techniques for Analytics
Number of Credits: 4(4L-0T-0P)
Contact Hours: 48 hours(48 L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course:	Linear Algebra, Vector Algebra	
Objective:	● To familiarize the students with some basic concepts of optimization techniques and approaches. ● To formulate a real-world problem as a mathematical programming model. ● To develop the model formulation and applications are used in solving decision problems. ● To solve specialized linear programming problems like the transportation and assignment problems.	
Content:	**Introduction to Operations Research** Introduction-Mathematical models of Operation Research - Scope and applications of Operation Research - Phases of Operation Research study - Characteristics of Operation Research - Limitations of Operation Research.	6 hours
	Linear Programming Introduction –Properties of Linear Programming-Basic assumptions-Mathematical formulation of Linear Programming-Limitations or constraints-Methods for the solution of LP Problem-Graphical analysis of LP-Graphical LP Maximization problem-Graphical LP Minimization problem.	6 hours
	Linear Programming Models Simplex Method-Basics of Simplex Method - Formulating the Simplex Method-Simplex Method with two variables - Simplex Method with more than two variables - Big M Method.	6 hours
	Dual Linear Programming Introduction- Primal and Dual problem - Dual problem properties-Solution techniques of Dual problem - Dual Simplex method-Relations between direct and dual problem-Economic interpretation of Duality.	6 hours
	Transportation and Assignment Models Introduction:Transportation problem - Balanced - Unbalanced - Methods of basic feasible solution Optimal solution-MODI	6 hours

	method. Assignment problem-Hungarian Method. **Network Analysis** Basic concepts-Construction of Network-Rules and precautions-CPM and PERT Networks Obtaining critical path. Probability and cost consideration. Advantages of Network. **Theory of Games** Introduction-Terminology-Two Person Zero-Sum game-Solution of games with saddle points and without saddle points-2X2 games-dominance principle – mX2 and 2Xn games-Graphical method. **Industry Perspective** Research and Analytical problems on various applications of the industrial issues.	 6 hours 8 hours 4 hours
Pedagogy:	Assignment / Quiz	
References/ Readings	**Text Book(s)** ● Hamdy Taha, Operations Research, 10th edition, Prentice Hall India, 2019. ● P. K. Gupta and D. S. Hira, Operations Research, S. Chand & co., 2007. **Reference Books** ● S.D. Sharma (2000), Operations Research, Nath & Co., Meerut. ● Maurice Solient, Arthur Yaspen, Lawrence Fridman, (2003), OR methods and Problems, New Age International Edition. ● J K Sharma (2007), Operations Research Theory & Applications, 3e, Macmillan India Ltd. ● P. Sankara Iyer, (2008), Operations Research, Tata McGraw-Hill. ● A Ravindran, Don T Philips and James J Solberg, Operations Research: Principles and practice, 2nd edition, John Wiley and sons, 2007	
Learning Outcomes	Student will be able to ● Apply operations research techniques like linear programming problems in industrial optimization problems. ● Solve allocation problems using various OR methods. ● Understand the characteristics of different types of decision making environments and the appropriate decision making approaches and tools to be used in each type. ● Recognize competitive forces in the marketplace and develop appropriate reactions based on existing constraints and resources.	

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Programme: MSc Integrated
Course Code: DSTC 410 **Title of the Course:** MLOps At Scale
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P**)**
Effective from AY: 2022-23

Prerequisites for the course	Familiarity with linear algebra, probability theory, machine learning , familiarity with python.	
Objectives	This course is aimed at any one who wishes to explore deep learning from scratch. This course offers a practical hands on exploration of deep learning, avoiding mathematical notation,preferring instead to explain quantitative concepts through programming using python API	
Content	Introduction to MLOps Rise of the Machine Learning Engineer and MLOps-What Is MLOps?-DevOps and MLOps-An MLOps Hierarchy of Needs-Implementing DevOps-Configuring-Continuous Integration with GitHub Actions-DataOps and Data Engineering-Platform Automation-MLOps	3 hours
	MLOps Foundations-Bash and the Linux Command Line-Cloud Shell Development Environments-Bash Shell and Commands-List Files Run CommandsFiles and Navigation-Input/Output-Configuration-Writing a Script-Cloud Computing Foundations and Building Blocks-Getting Started with Cloud Computing-	5 hours
	minimalistic python revision-Descriptive Statistics and Normal Distributions-Optimization-Machine Learning Key Concepts-Doing Data Science-Build an MLOps Pipeline from Zero	5 hours
	MLOps for Containers and Edge Devices Containers-Container Runtime-Creating a Container Running a Container-Best Practices-Serving a Trained Model Over HTTP-Edge Devices-	5 hours
	Coral Azure Percept-TFHub-Porting Over Non-TPU Models-Containers for Managed ML Systems-Containers in Monetizing MLOps-Build Once, Run Many MLOps Workflow	5 hours
	Continuous Delivery for Machine Learning Models-Packaging for ML Models-Infrastructure as Code for Continuous Delivery of ML Models-Using Cloud Pipelines-Controlled Rollout of Models-Testing Techniques for Model Deployment	5 hours
	AutoML and KaizenML-AutoML-MLOps Industrial Revolution-Kaizen Versus KaizenML-Feature Stores-Apple's Ecosystem-Apple's AutoML: Create ML-Apple's Core ML Tools orGoogle's AutoML and Edge Computer Vision or Azure's AutoMLor AWS	5 hours
	AutoML-Open Source AutoML Solutions-Ludwig-FLAML-Model Explainability	5 hours
	Monitoring and Logging-Observability for Cloud MLOps-Introduction to Logging-Logging in Python-Modifying Log Levels-Logging Different Applications-Monitoring and Observability-Basics of Model Monitoring-Monitoring Drift with AWS SageMaker-Monitoring Drift with Azure ML	5 hours

	MLOps for AWS-Introduction to AWS-Getting Started with AWS Services-MLOps on AWS-MLOps Cookbook on AWS-CLI Tools-Flask Microservice-AWS Lambda Recipes-AWS Lambda-SAM Local-AWS Lambda-SAM Containerized Deploy-Applying AWS Machine Learning to the Real World Machine Learning Interoperability-Why Interoperability Is Critical-ONNX: Open Neural Network Exchange-ONNX Model Zoo-Convert PyTorch into ONNX -Convert TensorFlow into ONNX-Deploy ONNX to Azure-Apple Core ML-Edge Integration. Building MLOps Command Line Tools and Microservices-Python Packaging-The Requirements File-Command Line Tools-Creating a Dataset Linter Modularizing a Command Line Tool-Microservices-Creating a Serverless Function-Authenticating to Cloud Functions-Building a Cloud-Based CLI-Machine Learning CLI Workflows Machine Learning Engineering and MLOps Case StudiesUnlikely Benefits of Ignorance in Building Machine Learning Models-MLOps Projects at Sqor Sports Social Network-Mechanical Turk Data Labeling-Influencer Rank-Athlete intelligence (AI product)-The perfect techniques versus the real world-critical challenges in MLops- Ethical and unintended consequences-lack of operational excellences- focus on prediction accuracy vs the big picture	5 hours
Pedagogy	Lectures/ tutorials/lab assignments/self-study	
References/ Readings	Main Reading :- 1. Practical MLops – Noah Gift and AlfredoDeza,O'Reilly Media, Inc, 2021. 2. Introduction to MLOps – Noah Gift and AlfredoDeza, Pragmatic AI Solutions, 2021.	
Learning Outcomes	Student will be able to understand ● What Is MLOps ● MLOps Foundations ● Continuous Delivery for Machine Learning ● Monitoring and Logging ● MLOps for AWS-Introduction ● Machine Learning Interoperability ● Machine Learning Engineering	

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Programme: M.Sc. Integrated
Course Code: DSPC 411
Title of the Course: Optimization Techniques for Analytics Lab
Number of Credits: 2(0L-0T-4P)
Contact Hours: 48 hours(0L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course:	Programming background,Linear Algebra, Vector Algebra	

Objective:	Learn to implement optimization techniques	
Content:	**Suggested Assignments** Implementation of simplex method(two different problems) Implementation of dual simplex method(two different problems) Implementation of hungarian method(two different problems Finding critical path method (two different problems) Game Theory(two different problems) Solution of the game using saddle point.(two different problems) Mini Project using any one technique	12 hours 12 hours 12 hours 12 hours
Pedagogy:	Assignment/Presentations	
References/Readings	• Optimization- Optimization in nutshell, 2021 • Pyomo-Optimization modeling in Python by William E Hart, 2021	
Learning Outcomes	Student will be able to: • Implement optimization techniques using programming language of your choice	

Programme: MSc Integrated
Course Code: DSPC 412 **Title of the Course:** MLOps at Scale Lab
Number of Credits: 2(0L-0T-4P) **Contact hours:** 48 hours(0L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course	Machine learning background, Python programming and MLOps background	
Objectives	After carrying out machine learning projects , learning to deploy the models.	
Content	Machine Learning in Production • A journey through Data • Data Labelling Machine Learning Data Lifecycle in Production • TFDV Exercise • Data Validation • Simple Feature Engineering • Feature Engineering Pipeline • Feature Selection • ML Metadata • Iterative Schema • Data Pipeline Components for Production ML • Feature Engineering with Weather Data • Feature Engineering with Accelerometer Data • Feature Engineering with Images Machine Learning Modeling Pipelines in Production	12 hours 12 hours 12 hours

	• Intro to Keras Tuner • Hyperparameter tuning and model training with TFX • Manual Dimensionality • Algorithmic_Dimensionality • Quantization and Pruning • TensorFlow Model Analysis • Model Analysis with TFX Evaluator • Fairness Indicators • Shapley Values • Permutation Feature Importance Deploying Machine Learning Models in Production • Intro to Docker and installation -First look at Tensorflow Serving with Docker -Serve a model with TensorFlow Serving • Intro to KFP • TFX Custom Components • TFS Model Versioning • Github Actions	12 hours
Pedagogy	Lab Assignments/ Presentations	
References/ Readings	• Practical MLOps by Noah Gift & Alfredo Deza,O'Reilly Media, Inc, 2021. • https://github.com/amanchadha/coursera-machine-learning-engineering-for-prod-mlops-specialization	
Learning Outcomes	Students will be able to deploy the ML models.	

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LIST OF ELECTIVE COURSES -

Programme: MSc Integrated
Course Code:
Title of the Course: Advanced Database Management Systems
Number of Credits: 4(2L-0T-4P)
Contact hours: 72 hours (24 L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course	Database Management Systems	
Objectives	• To evaluate emerging architectures for database management systems. • To develop an understanding of the manner in which relational systems are implemented and the implications of the techniques of implementation for database performance. • To assess the impact of emerging database standards on the facilities which future database management systems will provide.	
Content	**Unit 1** Theoretical concepts, Relational model conformity and	6 hours

	Integrity, Advanced SQL programming **Unit 2** Query optimization, Concurrency control and Transaction management, Database performance tuning, Distributed relational systems and Data Replication **Unit 3** Object oriented, deductive, spatial, temporal and constraint database management systems, New database applications and architectures: e.g. Data Warehousing; Multimedia; Mobility; NoSQL, Native XML databases (NXD), Document oriented databases **Unit 4** SQL standards development, Standards for interoperability and integration e.g. Web Services Unit 5 Database security - Data Encryption, redaction and masking techniques. Authentication and authorization. Database auditing	6 hours 6 hours 6 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	**Text Book:** 1. Date C. J., An Introduction to Database Systems, AddisonWesley Longman (8th Ed), 2003. 2. Silberschatz A., Korth H., and Sudarshan S., Database System Concepts, McGraw-Hill (6th Ed), 2010. **Reference Book:** 3. Melton, J., & Simon A., SQL 1999, Understanding Relational Language Components, MorganKaufmann, 2003. 4. Peter Adams : SQL: The Ultimate Guide from Beginner to Expert - Learn and Master SQL in No Time, Addison Wesley, 2016.	
Learning Outcomes	After reading this subject, students will be able to: ● Critically assess new developments in database technology ● Interpret and explain the impact of emerging database standards ● Evaluate the contribution of database theory to practical implementations of database management systems.	

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List of Challenging Experiments (Indicative)		
1.	Basic SQL Intermediate SQL Advanced SQL	6 hours
2.	ER Modeling	6 hours
3.	Database Design and Normalization	6 hours
4.	Accessing Databases from Programs using JDBC	6 hours

5.	Building Web Applications using PHP & MySQL	6 hours
6.	Indexing and Query Processing	6 hours
7.	Query Evaluation Plans	6 hours
8.	Concurrency and Transactions	6 hours

Programme: MSc Integrated
Course Code: **Title of the Course:** Cloud Computing
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Web Development, Programming	
Objectives	1. To provide students with the fundamentals and essentials of Cloud Computing. 2. To provide students a sound foundation of Cloud Computing so that they are able to start using and adopting Cloud Computing services and tools in their real life scenarios. 3. To enable students to explore some important cloud computing driven commercial systems such as Google Apps, Microsoft Azure and Amazon Web Services and other businesses cloud applications. 4. To impart knowledge in applications of cloud computing	
Content	**Introduction to Cloud Computing** Cloud Computing Overview: Characteristics – challenges, benefits, limitations, Evolution of Cloud Computing, Cloud computing architecture, Cloud Reference Model (NIST Architecture) **Infrastructure as a Service** Service Model, Characteristics, Benefits, Enabling Technologies Case Study : AWS, OpenStack **Platform as a Service** Service Model, Characteristics, Benefits, Enabling Technologies Case Studies : IBM Bluemix, GAE, Microsoft Azure **Software as a Service** Service Model, Characteristics, Benefits, Enabling Technologies Case Study : Salesforce.com, CRM, Online Collaboration Services **Data Analytics as a Service**	6 hours 7 hours 7 hours 7 hours 7 hours 7 hours 7 hours

	Hadoop as a service, MapReduce on Cloud, Chubby locking Service **Introduction to Public and Private Clouds** Shared Resources – Resource Pool – Usage and Administration Portal – Usage Monitor – Resource Management– Cloud Security – Workload Distribution – Dynamic provisioning. **Storage as a service** Historical Perspective, Datacenter Components, Design Considerations, Power Calculations, Evolution of Data Centers, Cloud data storage - CloudTM	
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1) Kai Hwang, Geoffrey Fox, Jack J. Dongarra, Morgan Kaufmann, "Distributed and Cloud Computing: From Parallel Processing to the Internet of Things," 1st Edition, 2011. 2) Gautham Shroff, "Enterprise Cloud Computing: Technology, Architecture, Applications", Cambridge press, 2010. Kris Jamsa, "Cloud Computing", Jones & Barlett Learning, 2013. 4) Rajkumar Buyya, James Broberg, Andrzej Goscinski, "Cloud Computing Principles and Paradigms", John Wiley & Sons, 2011. 5) John Rhoton and Risto Haukiojal, "Cloud Computing Architectured : Solution Design Handbook", Recursive Press, 2013. 6) George Recse, "Cloud Application Architectures: Building Application and Infrastructure in the Cloud" , O' Reilly Media, First Edition, 2009. 7) Dinkar Sitaram, Geetha Manjunathan, "Moving to the Cloud: Developing Apps in the new world of Cloud Computing", Syngress, 2012. 8) Samee. U. Khan, Albert. Y. Zomaya, "Handbook on Data Centers", Springer, 2015.	
Learning Outcomes	Students will be able to Understand: 1. Design, Develop & Demonstrate real-world applications from the Cloud Computing 2. The subtle architectural difference in Public and Private Clouds. 3. The requirements of various service paradigms in Cloud Computing. 4. The methods of processing multimedia elements and other information presentation concepts during multimedia communications.	

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Programme: MSc Integrated
Course Code: **Title of Course:** Data Driven Web App Development
Number of Credits: 4 (2L-0T-4P **Contact hours:** 72 hours (24L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of programming	
Objectives	The course will help the learner build websites and web applications.	
Content	**Foundation in Internet Technologies** ● Basic concepts in Computer Networks; Protocols ● Evolution of Internet and World Wide Web (WWW) ● Web Architectures & Standards ● Browsers & browser-engines	3 hours
	Web page design ● HTML:- markup language; XML & HTML; tag & attributes; semantic (header, main, nav, etc.) & non-semantic elements (div, span); headings, paragraphs, text-formatting tags; colors & background; tables & lists; entities, charsets; links; iframe; form & input - attributes & elements; SVG & canvas ● CSS:- syntax & selectors; box model; text & font properties; display, position, z-index; float & clear; styling for images & html form elements; 2-D/3-D transform, transition, animation; responsive, adaptive & mobile-first layout; viewport & media queries ● CSS library/ framework (e.g. Bootstrap, Foundation)	5 hours
	Client-side scripting ● Dynamic web pages ● JavaScript:- programming features; events; functions; Manipulating DOM; Beyond ECMA 4 ● Javascript library/ framework (e.g. JQuery, ReactJS)	4 hours
	HTTP & Middle-ware ● HTTP, Request & Response, methods & error code, ● headers, URL encoding & decoding ● XML, data & XPath ● JSON	4 hours
	Server-side Programming ● Server instance ● Request handling & response creation ● HTML forms & file uploads ● Session management & application data ● Database connectivity ● AJAX ● Introduction to a Server-side library and/or template engine and/or framework (e.g. PHP - Laravel; JSP - Spring)	4 hours
	Data-driven web pages ● User Experience Fundamentals:- gulf of evaluation and execution; 7 fundamental & universal design principles; Design Elements (line, color, shape, form vs space, value, texture, dot, typography, movement); Visual Design Principles (scale, dominance/emphasis, balance,	4 hours

	harmony); Wireframing, Mockup & Prototype (Paper & Digital); Use of tools (e.g. Pencil, Adobe XD, Sketch and/or Figma); Interaction & Animation ● Use of any data visualization library (D3.js, Chart.js):- charts, graphs, maps, diagrams; SVG; scales & visuals for multi-device ● Building UI for large forms, paginated tables, etc. ● JSON API & AJAX; lazy loading	
Pedagogy	Hands-on assignments / tutorials / peer-learning / project	
References/ Readings	1. Robert W. Sebesta, "Programming the World Wide Web", Pearson Education, 8th Edition 2. https://www.w3schools.com/ 3. Steven Holzner, "HTML 5 Black Book", 1st Edition 4. https://www.tutorialspoint.com/ 5. Frank W. Zammetti, "Modern Full-Stack Development", Apress, 1st Edition (2020) 6. https://www.youtube.com/watch?v=xkBheRZTkaw "Data Visualization with D3 – Full Course for Beginners [2022]" (free course from freecodecamp.org)	
Learning Outcomes	1. Learner will be able to make decision on what web technology to use and for what purpose 2. Learner will have fair idea on the popular 3. technologies used in website development 4. Learner will appreciate the architecture of web 5. applications and the design decisions 6. Learner will be able to design web applications for data driven	

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Suggested Lab Assignments (48 hours):

1. Web page design Assignments
   a. Create a website on a topic given by the instructor, evaluating the website with rubrics for good web design.
   b. Build a website using HTML & CSS by looking at a screenshot/picture of a website component given by the instructor.
   c. Websites built with tables, forms, images, iframes, etc.
   d. A website for each of design strategies (fixed, adaptive, responsive, fluid, mobile-first, etc.).
   e. Assignments using css pseudo-classes & -elements; grid & flex design; understanding the CSS box model & working with the browser developer tools; CSS transformations, transitions & animations
   f. Assignment to create a website built with Bootstrap based on a topic given by the instructor.
2. Client-side scripting Assignments

a. An assignment for understanding the programming aspects of JavaScript and working with the browser developer tools. The use of the newer features of JavaScript (after ECMA 4) is encouraged.
b. An assignment working with regular expressions. A search and filter utility can be built.
c. Assignments for form data processing and validation and use of HTML5 form elements. A web page with form and validated data could be put in a table. The code could be written using table DOM methods and/or HTML DOM methods and/or XML DOM methods.
d. Assignments using various events (mouse, keyboard, etc. events for the form elements, drag-and-drop, window, browser, etc.).
e. A web component built using HTML, CSS & JavaScript based on a existing Bootstrap component (e.g. Accordion)
f. Assignment with the use of a JavaScript library (JQuery, AngularJS, ReactJS, etc.)

3. Server-side programming Assignments
   a. Assignments to work with HTTP headers for passing data and meta-data, cookies, localStorage
   b. Assignments to handle data from web forms; handling the request and response payload
   c. Assignment to manage web sessions
   d. Assignment to develop a CRUD functionality by connecting to a database; AJAX calls
4. Data-driven web pages Assignments
   a. Build a dashboard for tourism data or bank branch
   b. Build a log visualiser
   c. Build a interactive region-map with drill-down, drill-up
   d. Take an API for weather forecast api and map it onto GoogleMap/OSM map
5. Developing a Game with HTML, CSS & JavaScript. The game should have at least 500 lines of (HTML+Javascript) code and make use of various mouse/keyboard events

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Programme: MSc Integrated
Course Code: **Title of the Course:** Data warehousing and Data Mining
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48 L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Probability and Statistics	
Objectives	Data warehousing and data mining are the essential components of decision support systems for the modern day industry and business. These techniques enable the knowledge worker (analyst, manager, executive) to make better and faster decisions. The objective of this course is to introduce the student to various Data Warehousing and Data Mining concepts and techniques. A database perspective has to be used throughout the course to introduce principles, algorithms, architecture, design and implementation of data mining and	

	data warehousing techniques.	
Content	**Introduction and Background:** Introduction to the multidisciplinary field of data mining. Discussion on the evolution of database technology that has led to the need for data warehousing and data mining. Stress on importance of its application potential. Introduction to the different key words and techniques. **Data Warehousing And OLAP:** Insight of data warehouse and on-line analytical processing, AggregationOperations, models for data Warehousing, star schema, fact and dimension tables Conceptualization of data warehouse and multidimensional databases. Life cycle of data warehouse development. Relationship between data warehouse and data mining. **Data Mining Primitives:** Data preprocessing including data cleaning, data integration, data transformation. Definition and Specification of a generic data mining task. Description of Data mining query language with few example queries. **Association Analysis:** Different methods(algorithms) for mining association rules in transaction based databases. Illustration of confidence and support. Multidimensional and multilevel association rules. Classification of association rules. Discussion on few association rule algorithms e.g. Apriori, frequent pattern growth etc. **Classification and Predictions:** Different Classification algorithm, including C4.5, CART etc., use of genie index, decision tree induction, Bayesian classification, neural network technique of back propagation, fuzzy set theory and genetic algorithms. **Clustering:** Partition based clustering, Hierarchical clustering, model based clustering for continuous and discrete data. Discussion on scalability of clustering algorithms. Parallel approaches for clustering. **Web Mining:** Web usage mining, web content mining, web log attributes. Use of web mining in efficient surfing and personalization **Mining Complex Type of Data:** Data mining issues in object oriented databases, spatial databases and multimedia databases, time series databases, and text databases. **Applications of Data Warehousing And Data Mining:** Exploration of websites on data warehousing and data mining applications including bibliography databases, Corporate Houses and Research labs.	6 hours 6 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	

References/ Readings	**Main Reading:** 1. Jiawei Han and Micheline Kamber, "Data Mining Concepts and Techniques," 1st Edition Indian Reprint 2001, Harcourt India Private Limited, ISBN 1-55860-489-8. 2. Margaret Dunham, "Data Mining: Introductory and Advanced Topics," 1st Edition, 2003, Prentice Hall (Pearson Publication), ISBN 0-13-088892-3. 3. Arun K Pujari, "Data Mining Techniques". University Press, 2001. **Supplementary Reading** 1. T. Mitchell, "Machine Learning", 1997, McGraw Hill. 2. S.M. Weiss and N. Indurkhya, "Predictive Data Mining", 1998, Morgan Kaufmann. 3. M. Jarke, M. Lenzerni, Y. Vassiliou, and P. Vassiladis, "Fundamentals of Data Warehouses", 2000, Springer Verlag, Isbn 3-540-65365-1.	
Learning Outcomes	Students will be able to understand Data Warehousing And OLAP, Data Mining Primitives, Association Analysis, Classification and Predictions, Clustering, Web Mining, Mining Complex Type of Data and applications of data mining and data warehousing.	

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Programme: MSc Integrated
Course Code: **Title of the Course:** Domain Specific Predictive Analytics
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Data science fundamentals and programming background	
Objectives	It introduces theoretical foundations, algorithms, methodologies for analyzing data in various domains such Retail, Finance, Risk and Healthcare.	
Content	**Retail Analytics** Understanding Customer: Profiling and Segmentation, Modelling Churn. Modelling Lifetime Value, Modelling Risk, Market Basket Analysis. **Risk Analytics** Risk Management and Operational Hedging: An Overview, Supply Chain Risk Management, A Bayesian Framework for Supply Chain Risk Management, Credit Scoring and Bankruptcy Prediction **Financial Data Analytics** Financial News analytics: Framework, techniques, and metrics, News events impact market sentiment, Relating news analytics to stock returns	8 hours 8 hours 8 hours 8 hours

	Financial Time Series Analytics Financial Time Series and Their Characteristics, Common Financial Time Series models, Autoregressive models, Markov chain models, Time series models with leading indicators, Long term forecasting	8 hours
	Introduction HealthcareAnalytics An Introduction to Healthcare Data Analytics, Electronic Health Records, Privacy-Preserving Data Publishing Methods in Healthcare, Clinical Decision Support Systems **Healthcare Data Analytics** Natural Language Processing and Data Mining for Clinical Text: Core NLP Components, Information Extraction and Named Entity Recognition, Social Media Analytics for Healthcare: Tracking of Infectious Disease Outbreaks, Readmission risk prediction. **Genomic Data Analytics** Microarray Data, Microarray Data Analysis , Genomic Data Analysis for Personalized Medicine , Patient Survival Prediction from Gene Expression Data , Genome Sequence Analysis	8 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. Chris Chapman, Elea McDonnell Feit "R for Marketing Research and Analytics", Springer, 2015. 2. Olivia Parr Rud “Data Mining Cookbook: Modeling Data for Marketing, Risk, and Customer Relationship Management”, Wiley, 2001. 3. Chandan K. Reddy, Charu C. Aggarwal "Healthcare Data Analytics", CRC Press, 2015. 4. Rene Carmona "Statistical Analysis of Financial Data in R", Springer, 2014. 5. James B. Ayers “Handbook Of Supply Chain Management” Auerbach Publications, 2006. 6. PanosKouvelis, Lingxiu Dong, OnurBoyabatli, Rong Li "The Handbook of Integrated Risk Management in Global Supply Chains", Wiley, 2012.	
Learning Outcomes	Students will be able to understand Retail Analytics, Risk Analytics, Financial Data Analytics, Financial Time Series Analytics, Healthcare Analytics, Healthcare Data Analytics and Genomic Data Analytics.	

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Programme: MSc Integrated
Course Code: **Title of the Course :** Image processing
Number of Credits: 6(4L-0T-4P) **Contact hours:** 96 hours(48L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course	Programming Skills(Java/Python)	
Objectives	• To introduce the concepts of image processing and basic analytical methods to be used in image processing. • To familiarize students with image enhancement and restoration techniques. • To explain different image compression techniques. • To introduce segmentation and morphological processing techniques.	
Content	**Introduction:** Image formation model, representation, spatial and Gray Level resolution, Colour models-RGB, CMY and HIS models **Image Enhancement In Spatial Domain:** Piecewise linear transformation, Histogram equalization,Histogram specification, image averaging, spatial filters – smoothing and sharpening, Laplacian filter, sobel operator, Canny edge detector. **Image Enhancement In Frequency Domain:** 2D Discrete Fourier transform and its inverse, filtering in frequency domain, Ideal and Gaussian Low pass filters, high pass filtering, separability property 0f 2D Fourier transform, Fast Fourier Transform. **Image Segmentation:** Line detection, Edge detection, Edge linking and boundary detection, Hough Transform, Thresholding, Region based segmentation **Morphological Image Processing:** Logic operations involving binary images, Dilation and Erosion, Opening and closing, Applications to Boundary extraction, region filling, connected component extraction. **Image Compression:** Coding redundancy- Huffman coding, LZW coding, run length coding, Lossy compression – Lossy predictive coding, transform coding- DCT, bit allocation, Compression standards – JPEG, video Compression. **Image Representation:** Boundary description, Shape numbers, Fourier descriptors, Texture, principal Components based description.	12 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	**Main Reading:** 1. Gonzalez and Woods, “Digital Image Processing”’ 2002, Pearson education, Asia.	

	2. Sonka, Hlavac and Boyle Brooks/Cole, "Image Processing, Analysis, and Machine Vision", 1999, Thomson Asia Pte Ltd Singapore. **Supplementary Reading:** 1. Jain and Rangachar, "Machine Vision", 1999, McGraw Hill International Edition. 2. Schalkoff, John Wiley and Sons, "Digital Image Processing & Computer, 1989.	
Learning Outcomes	After the successful completion of the course the students will be able to: 1. Explain the fundamentals of digital image and its processing 2. Perform image enhancement techniques in spatial and frequency domain. 3. Elucidate the mathematical modelling of image restoration and compression 4. Apply the concept of image segmentation.	

Suggested Lab Assignments (6 * 8 = 48 hours)

1. Program to calculate Fourier Transform of an Image
2. Program to calculate the Grayscale Histogram of an Image
3. Program to perform Median Filtering
4. Program to obtain the Gradient Image using Sobel-Operator.
5. Program for Optimal Thresholding Segmentation.
6. Program for Border-Tracing.
7. Program for Binary Erosion.
8. Program to generate the Binary Skeleton of an Image.

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Programme: MSc Integrated
Course Code:
Title of the Course: Industry 4.0
Number of Credits: 4(4L-0T-0P)
Contact hours: 48 hours (48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programme prerequisites and fundamentals of data science , machine learning	
Objectives	To describe various facets of Industry 4.0, to connect questions raised by Industry 4.0 with appropriate data science techniques, to develop data science tools for Industry 4.0, and to build data-centric business models.	
Content	Introduction to Industry 4.0 – Evolution and history Pillars of Industry 4.0 Industry 4.0 – India context Supplier selection as a classification problem Manufacturing 4.0	12 hours 12 hours

	Prognosis Quality 4.0 Inventory Optimization Dynamic Pricing Logistics 4.0 Future of Manufacturing Business Focus on new paradigm Next decade of Industry 4.0	12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Industry 4.0: Increasing the Competitiveness of Industrial Manufacturing. Published by Intueri, 2011 2. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist, 2011 The Fourth Industrial Revolution by Klaus Schwab 3.Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0 by Ibrahim Garbie,2016 4.Industry 4.0: Managing the digital transformation by Alp ustantag, Emry cevikan, 2018.	
Learning Outcomes	Students will be able to understand Evolution and history of Industry 4.0, Pillars, India context, Supplier selection as a classification problem, Manufacturing 4.0, Prognosis, Quality 4.0, Inventory Optimization, Dynamic Pricing, Logistics 4.0, Future of Manufacturing Business Focus on new paradigm and Next decade of Industry 4.0.	

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Programme: MSc Integrated
Course Code:
Title of the Course: Information Retrieval
Number of Credits: 4(4L-0T-0P)
Contact hours: 48 hours (48 L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Linear Algebra, Programming skills	
Objectives	Basic and advanced techniques for text-based information systems: efficient text indexing; Boolean and vector based retrieval models; Web search including crawling.	
Content	**Overview of Information Retrieval:** Function of an IR system, Kinds of IR systems, Components of an IR system, Problems in designing an IR system.The nature of unstructured and semi-structured text. **Text Analysis and Indexing:** Preliminary stages of text analysis and document processing, tokenization, stemming, lemmatization, stop words, phrases, Indexing: Boolean IR models, inverted files, indexing, signature	12 hours 12 hours

	files, PAT trees, Positional indices. Vector-based IR models: TF/IDF term weighing, similarity measures, test collections and issues. **Index construction and Compression:** Postings size estimation, merge sort, dynamic indexing, positional indexes, n-gram indexes. Index compression: lexicon compression and postings lists compression. Gap encoding, gamma codes, Zipf's Law. Blocking. Extreme compression. **Query Processing:** Query expansion: spelling correction and synonyms. Wild-card queries, permuterm indices, n-gram indices. Edit distance, soundex, language detection. **Matching techniques:** Similarity between documents and queries, Parametric or fielded search. Document zones. The vector space retrieval model, tf.idf weighting. Scoring documents, vector space scoring, the cosine measure, efficiency considerations, reduced dimensionality approximations, Latent Semantic Indexing (LSI), random projection, Page Ranking and HITS. **Information Extraction:** Information extraction, Named entity extraction, Question Answering. Summarization - Qualities of good summary, summary types, extract summary. **Evaluation of IR systems:** Assessment of the performance of IR systems - Precision, Recall, F-Measure. Criteria for evaluation, measuring 'goodness', tests of IR systems. Presentation of search results, display of search results, manipulation of search results. **Relevance feedback:** User modeling and information need: user profiling, Relevance judgments. Additional term selections to the system, Dynamic respond ally to judgments and selections, Personalization of search. **Taxonomy and Ontology:** Creating domain specific ontology, Ontology life cycle. **Distributed and Parallel IR:** Relationships between documents, Identify appropriate networked collections, Multiple distributed collections simultaneously. **Web Search Engines:** Web crawlers, robot exclusion, Web data mining, Metacrawler, Collaborative filtering, Web agents (web shopping, bargain finder,..), Economic, ethical, legal and political issues.	12 hours 12 hours

	Multimedia IR: Techniques to represent audio and visual documents, Query databases of multimedia documents, Display the results of multimedia searches.	
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. Managing Gigabytes, by I. Witten, A. Moffat, and T. Bell, 1999. 2. Modern Information Retrieval, by R. Baeza-Yates and B. Ribeiro-Neto, 1999. 3. Information Retrieval: Algorithms and Heuristics by D. Grossman and O. Frieder, 1998.	
Learning Outcomes	Students will be able to understand Overview of Information Retrieval, Text Analysis and Indexing, Index construction and Compression, Query Processing, Matching techniques, Information Extraction, Evaluation of IR systems, Relevance feedback, Taxonomy and Ontology, Distributed and Parallel IR, Web Search Engines and Multimedia IR.	

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Programme: MSc Integrated
Course Code: **Title of the Course:** IoT
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Internet Technologies, Computer Organization and architecture, Operating Systems.	
Objectives	To understand the fundamentals of Internet of Things and the protocols and standards designed for IoT	
Content	Introduction to IoT: Introduction, IoT ecosystem, Applications, Challenges. Fundamentals: IoT Devices - Sensors, Actuators, and gateways, Basics of the wireless sensor network.	10 hours
	IoT Architecture & Design: oneM2M, IoTWF, Additional Reference Models, Core functional stack, Data Management and compute stack. Communicating smart objects: Communication criteria, communication models, IoT access technologies – 3GPP MTC, IEEE 802.11, IEEE 802.15, WirelessHART, ZWave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7	14 hours
	IoT Network Layer: IP as IoT network layer, IPv6, 6LoWPAN, 6TiSCH, RPL, CORPL, CARP IoT Transport and Application protocols: Transport Layer: TCP, UDP, DCCP, SCTP, TLS, DTLS IoT application transport methods, HTTP, CoAP, XMPP, MQTT,	14 hours

	AMQP, DDS IoT Transport and Application protocols: Transport Layer: TCP, UDP, DCCP, SCTP, TLS, DTLS IoT application transport methods, HTTP, CoAP, XMPP, MQTT, AMQP, DDS Security in IoT: MAC802.15.4, 6LoWPAN, RPL, Application Layer security. IoT Application case study: Discuss any 3 applications of IoT	 10 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press, 2017 2. Hersent, Olivier, David Boswarthick, and Omar Elloumi, The internet of things: Key applications and protocols. John Wiley & Sons, 2011. 3. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and Paradigms. Elsevier, 2016.	
Learning Outcomes	After completing the course, students will be able to: ● Understand the concepts of the IoT Architecture Reference model ● Identify the IoT networking components and protocols.	

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Programme: MSc Integrated
Course Code: **Title of the Course:** Numerical Methods
Number of Credits: 4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Basic knowledge of multivariate calculus and elementary real analysis	
Objectives	Aimed at imparting numerical techniques required for dealing with data of scientific applications and builds Foundations for solving equations for Machine Learning models	
Content	**Root finding:** Functions and polynomials, zeros of a function, roots of a nonlinear equation, bracketing, bisection, secant, and Newton-Raphson methods. Interpolation, splines, polynomial fits, Chebyshev approximation. **Numerical Integration and Differentiation:** Evaluation of integrals, elementary analytical methods, trapezoidal and Simpson's rules, Romberg integration, Gaussian quadrature and orthogonal polynomials, multidimensional integrals, summation of series, Euler-Maclaurin summation formula, numerical differentiation and estimation of errors.	10 hours 14 hours 10 hours 14 hours

	Optimization: Extremization of functions, simple search, Nelder-Mead simplex method, Powell's method, gradient-based methods, simulated annealing. **Complex analysis:** Complex numbers, functions of a complex variable, analytic functions, conformal mapping, Cauchy's theorem. Calculus of residues. Fourier and Laplace Transforms, Discrete Fourier Transform, z transform, Fast Fourier Transform (FFT), multidimensional FFT, basics of numerical optimization.	
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	* Richard L. Burden and J. Douglas Faires, Numerical Analysis: Theory and Applications, India Edition, Cengage Brooks-Cole Publishers, 2010. * Press, W.H., Teukolsky, S.A., Vetterling, W.T., and Flannery, B.P., Numerical Recipes in C/FORTRAN, Prentice Hall of India, New Delhi, 1994. * Borse, G.J., Numerical Methods with MATLAB: A Resource for Scientists and Engineers, PWS Publishing Co., Boston, 1997.	
Learning Outcomes	Students will be able to understand Root finding, Numerical Integration and Differentiation, Optimization and Complex analysis.	

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Programme: MSc Integrated
Course Code: **Title of Course:** Programming Paradigms
Number of Credits: 4 (4L-0T-0P) **Contact hours:** 48 hours (48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of programming	
Objectives	To learn and understand various programming paradigms.	
Content	**Understanding Programming Paradigm** ● Programming paradigm concept, motivation, types and classification of paradigms. ● Factors with respect to programming languages: Binding times and flexibility; Scoping; First class values; Abstraction; Typing; Storage Allocation & Dynamic Memory	6 hours
	Imperative Programming ● Variables and data types; Operators and expressions; Input/Output operations, Decision constructs; Looping constructs ● Procedural (*in Python/C*) -- blocks & scope; procedures (functions) ● Object Oriented (*in Java/C++*) -- classes & objects,	6 hours

	object-oriented principles (encapsulation, abstraction, inheritance, polymorphism)	
	Functional Programming (*in Haskell/Clojure/Scala*) ● Revision of mathematical Functions' concepts ● Side effects; Pure functions ● Type induction ● Defining functions ● Currying; Function composition ● Recursion ● Lazy evaluation; infinite lists ● List comprehensions ● Higher order functions; Folds	10 hours
	Logic Programming (*in Prolog/ECLiPSe Constraint language*) ● Revision of mathematical Logic concepts ● Programming "without algorithms" ● Logic programming with facts, rules and goals ● Recursion; Lists ● Constraint logic programming; constraints as relationship between variables; solving puzzles (like sudoku)	10 hours
	Event-driven Programming (*in Python/.NET*) ● Events ● Main loop & callback ● Scheduler & Event handlers; Triggers ● Exception handling ● Reliable eventing ● Asynchronous triggers	8 hours
	Multi-Paradigms and more ● Language support for multi paradigms; Benefits & issues ● Parallel programming -- Data Parallelism (*in OpenMP*) and Message Passing (*in MPI*) ● Reactive programming (*in Elm/ReactiveX for Java, JS*) ● Meta programming (*in Lisp*) ● Natural Language Programming (*in SciLab/MATLAB*)	8 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching / pair programming/ reading research papers/ presentations	
References/ Readings	● Terrance W. Pratt, Marvin V. Zelkowitz, "Programming Languages - Design & Implementation" ● Robert L. Sebesta, "Concepts of Programming Languages" ● Ravi Sethi, "Programming Languages Concepts & Constructs" ● Bruce J. Mac Lennan, "Principles of Programming Languages: Design, Evaluation, and Implementation" ● Kenneth C. Louden, "Programming Languages: Principles and Practice"	

	• Allen Tucker, Robert Noonan, "Programming Languages: Principles and Paradigms" • Graham Hutton, "Programming in Haskell" • W. Clocksin, "Programming in Prolog" • Slim Abdennadher, Thom Frühwirth, "Essentials of Constraint Programming" • Roland Kuhn, Brian Hanafee, Jamie Allen, "Reactive Design Patterns"	
Learning Outcomes	1. Learner will be able to distinguish between different programming paradigms 2. Learner will be able to choose an adequate programming paradigm in solving specific software engineering problems 3. Learner will be able to recognize the similar concepts implemented in a different way across different programming languages and paradigms	

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Programme: MSc Integrated
Course Code: **Title of the Course:** Sequential Decision Making
Number of Credits:4(4L-0T-0P) **Contact hours:** 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Machine learning	
Objectives	Introductory level course for sequential decision making. It helps learners to find a stopping rule that optimizes the decision in terms of minimizing losses or maximizing gains , including observation costs.	
Content	Introduction to Online Learning, Halving algorithm Online Machine Learning; Perceptron and Winnow Intro to Regret; Online learning with expert advice - Hedge algorithm Online linear optimization Online convex optimization; Online learning summary Introduction to Multi armed Bandits - EXP3 Contextual MAB - EXP4 Stochastic MAB, Epsilon Greedy, Explore then commit Stochastic MAB, UCB, Thompson Sampling Stochastic MAB - Linear Bandits - LinUCB algorithm; MAB summary Introduction to Reinforcement Learning - Markov Decision Process Q-learning	12 hours 12 hours 12 hours 12 hours

Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Sequential decision making problems by cedric pralet,Thomas schiex,Gerard. 2. Introduction to sequential decision making by yan chen, chiic yu wang,Ray liu.	
Learning Outcomes	At the end of the course, students will be able to understand the differences between the various sequential decision making problems based on the type of feedback involved, recognize practical ML problems as sequential decision making problems whenever they are, learn about optimal algorithms for several sequential decision making settings, and apply the algorithms studied in the course to various practical sequential decision making scenarios.	

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Programme: MSc Integrated
Course Code:
Title of the Course: Soft Computing
Number of Credits: 6(4L-0T-4P)
Contact hours: 96 hours (48L-0T-48 P)
Effective from AY: 2022-23

Prerequisites for the course	Machine Learning	
Objectives	The objective of this course is to introduce methods for handling imprecise and uncertain data using Rough sets, Neuro Fuzzy Systems and foster their abilities in designing and implementing optimal solutions for real-world and engineering problems using derivative free optimization techniques.	
Content	**Module:1 Introduction to Soft Computing** Soft Computing Overview – Uncertainty in data, Hard vs Soft Computing **Module:2 Neural Networks** Introduction, RBF Networks, Self-Organizing Map, Boltzmann Machines, Convolutional Neural Networks. **Module:3 Fuzzy Systems** Fuzzy Sets, Fuzzy Relations, and Membership functions, Properties of Membership functions, Fuzzification and Defuzzification. **Module:4 Fuzzy logic** Fuzzy Rule based systems, Fuzzy Decision making, Fuzzy Classification, Fuzzy CMeans Clustering. **Module:5 Rough Sets** Rough Sets – Definition, Upper and Lower Approximations, Boundary Region, Decision Tables and Decision Algorithms. Properties of Rough Sets. Rough K-means clustering, Rough	8 hours 10 hours 10 hours 10 hours 10 hours

	Module:6 Optimization Techniques Introduction, Genetic Algorithm, Memetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization, Frog-Leaping. **Module:7 Hybrid Systems** GA Based Back Propagation Networks, Fuzzy Back Propagation Networks, Evolutionary Ensembles	
Pedagogy	Assignment / Quiz / Project / Seminar	
References/ Readings	Main Readings 1. S.N. Sivanandham and S.N.Deepa, “Principles of Soft Computing”, 2nd Edition, Wiley Publications. 2. Andries P. Engelbrecht, "Computational Intelligence: An Introduction", John Wiley & Sons,2007. 3. Laurene V. Fausett “Fundamentals of Neural Networks: Architectures, Algorithms And Applications”, Pearson,1993. 4. Simon Haykin "Neural Networks and Learning Machines" Prentice Hall,2008. Timothy Ross, “Fuzzy Logic with Engineering Applications”, Third Edition,Wiley.	
Learning Outcomes	After successfully completing the course the student will be able to • Have a general understanding of soft computing methodologies, to deal with imprecise and uncertain data • Develop computational neural network models for some simple biological systems; • Develop fuzzy models for engineering systems, particularly for control systems; • Apply derivative free optimization methods to solve real world problems Demonstrate some applications of computational intelligence Student Learning Outcomes (SLO):	

List of Challenging Experiments (Indicative) (6 * 8 =48 hours)

Project

The following is the sample project that can be given to students to be implemented in any programming language.

• Develop Fuzzy Decision-Making for Job Assignment Problem
• Implement TSP using OptimizationTechniques
• Develop a suitable method for Health Care Application using Neuro- Fuzzy Systems
• Develop a suitable method for Face RecognitionSystem
• Layout Optimization using GeneticAlgorithms
• Fault Diagnosis using rough set theory
• Software safety analysis using rough sets A Neuro-fuzzy Approach to Bad Debt Recovery in Healthcare

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Programme: MSc Integrated
Course Code: **Title of the Course:** Streaming processing and Analytics
Number of Credits: 6(4L-0T-4P) **Contact hours:** 96 hours (48 L-0T-48 P)
Effective from AY: 2022-23

Prerequisites for the course	None	
Objectives	It introduces theoretical foundations, algorithms, methodologies, and Applications of streaming data and also provides practical knowledge for handling and analyzing streaming data.	
Content	**Module:1 Introduction** Characteristics of the data streams, Challenges in mining data streams Requirements and principles for real time processing, Concept drift Incremental learning.	8 hours
	Module:2 Data Streams Basic Streaming Methods, Counting the Number of Occurrence of the Elements in a Stream, Counting the Number of Distinct Values in a Stream, Bounds of Random Variables, Poisson Processes, Maintaining Simple Statistics from Data Streams, Sliding Windows, Data Synopsis, Change Detection: Tracking Drifting Concepts, Monitoring the Learning Process	8 hours 8 hours
	Module:3 Decision Trees The Very Fast Decision Tree Algorithm (VFDT), The Base Algorithm, Analysis of the VFDT Algorithm, Extensions to the Basic Algorithm: Processing Continuous Attributes, Functional Tree Leaves, Concept Drift.	
	Module:4 Clustering from Data Streams Clustering Examples: Basic Concepts, Partitioning Clustering - The Leader Algorithm, Single Pass k-Means, Micro Clustering, Clustering Variables: A Hierarchical Approach	8 hours
	Module:5 Frequent Pattern Mining Mining Frequent Itemsets from Data Streams- Landmark Windows, Mining Recent Frequent Itemsets, Frequent Itemsets at Multiple Time Granularities Sequence Pattern Mining-Reservoir Sampling for Sequential Pattern Mining over data streams	8 hours
	Module:6 Evaluating Streaming Algorithms Evaluation Issues, Design of Evaluation Experiments, Evaluation Metrics, Error Estimators using a Single Algorithm and a Single Dataset, Comparative Assessment, The 0-1 loss function, Evaluation Methodology in Non-Stationary Environments, The Page-Hinkley Algorithm.	8 hours
	Module:7 Complex Event Processing Introduction to Complex Event Processing, Features of CEP, Need for CEP, CEP Architectural Layers, Scaling CEP, Events, Timing and Causality, Event Patterns, Rules and Constraint,	

	STRAW-EPL, Complex Events and Event Hierarchies	
Pedagogy	Assignment / Quiz / Project / Seminar	
References/ Readings	1. Joao Gama, "Knowledge Discovery from Data Streams", CRC Press, 2010. 2. David Luckham, "The Power of Events: An Introduction to Complex Event Processing in Distributed Enterprise Systems", Addison Wesley, 2002. 3. Charu C. Aggarwal, "Data Streams: Models And Algorithms", Kluwer Academic Publishers, 2007.	
Learning Outcomes	1. Recognize the characteristics of data streams that make it useful to solve real-world problems. 2. Identify and apply appropriate algorithms for analyzing the data streams for a variety of problems. 3. Implement different algorithms for analyzing the data streams 4. Identify the metrics and procedures to evaluate a model	

List of Challenging Experiments (Indicative) (6 * 8 =48 hours)

1	Exploring one stream processing engine like storm or STREAM etc
2	Implementation of algorithms for example : VFDT, CVFDT
3	Implementation of Clustering
4	Implementation of Frequent pattern mining
5	Exploring one CEP engine like ESPER or DROOLS
6	Exercise with continuous queries Logical operations on single stream
7	Exercise with continuous queries Logical operations on multiple streams
8	Exercise with continuous queries temporal operators on single stream
9	Exercise with continuous queries temporal operators on multiple streams Exercise with complex continuous queries with logical, relational & temporal operators on multiple streams

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Programme: MSc Integrated
Course Code: **Title of the Course:** Text Analytics and Text Mining
Number of Credits: 6(4L-0T-4P) **Contact hours:** 96 hours(48 L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course	Machine Learning, Probability and Statistics.	
Objectives	Widely used in knowledge-driven organizations, text mining is the process of examining large collections of documents to discover new information or help answer specific research questions. Text mining identifies facts, relationships and assertions that would otherwise remain buried in the mass of textual big data.	
Content	An overview of natural language processing techniques and text representation, which are the foundation for all kinds of text-mining applications, and word association mining with a particular focus on mining one of the two basic forms of word associations (i.e., paradigmatic relations) Word association mining with a particular focus on mining the other basic form of word association (i.e., syntagmatic relations), and start learning topic analysis with a focus on techniques for mining one topic from text. Topic analysis in depth, including mixture models and how they work, Expectation-Maximization (EM) algorithm and how it can be used to estimate parameters of a mixture model, the basic topic model, Probabilistic Latent Semantic Analysis (PLSA), and how Latent Dirichlet Allocation (LDA) extends PLSA. Text clustering, including the basic concepts, main clustering techniques, including probabilistic approaches and similarity-based approaches, and how to evaluate text clustering. You will also start learning text categorization, which is related to text clustering, but with predefined categories that can be viewed as pre-defining clusters. Various methods for text categorization, including multiple methods classified under discriminative classifiers, and you will also learn sentiment analysis and opinion mining, including a detailed introduction to a particular technique for sentiment classification (i.e., ordinal regression). Sentiment analysis and opinion mining with a focus on Latent Aspect Rating Analysis (LARA), and you will learn about techniques for joint mining of text and non-text data, including contextual text mining techniques for analyzing topics in text in association with various context information such as time, location, authors, and sources of data	6 hours 6 hours 12 hours 12 hours 12 hours

Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Natural Language Processing with Python by Steven Bird, Ewan Klein and Edward Loper. 2. Text Mining with R by Julia Silge and David Robinson. 3. Taming Text by Grant Ingersoll, Thomas Morton and Drew Farris. 4.Deep Learning in Natural Language Processing by Li Deng, Yang Liu.	
Learning Outcomes	Students will be able to understand artificial intelligence (AI) technology that uses natural language processing (NLP) to transform the free (unstructured) text in documents and databases into normalized, structured data suitable for analysis or to drive machine learning (ML) algorithms.	

Suggested Lab Assignments (6 *8 = 48 hours)

1. Programming exercises to understand the basic library of python- NLTK, Numpy and Scipy Write program to implement naïve bayes classifier.
2. Write program to implement hierarchical clustering
3. Write a program to implement a back propagation model of a neural network.
4. Write program to implement forward algorithm of HM
5. Write a program to implement the Viterbi algorithm of HMM.
6. Write program to implement baum Welsh
7. Document level sentiment analysis
8. Sentence level sentiment analysis
9. Aspect based sentiment analysis

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Programme: MSc Integrated

Course Code:
Title of the Course: Video Analytics
Number of Credits: 4(4L-0T-0P)
Contact hours: 48 hours(48L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Image Processing, Probability, Linear Algebra.	
Objectives	The main goal of video analytics is to automatically recognize temporal and spatial events in videos. A person who moves suspiciously, traffic signs that are not obeyed, the sudden appearance of flames and smoke; these are just a few examples of what a video analytics solution can detect.	

Content	Revisit to Digital Image and Video Processing Camera Models Background Modelling Object Detection and Recognition Local Feature Extraction Biologically Inspired Vision Object Classification Segmentation Object Tracking Activity Recognition Anomaly Detection Handling Occlusion Scale and Appearance changes Other Applications	12 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer 2010. 2. Forsyth, D.A., and Ponce, J., Computer Vision: A Modern Approach, Pearson Education, 2003.	
Learning Outcomes	Students will be able to understand Digital Image and Video Processing, Camera Models, Background Modelling, Object Detection and Recognition, Local Feature Extraction, Biologically Inspired Vision, Object Classification, Segmentation, Object Tracking, Activity Recognition, Anomaly Detection, Handling Occlusion, Scale and Appearance changes and Other Applications.	

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Annexure IV

MCA REVISED COURSE STRUCTURE to be effective from Academic Year 2022-23					
SEMESTER – 1					
Course-Code	***Course Title***	***L***	***T***	***P***	***Credits***
Discipline Specific Core Courses(DSCC)					
CSA-500	*Data Structures & Algorithms*	*2*	*0*	*0*	***2***
CSA-501	*Object Oriented Concepts*	*2*	*0*	*0*	***2***
CSA-502	*Operating Systems*	*2*	*0*	*0*	***2***
CSA-503	*Internet Technologies*	*3*	*0*	*0*	***3***
CSA-504	*Data Structures & Algorithms Lab*	*0*	*0*	*4*	***2***
CSA-505	*Object Oriented Programming Lab*	*0*	*0*	*4*	***2***
CSA-506	*LINUX Lab*	*1*	*0*	*4*	***3***
	Total Credits for DSCC				***16***
Discipline Specific Elective Courses(DSEC)					
CSA-521	*Mathematics for Computer Science*	*4*	*0*	*0*	***4***
CSA-522	*Discrete Mathematical Structures*	*4*	*0*	*0*	***4***
	Total Minimal Credits for DSEC				***4***
Total Minimum Credits Semester – 1					***20***
2 Value Added Courses, Students to be encouraged / made mandatory to go through the courses, but not considered for GPA Calculation, will appear on Grade Card					
	Yoga and Meditation	*0*	*0*	*4*	*0*
	Any Community Engagement Course like - Swachh Bharat Student Internship(SBSI) or Community Engagement and Rural Development (CERD) Course	*0*	*0*	*4*	*0*
MCA REVISED COURSE STRUCTURE to be effective from Academic Year 2022-23					
SEMESTER – 2					
Course-Code	***Course Title***	***L***	***T***	***P***	***Credits***
CSA-507	*Web Development*	*2*	*0*	*0*	***2***
CSA-508	*Database Management Systems*	*2*	*0*	*0*	***2***
CSA-509	*Machine Learning*	*3*	*0*	*0*	***3***
CSA-510	*Web Development Lab*	*1*	*0*	*4*	***3***
CSA-511	*Database Management Systems Lab*	*1*	*0*	*4*	***3***
CSA-512	*Machine Learning Lab*	*1*	*0*	*4*	***3***

Total Credits for DSCC					***16***
Discipline Specific Elective Courses (DSEC)					
CSA-523	*Cryptography and Network Security*	*4*	*0*	*0*	***4***
CSA-524	*Natural Language Processing*	*2*	*0*	*2*	***4***
CSA-525	*Network Programming*	*4*	*0*	*0*	***4***
CSA-526	*Human Computer Interaction*	*4*	*0*	*0*	***4***
CSA-527	*Agile Methodology*	*4*	*0*	*0*	***4***
CSA-528	*Modern Development Platforms*	*4*	*0*	*0*	***4***
CSA-529	*Ethical Hacking*	*4*	*0*	*0*	***4***
CSA-530	*Advanced Unix Programming*	*4*	*0*	*0*	***4***
CSA-531	*Theory of Computation*	*4*	*0*	*0*	***4***
Total Minimum Credits for DSEC					***4***
Total Minimum Credits Semester - 2					***20***

MCA REVISED COURSE STRUCTURE to be effective from Academic Year 2022-23					
SEMESTER – 3					
Course-Code	***Course Title***	***L***	***T***	***P***	***Credits***
The following Research Specific Elective Courses(RSEC) to be opted in consultation with the Mentor based on the Dissertation type opted by the student for Semester 4.					
CSA-600	*Speech Processing*	*2*	*0*	*4*	***4***
CSA-601	*Machine Translation*	*2*	*0*	*4*	***4***
CSA-602	*Educational Technology*	*2*	*0*	*4*	***4***
CSA-603	*Computer Graphics*	*2*	*0*	*4*	***4***
CSA-604	*Data Science*	*2*	*0*	*4*	***4***
CSA-605	*IoT Architecture and Protocols*	*4*	*0*	*0*	***4***
CSA-606	*Mobile App Development*	*2*	*0*	*4*	***4***
CSA-607	*Research Methodology*	*2*	*0*	*4*	***4***
CSA-608	*Deep Learning*	*2*	*0*	*4*	***4***
CSA-609	*Programming Paradigms*	*4*	*0*	*0*	***4***
CSA-610	*Software Testing*	*2*	*0*	*4*	***4***
CSA-611	*Artificial Intelligence*	*2*	*0*	*4*	***4***
CSA-612	*MLOps*	*2*	*0*	*4*	***4***
CSA-613	*IoT application development*	*2*	*0*	*4*	***4***
Total Minimum Credits for RSEC					***8***

Generic Elective Courses(GEC)- total 12 credits to be opted					
CSA-621	Corporate Skills	4	0	*0*	4
CSA-622	Seminar Course	*4*	*0*	*0*	***4***
	Value Added Course / Skill Enhancement Courses / Community Engagement Course / Multidisciplinary Course	2	0	*4*	4
	Any one offered by Commerce Discipline for that semester can be opted	*4*	*0*	*0*	***4***
	Any one offered by Economics Discipline for that semester can be opted	*4*	*0*	*0*	***4***
	Any one offered by Management Studies Discipline for that semester can be opted	*4*	*0*	*0*	***4***
	Foreign or Indian Language Course	*4*	*0*	*0*	***4***
Total Minimum Credits for GEC					***12***
SWAYAM / MOOC Courses ***can be opted over and above the regular prescribed as Audit Courses***					
Total Minimum Credits for Semester 3					***20***

MCA REVISED COURSE STRUCTURE to be effective from Academic Year 2022-23					
SEMESTER – 4					
The following Research Specific Elective Courses(RSEC) to be opted in consultation with the Mentor based on the Dissertation type opted by the student for Semester 4. It could be completed in Semester 3 before going for Internship.					
CSA-600	*Speech Processing*	*2*	*0*	*4*	***4***
CSA-601	*Machine Translation*	*2*	*0*	*4*	***4***
CSA-602	*Educational Technology*	*2*	*0*	*4*	***4***
CSA-603	*Computer Graphics*	*2*	*0*	*4*	***4***
CSA-604	*Data Science*	*2*	*0*	*4*	***4***
CSA-605	*IoT Architecture and Protocols*	*4*	*0*	*0*	***4***
CSA-606	*Mobile App Development*	*2*	*0*	*4*	***4***
CSA-607	*Research Methodology*	*4*	*0*	*0*	***4***
CSA-608	*Deep Learning*	*2*	*0*	*4*	***4***
CSA-609	*Programming Paradigms*	*4*	*0*	*0*	***4***

CSA-610	*Software Testing*	*2*	*0*	*4*	***4***
CSA-611	*Artificial Intelligence*	*2*	*0*	*4*	***4***
CSA-612	*MLOps*	*2*	*0*	*4*	***4***
CSA-613	*IoT application development*	*2*	*0*	*2*	***4***
Total Minimum Credits for RSEC					***4***

Dissertation Type	***Credits***
CSA-652: Industry Internship / Software Project Development ***OR*** *CSA-651: Research Project in Academic or Research Institutes*	*16*
Total Credits for Dissertation	***16***
Total Minimum Credits for Semester-4	***20***
Total Minimum Credits for two-year MCA degree Programme	***80***

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MCA SEMESTER I COURSES

Programme: MCA
Course Code: CSA-500 **Title of Course:** Data Structures & Algorithms
Number of Credits: 2 (2L-0T-0P) **Contact Hours:** 30 hours (30L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programming using any Programming Language	
Objectives	The aim of the course is to emphasize the importance of data structures in implementing efficient algorithms. It provides an exposure to various algorithm design techniques and an introduction to algorithm analysis.	
Content	**Revision of Programming & Data Structures** Problem solving, Data Types: Primitive and User Defined Selection Constructs, Repetition Constructs, Recursion Pointers Algorithm Representation: - Pseudocode and flowcharts Three level Approach Abstract Data Types (ADTs) Basic Linear Data Structures (LinkedList, Stack, Queue)	5 hours
	Algorithm Analysis Analysis of Algorithms Algorithm Complexity: Space and Time Cases of Complexity: Best, Worst and Average Growth of Functions: Asymptotic Notation	3 hours
	Advanced Linear Data Structures Variants of Linked List and its applications (e.g. Polynomial	4 hours

	addition, Sparse matrices) Applications of stacks (e.g. Infix-to-Postfix conversion, Evaluating Postfix Expressions, Bracket Matching) Variants of Queue and Applications	
	Nonlinear Data Structures: Trees: Binary Search Trees, AVL Trees, B-trees & variants. Tree Traversal Algorithms Heaps and its applications (e.g. implementation of Priority Queue) Graph: Adjacency Matrix and Adjacency List Representations Graph Traversal Algorithms: Breadth First Search and Depth First Search	10 hours
	Divide & Conquer Strategy Algorithms based on Divide and Conquer Strategy: Sorting Algorithms (QuickSort, MergeSort) Binary Search	3 hours
	Greedy Algorithms Huffman Coding Algorithm Minimum Cost Spanning Tree (Prim's, Kruskal's) Single Source Shortest Path (Dijkstra's)	2 hours
	Dynamic Programming Coin Change Problem Longest Common Subsequence All-pair shortest Path (floyd-warshall)	3 hours
Pedagogy	● Lectures/Tutorials/Assignments/Quizzes ● Each data structure should be explained along with implementation of its ADT, its applications and complexity	
References/ Readings	1. Horowitz, Ellis, Sartaj Sahni, and Susan Anderson-Freed. "Fundamentals of data structures in C" WH Freeman & Co., Latest Edition. 2. Thomas H. Cormen, Charles E. Leiserson, et al "Introduction to Algorithms", Latest Edition 3. Allen, Weiss Mark. Data structures and algorithm analysis in C. Pearson Education India, Latest Edition. 4. Dasgupta, Papadimitriou, and Vazirani,Algorithms, by McGraw-Hill. 5. Jeri R. Hanly and Eliot B. Koffman "Problem Solving and Program Design in C" Pearson Education, VII Edition, 2012 6. R.G.Dromey "How to Solve it by Computer ", PHI , Latest Edition	
Learning Outcomes	Upon successful completion of the course, a student will be able to ● Implement common data structures such as lists, stacks, queues, graphs, and binary trees for solving programming problems.	

	● Identify and use appropriate data structures in the context of a solution to a given problem. ● Be able to analyze the complexity of a given algorithm	

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Programme: MCA
Course code: CSA-501 **Title of course:** Object Oriented Concepts
Number of credits: 2 (2L-0T-0P) **Contact hours:** 30 hours(30L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of Programming using any Programming Language	
Objectives	Aim of this course is to introduce the learner to the object oriented paradigm.	
Content	**Classes and objects** Programming paradigm; procedural to object oriented Class; attributes & methods; classes as modules & types; uniform type system, wrapper type classes Object; object references; objects instantiation & interaction; constructor & destructor; pass-by-reference & pass-by-value Object copying & cloning; composite objects Static & non-static members Enumeration & Annotations	8 hours
	Object oriented principles Encapsulation Inheritance; types of inheritance; diamond problem Abstraction; virtual methods Polymorphism; overloading and overriding	8 hours
	Object oriented features Interfaces Access modifiers Errors & Exceptions; user-defined exceptions Collections Anonymous & Inner classes Type parametric polymorphism (e.g. Generics in Java & Templates in C++)	8 hours
	Advanced features Persistence & Serialization; JSON User packages & custom libraries; reflection Predicates & streams Lambda functions	6 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching / flip classroom. Concepts can be explained using UML class diagrams.	
References/ Readings	**Main Reading** 1. Timothy Budd, "An Introduction to Object Oriented Programming", Pearson Education, 3rd Edition 2. Brett D. McLaughlin, Gary Pollice & David West, "Head	

	First Object-Oriented Analysis Design", O'Reilly 3. Ken Arnold, James Gosling, David Holmes, "The Java Programming Language", Addison-Wesley Professional 4. Stanley Lippman, "C++ Primer", Addison Wesley 5. Cay S. Horstmann, "Core Java Volume I—Fundamentals", Pearson 6. Herbert Schildt, "Java: The Complete Reference", Oracle Press 7. Joshua Bloch, "Effective Java", Addison Wesley 8. Kathy Sierra & Bert Bates, "Head First Java", O'Reilly 9. Bjarne Stroustroup, "The C++ Programming Language", Addison Wesley 10. https://www.tutorialspoint.com/java/index.htm	
Learning Outcomes	1. Learner will appreciate mapping real-world scenarios in the object-oriented world 2. Learner will understand object-oriented principles 3. Learner will be able to design object oriented softwares 4. Learner will be able to analyse a given problem and breakdown into logical units and solve via a bottom-up approach	

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Programme: MCA
Course Code: CSA-502 **Title of the Course:** Operating System
Number of Credits: 2 (2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Computer Architecture Basics	
Objectives	This course focuses on the principles and understanding of the functionality of an operating system and evaluates their trade-off in various environments.	
Content	**Introduction and Systems Structures** Computing Environments, Operating-systems Services, System Calls, System Programs, Virtual Machines, monolithic and micro kernel architectures	2 hours
	Process Management Process - Concept and states, Process Creation and Control, Scheduling Criteria, Scheduling Algorithms, MultiLevel Queues, Multiple-processor scheduling, Real time CPU scheduling	3 hours
	Threads Motivation and Challenges, Multithreading Models, Threading Issues, Thread libraries, Thread scheduling	3 hours
	Process Synchronization Cooperating processes and Race Conditions, The critical-section problem, Peterson's solution, mutex locks, Synchronization Hardware, Semaphores and their Implementation, Classic problems of synchronization	4 hours

	Inter process Communication, Overview of IPC, Examples of IPC Systems, Communication in Client Server Systems.	2 hours
	Deadlocks System Model, Deadlock characterization, Methods for Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Recovery From Deadlock	3 hours
	Memory Management Hardware Support, Address Binding, Swapping , Contiguous Memory Allocation, Fragmentation, Memory Protection, Paging, Structure of the page table, Segmentation, Example: Intel architecture	4 hours
	Virtual-Memory Management Background, Demand Paging, Copy-on-write, Page Replacement algorithms, Allocation of Frames, Thrashing, Allocating Kernel Memory	4 hours
	File System File Concept, Access Methods, Directory Structure, File-system mounting, File sharing, Protection. Virtual file systems, Implementing File Systems, Directory implementation, Allocation Methods, Free-space Management, Efficiency and performance, Recovery, Log-structured file systems	3 hours
	Secondary-storage Structure Overview of Mass-storage Structure, Disk Structure, Disk Attachment, Disk Scheduling, Disk Management, Swap-Space Management	2 hours
Pedagogy	lectures/ tutorials/assignments/class presentations and debates/peer reviews/self-study.	
References/ Readings	**Main Reading** 1. Silberschatz ,Galvin and Gagne , Operating systems Principles – 8th edition or Later(Wiley Asia Student Edition) 2. Deitel H.M., “An Introduction to Operating Systems”, Addison Wesley Publishers Company, Latest Edition 3. Milenkovic M., “Operating Systems : Concepts and Design”, McGraw Hill International Edition Computer Science series ; Latest Edition 4. Tanenbaum A. S., Modern Operating Systems”, Prentice Hall of India Pvt. Ltd.,Latest Edition 5. Operating Systems – a modern perspective - Gary Nutt , Addison Wesley, Latest Edition	
Learning Outcomes	1. To understand the services provided by and the design of an operating system. 2. To understand the structure and organization of the file system. 3. To understand what a process is and how processes are synchronized and scheduled.	

	4. To understand different approaches to memory management. 5. Students should be able to understand the implementation and use of system calls for managing processes, memory and the file system. 6. Students should understand the data structures and algorithms used to implement an OS. 7. Evaluate operating system implementations	

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Programme: MCA
Course Code: CSA-503
Title of the Course: Internet Technologies
Number of Credits: 3 (3L-0T-0P)
Contact Hours: 45 hours (45L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programme requisites	
Objectives:	The objective of the course is to introduce the TCP/IP architecture and allied protocols of the Internet by following a top-down approach.	
Content:	**Computer Networks and the Internet:** Networking and Inter-networks, Internetworking devices, Internet: Network edge, and the Network core. TCP/IP protocol stack: Protocol stack, Connection-oriented, connectionless services, Packet switching, circuit switching, Delay, Loss, and Throughput in Packet-Switched Networks.	6 hours
	Application layer: Principles of Application Layer Protocols, the Web and HTTP, MIME, mail access protocols, DNS, Peer to Peer Applications, Video Streaming, and Content Distribution Networks.	8 hours
	Transport layer: Transport-layer services, Multiplexing and demultiplexing, UDP protocol, Principles of reliable data transfer, Connection-oriented transport - TCP protocol, Principles of congestion control, TCP congestion control.	8 hours
	Network layer: Packet switching: virtual circuit & datagram networks, Forwarding and Routing (Network Data and control planes). The Internet Protocol (IP): IPv4 Datagram format, fragmentation, IPv4 Addressing in the Internet, route aggregation, subnetting, CIDR, Network Address Translation, DHCP, ICMP. Control Plane: Routing protocols- shortest path, link state routing algorithm, distance vector routing. Autonomous Systems (AS), Intra-AS Routing in the Internet: OSPF, Internet routing: RIP, OSPF, BGP, Address Resolution Protocol (ARP), and RARP.	12 hours
	Wireless and Mobile Networks: WiFi (802.11 Wireless LAN), Bluetooth, and Cellular Internet Access.	5 Hours
	Security in Computer Networks: Basic cryptography concepts,	6 hours

	Secure Socket Layer (SSL), Internet Security Protocol (IPSec), Virtual Private Network (VPN).	
Pedagogy:	lectures/ tutorials/assignments/self-study/ flipped classroom	
References/ Readings	1. Forouzan, Behrouz A., and Firouz Mosharraf. “Computer networks: a top-down approach”. McGraw-Hill, 2012. 2. Andrew S. Tanenbaum., “Computer Networks”, (5th Edition) Prentice Hall of India. 3. James F. Kurose, Keith W. Ross, “Computer Networking: A Top-Down Approach” Pearson, Sixth Edition 2017.	
Learning Outcomes	After completion of this course, students will be able to • Have a good understanding of layered communication architecture (TCP/IP) and knowledge of some of the important networking protocols • Understand the concepts of reliable data transfer and how TCP implements these concepts. • Basic knowledge of routing algorithms. • Basic knowledge of security in computer networks.	

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Programme: MCA
Course Code: CSA-504 **Title of Course:** Data Structures & Algorithms Lab
Number of Credits: 2 (0L-0T-2P) **Contact Hours:** 60 hours (0L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Programing Knowledge	
Objectives	To develop skills to design and implement linear and nonlinear data structures and to identify the most appropriate data structure for solving a real world problem.	
Content	**Lab Assignments may be based on the following** Advanced Linear Data Structures Infix-to-Postfix conversion, Evaluating Postfix Expressions, Bracket Matching Non-linear data structures Binary Trees Tree Traversal Algorithms Binary Search Trees Heap Priority Queue using Heap Heap Sort Graph implementation using Adjacency list and matrix Graph Traversal Algorithms Divide & Conquer Strategy MergeSort QuickSort Binary Search Algorithm Greedy Algorithms Huffman Coding Algorithm	8P 20P 12P

	Prims' and Kruskal's Algorithm Dijkstra's Algorithm Dynamic Programming Coin Change Problem Longest Common Subsequence Floyd-Warshall Algorithm A Mini Project	12P 8P
Pedagogy	Programming assignments/ discussions/ self-review/ peer-review/ testing of code/ debugging of code/ projects	
References/ Readings	1. Horowitz, Ellis, Sartaj Sahni, and Susan Anderson-Freed. "Fundamentals of data structures in C" WH Freeman & Co., Latest edition. 2. Thomas H. Cormen, Charles E. Leiserson, et al "Introduction to Algorithms", Latest Edition 3. Allen, Weiss Mark. "Data structures and algorithm analysis in C." Pearson Education India, Latest Edition. 4. Dasgupta, Papadimitriou, and Vazirani, "Algorithms" McGraw-Hill. 2017	
Learning Outcomes	Upon successful completion of the course, a student will be able to ● Implement common data structures such as lists, stacks, queues, graphs, and binary trees for solving programming problems. Identify and use appropriate data structures in the context of a solution to a given problem.	

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Programme: MCA
Course code: CSA-505 **Title of course:** Object Oriented Programming Lab
Number of credits: 2 (0L-0T-4P) **Contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Basic Programming Skills	
Objectives	To impart programming skills using object oriented paradigms.	
Content	**Understanding Object Oriented Programming** Suggested sample (non-exhaustive) assignments using an OO visual programming platform like Greenfoot/Alice:- ● Given a game scenario and conditions, create a game and check/modify the OO code generated (e.g. Racing game, Archery, etc.) Suggested sample (non-exhaustive) assignments using an OO language like Java/C++/C# (No CLI input. All values hardcoded in the main method.):- ● Write a procedural program in the OO language (to familiarize with the syntax) and convert the same to an	12 hours

	OO code	
	Applying Object Oriented Principles Suggested sample (non-exhaustive) assignments using an OO language like Java/C++/C# (No CLI input, all values hardcoded in the main method.):- ● Write source code for OO design of a board game (e.g. Chess, Solitaire, etc.) ● Write source code for OO design of an outdoor game (e.g. Football, Tennis) ● Write source code for OO design of your house and allow navigating in the house.	24 hours
	Leveraging the OO features provided by languages Various lab assignments can be given demonstrating the use of the feature and advanced features in the attached 'Object Oriented Concepts' course.	12 hours
	Mini-Project	12 hours
Pedagogy	Hands-on assignments / pair programming / group project/ git project management.	
References/ Readings	**Main Reading** 1. Timothy Budd, "An Introduction to Object Oriented Programming", Pearson Education, Latest Edition. 2. Brett D. McLaughlin, Gary Pollice & David West, "Head First Object-Oriented Analysis Design", O'Reilly, Latest Edition. 3. Ken Arnold, James Gosling, David Holmes, "The Java Programming Language", Addison-Wesley Professional, Latest Edition 4. Stanley Lippman, "C++ Primer", Addison Wesley, 2012 5. Cay S. Horstmann, "Core Java Volume I—Fundamentals", Pearson, 2018 6. Herbert Schildt, "Java: The Complete Reference", Oracle Press, latest edition 7. Joshua Bloch, "Effective Java", Addison Wesley 8. Kathy Sierra & Bert Bates, "Head First Java", O'Reilly, 2012 9. Bjarne Stroustroup, "The C++ Programming Language", Addison Wesley, Latest Edition 10. https://www.tutorialspoint.com/java/index.htm	
Learning Outcomes	1. Learner will be able to write good object oriented code 2. Learner will understand object-oriented principles 3. Learner will be able to design object oriented softwares	

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Programme: MCA
Course Code: CSA-506 **Title of the Course:** LINUX Lab
Number of Credits: 3 (1L-0T-2P) **Contact hours:** 75 hours (15L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Program Prerequisites	
Objectives:	The objective is to introduce students to the Linux operating system environment and provide knowledge of basic Linux commands and shell scripting and system call API.	
Content:	**LINUX Environment** Linux Installation and disk partitioning. Shell, Linux commands, Internal and External Commands, using the documentation/manual, users in Linux: user id, effective user id, use of commands su, sudo, id Basic commands: echo, who, whoami, date, cal, ls, passwd, history, shutdown. Input and output redirection operators (<,<<, >, >>)	3L + 12P
	The Linux File System, File and Directory management Structure of LINUX file system. Parent-child relationship. Concept of Home directory, current working directory and referring to home directory. Special Files: . and .. Absolute and relative pathnames. Use of PATH variable, Use of command: mkdir, rmdir, pwd, ls and cd. Use of file management commands: nano, touch, cat, cp, mv and rm. FIND command: Searching for a file using find, Finding List of files and directories. Concept of hard disk partitions, file system, Superblock and Inodes, General structure of Linux inode. use of stat command. Analysing the output of ls -l command. File type and permission. Use of chmod command. File ownership: Changing ownership using chown and chgrp commands. Modification and access times. Default file and directory permissions. Use of umask command. Concept of symbolic links. Hard and soft links. Use of ln command to create hard and soft links. Use of commands du, df, tar, zip, gzip, type, which	3L + 12P
	Filters: File commands- sort, wc, uniq, comm, cmp, diff, pg, tail, head, less, and more , Cut and Paste command Shells' sequence of interpretation of a command; Connecting commands with pipes Regular expressions: grep & sed command AWK script: Selection criteria and action- The BEGIN and END sections, Splitting a line into fields and using printf. Getline function and reading input from files. Writing output to file and pipes. Awk system variables. Using regular expressions. Relational and	4L + 16P

	Boolean operations. Command line parameters and environment variables. Programming constructs: if, for, while.	
	Process Management Concept of UNIX process. Role of init in process creation. Process ID and exit status of a process. Displaying process attributes using ps command, Killing processes, foreground and background processes. Use of commands job, fg, bg **Package management:** Installing & removing packages	1L + 4P
	Shell Script Shell scripts and execution methods. The dot command, Interactive and Non Interactive execution. Use of export command, Aliases and command history. Shell variables, Special variables, Built-in shell parameters. Command line arguments. Escaping and quoting. Difference between single and double quotes. Command substitution, brace and tilde expansion, I/O using read and echo. Escape sequences, 'test' command, arithmetic expressions, operators, Control flow: For, If, While, Case. Shell functions, error handling, debugging.	4L + 16P
Pedagogy:	Practical/ tutorials/assignments/self-study	
References/ Readings	1. Unix Concepts and Applications – Sumitaba Das, Tata MacGraw Hill. 2. Unix and Shell Programming – Graham Glass and King Ables Pearson Education 3. UNIX man pages	
Learning Outcomes	Upon completion of this course, the student will be able to: 1. Run various LINUX commands 2. Write shell script on LINUX OS. 3. Use various advanced LINUX tools such as grep, SED and AWK	

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Programme: MCA
Course code: CSA-521 **Title of course:** Mathematics for Computer Science
Number of credits: 4 (4L-0T-0P) **Total contact hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Program prerequisites	
Objectives	• To build a strong foundation in maths required for learning computer science/data science subjects. • To understand fundamental concepts and tools in linear algebra etc with emphasis on their applications to computer science in particular data science/machine learning	
Content	**Mathematical logic:** Statement (Proposition), Logical Connectives, Conditional, Bi-conditional, Converse, Inverse,	8 hours

	Contrapositive, Exclusive OR, NAND, NOR, Tautology, Contradiction, Satisfiable, Duality Law, Algebra of propositions.	
	Functions and Relations: Basics of Set theory, Application of set theory, Relations and their properties, n-ary relations and their applications, representing relations, closures of relations, equivalence relations, partial orderings. Functions, properties of functions, Composition of Functions, Recursive functions.	10 hours
	Graphs: Basic Concepts of Graphs, Computer Representations of Graphs, Isomorphic Graphs, Paths, Cycles and Circuits, Eulerian and Hamiltonian Graphs, Planar Graphs, Graph Coloring, Applications of Graphs. Trees: Trees, Spanning trees, Minimal Spanning Trees, Rooted Trees, Binary Trees, Binary Search Trees.	12 hours
	Linear Algebra Scalars, Vectors, Matrices and Tensors -Multiplying Matrices and Vectors - Identity and Inverse Matrices -Linear Dependence and Span -Norms -Special Kinds of Matrices and Vectors - Eigen decomposition -Singular Value Decomposition -The Moore-Penrose Pseudoinverse -The Trace Operator - The Determinant - Example: Principal Components Analysis. **Numerical Computation** Overflow and Underflow -Poor Conditioning - Gradient-Based Optimization - Constrained Optimization -Example: Linear Least Squares. **Calculus** Functions of a single variable, limit, continuity, differentiability-Mean value theorems, indeterminate forms, L'Hospital's rule-Maxima and minima-Product and chain rule-Taylor's series, infinite series summation/integration concepts-Fundamental and mean value-theorems of integral calculus, evaluation of definite and improper integrals-Beta and gamma functions-Functions of multiple variables, limit, continuity, partial derivatives-Basics of ordinary and partial differential equations.	15 hours
	Probability, Statistics, and Information Theory Why Probability? -Random Variables -Probability Distributions -Marginal Probability - Conditional Probability -The Chain Rule of Conditional Probabilities -Independence and Conditional Independence -Expectation, Variance and Covariance -Common Probability Distributions - Useful Properties of Common Functions -Bayes' Rule - Technical Details of Continuous Variables - Information Theory -Structured Probabilistic Models . **Statistics** Data summaries and descriptive statistics, central tendency, variance, covariance, correlation-Basic probability: basic idea, expectation, probability calculus, Bayes' theorem, conditional probability-Probability distribution functions: uniform, normal,	15 hours

	binomial, chi-square, Student's t-distribution, central limit theorem-Sampling, measurement, error, random number generation-Hypothesis testing, A/B testing, confidence intervals, p-values, ANOVA, t-test-Linear regression, regularization	
Pedagogy	Problem-solving approach and carrying out small project work using MatLab tools	
References/ Readings	1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill Pub. Co. Ltd. (latest edition) 2. Sheldon M. Ross, "A First Course in Probability", Pearson Prentice Hall, latest edition. 3. Andy Field, Jeremy Miles, Zoë Field, "Discovering Statistics Using R", SAGE, latest edition 4. Omi M Inouye, "Introductory Calculus For Infants", latest edition 5. Robert S. Witte, John S. Witte, "Statistics", Wiley, latest edition. 6. Gilbert Strang, "Introduction to Linear Algebra", Wellesley-Cambridge Press, Fifth Edition (2016).	
Learning Outcomes	Students will be able to: Apply mathematics concepts in the modelling and design of computational problems and gain a deeper understanding of subjects like machine learning/deep learning and other computer science subjects.	

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Programme: MCA
Course Code: CSA-522 **Title of the Course:** Discrete Mathematical Structures
Number of Credits: 4 (4L-0T-0P) **Contact Hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programme requisites	
Objectives:	The objective of the course is to introduce concepts of mathematical induction, relations, graph theory and boolean functions.	
Content:	Logic, Propositional equivalences, predicates and quantifiers, nested quantifiers, methods of proof, functions.	6 hours
	Mathematical induction, recursive definitions and structural induction, recursive algorithms, programme correctness, Pigeonhole principle, permutations and combinations.	6 hours
	Recurrence relations, solving recurrence relations, divide and conquer algorithms and recurrence relations, generating functions, inclusion and exclusion, applications of inclusion and exclusion.	12 hours
	Relations and their properties, n-ary relations and their applications, representing relations, closures of relations,	12 hours

	equivalence relations, partial orderings.	
	Introduction to graphs, graph terminology, representing graphs and graph isomorphism, connectivity, Euler and Hamiltonian paths, shortest path problems, planar graphs.	12 hours
	Introduction to trees, applications of trees, tree traversal, spanning trees, minimum spanning trees.	6 hours
	Boolean functions, representing Boolean functions, logic gates, minimization of circuits.	6 hours
Pedagogy:	lectures/ tutorials/assignments/self-study/ flipped classroom	
References/Readings	1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill Pub. Co. Ltd. 2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, PHI Learning Pvt. Ltd.	
Learning Outcomes	After completion of this course, students will be able to ● Have a good understanding of mathematical induction. ● Understand the concepts of Recurrence relation. ● Inherits fundamental knowledge graph theory. ● Acquire Basic knowledge of boolean functions.	

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MCA SEMESTER II COURSES

Programme: MCA
Course code: CSA-507 **Title of course:** Web Development
Number of credits: 2 (2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of HTML and basic of CSS; Internet Technologies & required protocols; object oriented programming	
Objectives	This course will introduce the learner to the different website development technologies	
Content	**Introduction** ● Evolution of internet & World Wide Web ● Client-Server Architecture ● Revisit HTML & CSS	1 hour
	Enhancing HTML & CSS ● HTML 5 ● CSS3	2 hours
	Front-end Design ● Good Design Rubrics ● Separation of concerns for HTML & CSS; structure vs visual representation ● HTML DOM ● CSS Box Model, pseudo -classes & -elements, CSS animation ● Adaptive & responsive design, viewport & media queries, mobile-first design ● Introduction to a design library and/or & framework (e.g.	4 hours

	Bootstrap)	
	Client-side Scripting ● Dynamic web pages ● JavaScript, programming features, javascript events & functions ● Manipulating DOM ● Beyond ECMA 4 ● Introduction to a Javascript library and framework (e.g. JQuery, ReactJS)	8 hours
	HTTP & Middle-ware ● HTTP, Request & Response, methods & error code, headers, URL encoding & decoding ● XML, data & XPath ● JSON	3 hours
	Server-side Programming ● Server instance ● Request handling & response creation ● HTML forms & file uploads ● Session management & application data ● Database connectivity ● Introduction to a Server-side library and/or template engine and/or framework (e.g. PHP - Laravel; JSP - Spring)	6 hours
	Advanced Web Development ● Model-View-Controller (MVC) & Model-View-ViewModel and others ● Web service architecture and micro-services ● REST calls, Asynchronous JavaScript and XML (AJAX) ● Independent client-server web development ● Difference between Server-side vs client-side rendering ● Introduction to Web stacks, JAM stack & full stack development	6 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching / flip classroom/ presentations	
References/ Readings	1. Robert W. Sebesta, “Programming the World Wide Web”, Pearson Education 2. https://www.w3schools.com/ 3. Steven Holzner, “HTML 5 Black Book” 4. https://www.tutorialspoint.com/ 5. Frank W. Zammetti, “Modern Full-Stack Development”, Apress 6. Nader Dabit, “Full Stack Serverless”, O’Reilly	
Learning Outcomes	1. Learner will be able to make decision on what web technology to use and for what purpose 2. Learner will have fair idea on the popular technologies used in website development 3. Learner will appreciate the architecture of web applications	

	and the design decisions	

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Programme: MCA
Course Code: CSA-508 **Title of Course:** Database Management Systems
Number of Credits: 2 (2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	A High-Level Programming Language, Data Structures and Algorithms(CS101), Operating Systems(CS103).	
Objectives	This course will enable the learner to understand the different issues involved in the design and implementation of a database system and provide both theoretical knowledge and practical skills required in the creation and use of a Relational DataBase Management System.	
Content	**Basic concepts:** Database & Database Users, Characteristics of the Database Approach, Database Systems, Concepts & Architecture Data Models(RDBMS, Legacy systems, Object Oriented, NoSQL), Schemes & Instances DBMS Architecture of Data Independence, Database languages & Interfaces	3 hours
	Data Modelling using the Entity – Relationship approach	4 hours
	Relational Model, Languages & Systems Relational Data Model & Relational Algebra Relational Model Concepts Relational Model Constraints, Relational Algebra/Relational Calculus	5 hours
	SQL-A Relational Database Language Data SQL - DDL, DML. Views & Queries in SQL. Specifying Constraints & Indexes in SQL. Nested Subqueries, correlated Subqueries	2 hours
	Advanced SQL Embedded SQL, Dynamic SQL, Triggers and Stored Procedures.	2 hours
	Relational Database Design Function Dependencies & Normalization for Relational Database Functional Dependencies Normal forms based on primary keys (1NF, 2NF, 3NF, BCNF) Covers of Functional Dependencies, Canonical covers. Lossless join and Dependency preserving decomposition algorithms.	5 hours
	Transactions and Recovery Techniques Concept of a transaction, Recovery concepts, Recovery Techniques.	4 hours
	Concurrency Control Serializability, Locking Techniques, Time stamp ordering Granularity of Data items	5 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching / troubleshooting	

References/ Readings	**Main Reading** 1. Korth, Silberchartz, " Database System Concepts" McGrawhill Publication. 2. Elmasri and Navathe, " Fundamentals of Database Systems", Addison Wesley, New Delhi. 3. Database Management Systems –R. Ramakrishnan, J.Gehrke – T.McGraw Hill 4. Desai B., " An Introduction to Database Concepts", Galgotia Publications, New Delhi. 5. 2. Rob,Coronel, "Database Systems (Design, Implementation and Management)" 6. Date C. J. , " An Introduction to Database Systems", Publication House, New Delhi.	
Learning Outcomes	1. Understand and evaluate the role of a DBMS in information Technology applications in Organizations. 2. Recognise and use logical design methods and tools required in the design of DB applications. 3. Understand the relational database design principles. 4. Implement a database Solution to an IT Platform. 5. Understand the basics of SQL and construct queries using SQL. 6. Develop sophisticated queries to extract information from databases. 7. Use embedded SQL queries in a Host Level Language. Understand how the DBMS manages and recovers from concurrent and multiple transactions.	

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Programme: MCA
Course Code: CSA-509 **Title of the Course:** Machine Learning
Number of Credits: 3 (3L+0T-0P) **Contact hours:** 45 hours(45L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Basic concepts of Linear Algebra, Probability theory	
Objectives:	This course provides students with an in-depth introduction to three main areas of Machine Learning: supervised and unsupervised and reinforcement learning.this course will cover some of the main models and algorithms for regression, classification, clustering and Markov decision processes. Topics will include linear and logistic regression, regularisation, SVMs and kernel methods, ANNs, clustering, and dimensionality reduction ,sequential learning Like HMM and reinforcement learning.	
Content:	1. Introduction :- well posed learning problem – designing a learning system-perspectives and issues in machine learning.	2 hours

	2. Concept learning – concept learning task –notation – inductive learning hypothesis-concept learning as search-version space and candidate elimination algorithm-decision tree –random forest. 3. Linear regression - logistic regression-Support vector machine kernel- Model selection and feature selection-Ensemble methods: Bagging, boosting. Evaluating and debugging learning algorithms. 4. Continuous Latent Variables-Revision of Principal Component Analysis -Maximum variance formulation - Minimum-error formulation - Applications of PCA - PCA for high-dimensional data. 5. Neural Networks -Feed-forward Network Functions – perceptron -Weight-space symmetries -Network Training -Parameter optimization -Local quadratic approximation - Use of gradient information - Gradient descent optimization - Error Backpropagation - Evaluation of error-function derivatives - A simple example - Efficiency of backpropagation . 6. Probabilistic model – The normal distribution and its geometric interpretation-probabilistic models for categorical data -using naïve bayes model for classification,training a naïve bayes model -discriminative learning by optimizing conditional likeleihood -probability models with hidden variables : Expectation-Maximization,Gaussian mixture model 7. Distance-based models – neighbour and exemplers -nearest-neighbour classification -distance based clustering -K means algorithm, clustering around medoids , silhouetees-hierarchical clustering -from kernels to distances 8. Sequential Data - Markov Models - Hidden Markov Models - Maximum likelihood for the HMM -The forward-backward algorithm - The sum-product algorithm for the HMM -Scaling factors - The Viterbi algorithm. 9. Reinforcement learning – Introduction- learning task-Q learing-non deterministic rewards and actions-temporal difference learning.	5 hours 6 hours 6 hours 8 hours 6 hours 5 hours 4 hours 3 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	Main Reading :- 1.Introduction to Statistical Learning, Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Springer, 2013. 2. EthemAlpaydin, Introduction to Machine Learning, MIT Press.	

	3. Richard O. Duda, Peter E. Hart, David G. Stork Pattern Classification,. 4. Peter Flach , Machine Learning , Cambridge 5.Christopher M. Bishop,Pattern recognition and machine Learning, springer. 6.Deep Learning, Ian Good fellow, MIT press 7.Tom Michele, Machine Learning, McGraw-Hill.	
Learning Outcomes	By the end of the course , students should: ● Develop an appreciation for what is involved in learning from data. ● Understand a wide variety of learning algorithms. ● Understand how to apply a variety of learning algorithms to data. ● Understand how to perform evaluation of learning algorithms and model selection. ● Equips them with a general understanding of deep learning.	

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Programme: MCA
Course code: CSA-510 **Title of course:** Web Development Lab
Number of credits: 3 (1L-0T-4P) **Contact hours:** 75 hours (15L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Hands-on experience working with HTML and basic of CSS; Internet Technologies; object oriented programming	
Objectives	This course will focus on the practical use and aspects of the different website development technologies	
Content	**Web Design Assignments** Suggested Sample (non-exhaustive) Assignments:- ● Create a website on a topic given by the instructor. Evaluating the website with rubrics for good web design. ● Build a website using HTML & CSS by looking at a screenshot/picture of a website component given by the instructor. ● Websites built with tables, forms, images, iframes, etc. ● A website for each of design strategies (fixed, adaptive, responsive, fluid, mobile-first, etc.). ● Assignments using css pseudo-classes & -elements; grid & flex design; understanding the CSS box model & working with the browser developer tools; CSS transformations, transitions & animations ● Assignment to create a website built with Bootstrap based on a topic given by the instructor.	3L +15P
	Client-side Scripting Assignments Suggested Sample (non-exhaustive) Assignments:- ● An assignment for understanding the programming aspects of JavaScript and working with the browser developer tools. The use of the newer features of JavaScript (after ECMA 4) is	3L + 15P

	encouraged. ● An assignment working with regular expressions. A search and filter utility can be built. ● Assignments for form data processing and validation and use of HTML5 form elements. A web page with form and validated data could be put in a table. The code could be written using table DOM methods and/or HTML DOM methods and/or XML DOM methods. ● Assignments using various events (mouse, keyboard, etc. events for the form elements, drag-and-drop, window, browser, etc.). ● A web component built using HTML, CSS & JavaScript based on a existing Bootstrap component (e.g. Accordion) ● Assignment with the use of a JavaScript library (JQuery, AngularJS, ReactJS, etc.)	
	Developing a Game with HTML, CSS & JavaScript. The game should have at least 500 lines of (HTML+Javascript) code and make use of various mouse/keyboard events.	1L + 4P
	Server-side Programming Assignments Suggested Sample (non-exhaustive) Assignments:- ● Assignments to work with HTTP headers for passing data and meta-data, cookies, localStorage ● Assignments to handle data from web forms; handling the request and response payload ● Assignment to manage web sessions ● Assignment to develop a CRUD functionality by connecting to a database; AJAX calls	2L + 12P
	Full stack Web Developments Develop a CRUD application with MEAN/MERN stack	2L + 2P
	Mini-project Ideally done in a group. It should include design and implementation of a web application. Project implementation should mandatorily be built using a templating engine or programming framework (client-side and/or server-side). Project should also use a design framework (e.g. Bootstrap). Conduct and progress of the project could follow industry practices (e.g. git, scrum etc.).	4L + 12P
Pedagogy	Hands-on assignments / tutorials / peer-teaching / projects	
References/ Readings	1. Robert W. Sebesta, “Programming the World Wide Web”, Pearson Education 2. https://www.w3schools.com/ 3. Steven Holzner, “HTML 5 Black Book” 4. https://www.tutorialspoint.com/ 5. Frank W. Zammetti, “Modern Full-Stack Development”, Apress 6. Nader Dabit, “Full Stack Serverless”, O’Reilly	
Learning	1. Learner will be gain experience and be able to create	

Outcomes	complete websites 2. Learner will be able to make decision on what web technology to use and for what purpose 3. Learner will appreciate the architecture of web applications and the design decisions	

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Programme: MCA
Course Code: CSA-511 **Title of Course:** Database Management Systems LAB
Number of Credits: 3 (1L-0T-2P) **Contact hours:** 75 hours (15L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Hands-on experience in object-oriented programming.	
Objectives	This course aims at enabling learners to develop a skill set to design and implement a realistic application, representative of a typical real-life software system.	
Content	**Installation of DBMS Softwares**	2P
	Data Definition Language(DDL) Statements ● Creating a Database. ● Creating a table, with or without constraints. ● Understanding Data types. ● Altering the structure of the table like adding attributes at a later stage, modifying size of attributes or adding constraints to attributes. ● Removing the table created, i.e Drop table in SQL. ● Creating Sequence (Auto increment field)	1L+4P
	Query in Data Dictionary ● To view the structure of the table created by the user. ● To view user information. ● To view integrity constraints. ● Altering Session Parameters	1L+2P
	Data Manipulation Language(DML) Statements ● Inserting Data into the table. ● Updating Data into the table. ● Deleting Data from the table.	1L+4P
	Simple SQL statements ● Displaying all the attributes and tuples from the table. ● Displaying selected attributes/tuples from the table. ● Using Logical and comparison operators. ● String manipulation ● Date Comparisons	2L+6P
	Complex SQL Statements ● Using aggregate functions (using Group by and having clauses). ● Sorting Data. ● Creating SQL Aliases and Views.	4L+14P

	• Joins and Nested queries. • Correlated subquery • Derived tables • Given a complex table structure, display records from tables.	
	Transaction Control Language(TCL) statements • Transactions could be made permanent in memory • To rollback the transaction.	1L+2P
	Embedded SQL statements • Loops/ if else statements • Creating Triggers/Procedures/packages • ArrayList and Cursor. • PL/SQL Strings • PL/SQL Object Oriented • Exceptions	4L+16P
	No SQL	1L+4P
	Project • The analysis of project • Design (ER diagram and normalized tables) and implementation of a real life project of students choice. • The project report that they submit consists of (i) Feasibility study (ii) ER Diagrams (iii) Tables normalized in an appropriate normal form with integrity and domain constraints noted. (iv) User Interface Design - Form and Report design , including triggers that may need to be written (v) User Manual Peer reviews of ERDs are held in the class.	6P (in class)
Pedagogy	Hands-on assignments / tutorials / peer-teaching / troubleshooting	
References/ Readings	1. Korth, Silberchartz, " Database System Concepts" McGrawhill Publication. 2. Elmasri and Navathe, " Fundamentals of Database Systems", Addison Wesley, New Delhi.	
Learning Outcomes	1. Design and implement a database schema for a given problem-domain 2: Create and maintain tables using SQL 3: Populate and query a database 4. Use Transaction Control Language 5. Creating and Using User Defined Data Types 6. Writing Triggers & Stored Procedures 7. Prepare reports 8. Application development using PL/SQL & front end tools	

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Std. Com.X AC-6
15 & 22.05.2023

Programme: MCA
Course Code: CSA-512 **Title of the Course:** Machine Learning Lab
Number of Credits: 3 (1L+0T+ 2P) **Contact Hours:** 75 hours (15L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Course: Mathematics for Computer Science and Programming language background.	
Objectives:	The objective is to learn to build the different machine learning models by doing a set of assignments and mini projects.	
Content:	Introduction to python libraries for machine learning - scikit learn, tensor flow, keras, pytorch,pandas, matplotlib, seaborn, numpy and other relevant libraries.	1L + 5P
	Four branches of machine learning-supervised, unsupervised,self-supervised, reinforcement, Evaluating machine learning models ,Data preprocessing,featue engineering and feature learning, overfitting and underfitting-Numerical Programming fundamentals-finding nearest neighbours via euclidean distance-splitting data sets into training and testing.	1L + 8P
	Regression,cross validation and regularization-polynomial regression -model selection on a fixed validation set -Polynomial Regression - Model Selection with Cross-Validation-Polynomial Regression with L2 Regularization - Model Selection with Cross-Validation-Comparison of methods on the test set. Evaluating Binary Classifiers and Implementing Logistic Regression-Binary Classifier for movies reviews-classifying newswires-predicting house prices -Computing the Loss for Logistic Regression without Numerical Issues	2L + 10P
	Neural Networks and Stochastic Gradient Descent-MLPs with L-BFGS: What model size is effective?-MLPs with SGD: What batch size and step size?-Producing your own figure comparing batch size and learning rate.	2L + 10P
	Trees and Random Forests for Bag of Words-Code Implementation of Decision Tree Regression-Decision Trees for Review Classification -Random Forests for Review Classification -Comparing Trees to Linear Models for Review Classification.	2L + 5P
	Implementation of CNN, RNN, LSTM, Implementation of Boltzmann machine and Transformers (BERT, GPT3) .Generative deep learning (GAN).	
	Project discussions -Classifying Images with Feature	2L + 10 P

	Transformations-Classifying Sentiment from Text Reviews-Recommendation Systems via Matrix Factorization-Text summarization - language Translation -Sentimental analysis-speech to text translatioXiv, Explore the keras ecosystem.	2L + 5P
Pedagogy:	Programming in lab and practical exercises	
References/Readings	1. Hands on machine learning with scikit learn by Aurielien 2. Deep learning with python by Francois 3. Text Analytics with Python: A Practitioner's Guide to Natural Language Processing by dipanjan sarkar. 4. keras: the python deep learning API 5. https://www.cs.tufts.edu/comp/135/2020f/assignments.html 6. Python library reference	
Learning Outcomes	To be able to collect data and preprocess them and choose the suitable machine learning model and study its performance and able to carry out mini project	

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Programme: MCA
Course Code: CSA-523 **Title of Course:** Cryptography and Network Security
Number of Credits: 4 (4L-0T-0P) **Contact Hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Internet Technologies	
Objectives	1. To understand the basics of Cryptography and Network Security. 2. To be able to secure a message over an insecure channel by various means. 3. To learn about how to maintain the Confidentiality, Integrity and Availability of data. 4. To understand various protocols for network security to protect against the threats in the networks.	
Content	**Foundations of Cryptography and Security** Ciphers and Secret Messages, Security Attacks and Services. Classical encryption techniques. **Mathematical Tools for Cryptography** Substitutions and Permutations, Modular Arithmetic, Euclid's Algorithm, Finite Fields, Polynomial Arithmetic. **Design Principal of Block Ciphers** Theory of Block ciphers, Feistel Cipher network Structures,	6 hours 3 hours 9 hours

	DES and triple DES, Modes of Operation (ECB, CBC, OFB, CFB), Strength of DES, AES **Pseudo Random Numbers and Stream Ciphers** Pseudo random sequences, Linear Congruential generators, Cryptographic generators, Design of stream Ciphers, RC4. **Public Key Cryptography** Prime Numbers and testing for primality. Factoring large numbers, Discrete Logarithms. **Asymmetric Algorithms** RSA, Diffie-Hellman, ElGamal, Introduction of Ecliptics curve cryptosystems, Key Management, Key exchange algorithms, Public Key Cryptography Standards. **Hashes and Message Digests** Message Authentication, MD5, SHA-3, HMAC **Digital Signatures, Certificate and Standards** Digital signature standards (DSS and DSA), Public Key Infrastructures, Digital certificates and Basics of PKCS standards. **Authentication** Kerberos , X509 Authentication Service **Web Security protocols** IP Security, Transport Layer Security(TLS), Wireless Security, **System Security** Intrusion detection , Password management, Firewalls management	3 hours 3 hours 9 hours 6 hours 6 hours 3 hours 6 hours 6 hours
Pedagogy	Lectures/ Hands-on assignment/tutorials/Presentations	
References/ Readings	Main Reading: 1. Stallings William, " Cryptography and Network Security: Principles and Practises", 5th edition, Prentice Hall 2. Kahate Atul, "Cryptography and Network Security" Tata McGraw-Hill.	
Learning Outcomes	1. Provide security of the data over the network. 2. Implement various networking security protocols. 3. Protect any network from the threats in the world.	

Programme: MCA
Course Code: CSA 524 **Title of Course:** Natural Language Processing
Number of Credits: 4 (2L-0T-2P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Fundamentals of Artificial Intelligence; Mathematical Foundations for Artificial Intelligence. Machine Learning and Programming background. Introduction to NLP (Theory), Mathematical foundations for AI.	
Objectives	This course will focus on understanding the essentials of Natural Language Processing (NLP), areas in NLP, algorithms, and NLP tasks. Students who complete this course will gain a foundational understanding in natural language processing methods and strategies. They will also learn how to evaluate the strengths and weaknesses of various NLP technologies and frameworks as they gain practical experience in the NLP toolkits available.	
Content	Part I: Foundations of Natural Language Processing Introduction ● Natural Language Processing - Problems and perspectives ● Introduction/Recall to/of probability calculus ○ N-grams and Language Models ○ Markov Models ● Introduction to Machine Learning and Deep Learning ● Recurrent Neural Network Language Models ● The evaluation of NLP applications Corpora ● Corpora and their construction: representativeness ● Concordances, collocations and measures of words association ● Methods for Text Retrieval ● Regular expressions	8 hours
	Part II: Natural Language Processing ● Computational Phonetics and Speech Processing ○ Speech samples: properties and acoustic measures ○ Analysis in the frequency domain, Spectrograms ○ Applications in the acoustic-phonetic field. ○ Speech recognition with HMM and Deep Neural Networks ● Tokenisation and Sentence splitting ● Computational Morphology ○ Morphological operations ○ Static lexica, Two-level morphology ● Computational Syntax ○ Part-of-speech tagging ○ Grammars for natural language ○ Natural language Parsing	16 hours

	○ Supplementary worksheet: formal grammars for NL ■ Formal languages and Natural languages. Natural language complexity ■ Phrase structure grammars, Dependency Grammars ■ Treebanks ■ Modern formalisms for parsing natural languages ● Computational Semantics ○ Lexical semantics: WordNet and FrameNet ○ Word Sense Disambiguation ○ Distributional Semantics & Word-Space models ○ Logical approaches to sentence semantics	
	Part III: Applications and Case studies: ● Solving Downstream Tasks: Document classification, Sentiment Analysis, Named Entity Recognition, Semantic Textual Similarity ● Prompting Pre-Trained Language Models ● Network Embedding	6 hours
	Sample list of Assignments Assignment -1 -Import nltk and download the 'stopwords' and 'punkt' packages. Assignment-2 -Import spacy and load the language model. Assignment -3 -How to tokenize a given text? Assignment-4 -How to get the sentences of a text document ? Assignment- 5-How to tokenize a text using the \`transformers\` package? Assignment -6 - How to tokenize text with stopwords as delimiters? Assignment- 7- How to remove stop words in a text?	 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours
	Assignment -8- How to add custom stop words in spaCy? Assignment- 9 -How to remove punctuations? Assignment-10 - How to perform stemming? Assignment -11 -How to lemmatize a given text? Assignment-12 -How to extract usernames from emails? Assignment -13-How to find the most common words in the text excluding stopwords Assignment -14- How to do spell correction in a given text? Assignment -15- How to tokenize tweets? Assignment -16- How to extract all the nouns in a text? Assignment -17- How to extract all the pronouns in a text? Assignment - 18 - How to find similarity between two words? Assignment -19- How to find similarity between two documents? Assignment -20 -How to find the cosine similarity of two documents?	3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours
Pedagogy	Hands-on assignments/tutorials / peer-teaching / pair	

	programming/presentations / mini-project. Lectures / Practical / tutorials / assignments / self-study / mini-project	
References/ Readings	1. Allen, James, Natural Language Understanding, Second Edition, Benjamin/Cumming, 1995. 2. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993. 3. Jurafsky, Dan and Martin, James, Speech and Language Processing, Second Edition, Prentice Hall, 2008. 4. Manning, Christopher and Heinrich, Schutze, Foundations of Statistical 5. Natural Language Processing, MIT Press, 1999. 6. Tamburini, F.. Neural Models for the Automatic Processing of Italian, Bologna: Pàtron. 2022 7. T. McEnery and A. Wilson. Corpus Linguistics, EUP. 2001 **8.** https://corpora.ficlit.unibo.it/NLP/ 9. https://www.machinelearningplus.com/nlp/nlp-exercises/ 10. Deep Learning by Goodfellow, Bengio, and Courville free online 11. Machine Learning — A Probabilistic Perspective by Kevin Murphy online 12. Natural Language Processing by Jacob Eisenstein free online Speech and Language Processing by Dan Jurafsky and James H. Martin (3rd ed. draft)	
Learning Outcomes	1. Learners will learn about the concepts in natural language processing. 2. Learners will have a fair idea of different areas in NLP 3. Learners will appreciate the complexities involved in natural language processing. 4. Through lectures and practical assignments, students will learn the necessary tricks for making their models work on practical problems. 5. They will learn how to contribute towards the development of NLP Resources and Tools.	

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Programme: MCA
Course Code: CSA-525 **Title of Course:** Network Programming
Number of Credits: 4 (4L-0T-0P) **Contact Hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Linux lab, Internet technology, Operating Systems	
Objectives	To introduce the basic concept of network programming in UNIX and Windows OS environments.	
Content	Basic UNIX programming: Overview of process, signal handling and related system calls. Systems calls related to process, user	6 hours

	and signal Management. File descriptors and inheritance. Named and unnamed pipes and related system calls.	
	Elementary Socket Programming: Berkley Sockets Overview, Introduction to sockets, Socket addresses, Basic Socket system calls, Error handling. Concept of Reserved ports, Elementary TCP and UDP socket programming. Socket options. Name and Address Conversion functions. Interface Operations using 'ioctl'.	15 hours
	I/O Operations: Synchronous vs. Asynchronous I/O. I/O Multiplexing using 'select' and 'pselect'., Sockets and signals, Signal driven I/O. Nonblocking I/O: Non blocked 'accept' and 'connect'. Broadcasting and Multicasting. Sending and Receiving Out of Band data using 'select' and signals. Advance I/O functions.	15 hours
	Daemon processes and Inetd Super Server	4 hours
	Network Programming in the .NET Framework: System.Net classes overview, working with URI, IP addresses, DNS class, Requests and responses, authentication, and permission.	6 hours
	Socket programming in .NET Working with sockets in .NET, Asynchronous programming, socket permission, support for IPv6, support for TCP, .NET Remoting, support for UDP, multicast sockets. Network tracing, network information, cache management, security.	8 hours
	Programming applications: Time and date routine, Ping, Trivial file transfer protocol, design of chat application using multicast socket programming.	6 hours
Pedagogy	lectures/ Hands-on assignment/tutorials	
References/ Readings	Main Reading: 1. Steven W.R., Unix Network Programming, Prentice Hall of India. 2. Microsoft Software Developers Network Documentation.	
Learning Outcomes	After completing the course, students will be able to: ● Analyze and write socket API based programs ● Design and implement client-server applications using TCP and UDP sockets	

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Programme: MCA
Course Code: CSA-526 **Title of Course:** Human Computer Interaction
Number of Credits: 4 (4L-0T-0P) **Contact hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Program Prerequisites	
Objectives	To build human-centered design skills, so that you have the principles and methods to create excellent interfaces with any technology.	

Content	Introduction: Human-Computer Interaction, The Power of Prototyping, Evaluating Designs, The Birth of HCI	8 hours
	Needfinding: Participant Observation, Interviewing, Additional Needfinding	8 hours
	Rapid Prototyping: Paper Prototyping and Mockups, Video Prototyping, Creating and Comparing Alternatives	10 hours
	Heuristic Evaluation: Heuristic Evaluation — Why and How? Design Heuristics	8 hours
	Direct Manipulation and Representations: Direct Manipulation, Mental Models, Representations Matters, Distributing Cognition	10 hours
	Visual Design and Information Design: Visual Design, Typography, Grids and Alignment, Reading and Navigating	8 hours
	Designing experiments: Designing Studies That You Can Learn From, Assigning Participants To Conditions, InPerson Experiments, Running Web Experiments, Comparing Rates.	8 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching / pair programming / presentations / mini-project	
References/ Readings	1. Alan Dix, Janet Finlay, Gregory D. Abowd, and Russell Beale, Human-Computer Interaction (3rd Edition), Pearson, 2004. 2. Ben Shneiderman and Catherine Plaisant, Designing the User Interface: Strategies for Effective HumanComputer Interaction (5th Edition), 5th ed., Pearson Addison-Wesley, 2009 3. Donald A. Norman, The Design of Everyday Things, Basic Books, 2002	
Learning Outcomes	2. Learners will be introduced to the concepts in Human centered design skill.	

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Programme: MCA
Course Code: CSA-527 **Title of Course:** Agile Methodology
Number of Credits: 4 (4L-0T-0P) **Contact Hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programming Knowledge	
Objectives	The objective of the course is to provide students with a theoretical as well as practical understanding of agile software development practices and how small teams can apply them to create high-quality software.	
Content	**Introduction to Agile Software Development:** Understanding how traditional software development works and it's problems; Role of Agile practices in the world of software development & Tools used **Agile Project Planning And Management:**	

	Requirement Analysis, Estimation techniques, Iteration planning, Introduction to development practices:TDD : Test Driven Development & Pair Programming, Introduction to QA Practices:Fail Fast & Automated functional testing, Introduction to Continuous Integration **Coding and testing practices:** Practicing TDD and pair programming as alternative to traditional documentation; Configuring Continuous Integration tools; Automated function testing in detail, Source Control **Agile Software development and deployment:** Iterative and incremental software development, Automated and scripted deployment strategies, Handling change requests	
Pedagogy	Lectures/ Hands-on assignment/tutorials	
References/ Readings	1. Agile Software Development with Scrum, Ken Schwaber, Mike Beedle, Prentice Hall 2. Agile Estimating and Planning by Mike Cohn, Prentice Hall PTR 3. Continuous Integration: Improving Software Quality and Reducing Risk, Paul M. Duvall, Steve Matys, Andrew Glover, Addison Wesley 4. Leading Lean Software Development: Results Are not the Point Mary Poppendieck , Tom Poppendieck	
Learning Outcomes	Student will be able to understand, appreciate and apply Agile practices for Software development as well as in real life	

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Programme: MCA
Course Code: CSA-528 **Title of Course:** Modern Development Platforms
Number of Credits: 4 (4L-0T-0P) **Contact hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programming(Program Prerequisites), Knowledge of OS (CSC-103), Internet Technologies (CSC-104) and Web Development (CSC-201,CSC-205)	
Objectives	This course will focus on the modern development technologies, tools and platforms prevalent in the software development industry	
Content	**Overview** ● Ever-changing development terrain, Importance of development at scale. Emergence of Cloud Services, Devops	2 hours
	Development at scale ● Introduction to API Query	4 hours

	● Introduction to ELK stack	
	Cloud Computing ● Overview ● Cloud Models - IaaS, PaaS, SaaS, Public/Private/Hybrid Cloud ● Components - Virtualisation & VMs, File Storage, Server Instances, Content Delivery Network, etc. ● Setting up cloud ● Cloud Services ● Case study of any one cloud (e.g. Amazon AWS/ Google Cloud/ MS Azure)	24 hours
	DevOps ● Overview of DevOps: ○ Introduction to DevOps ○ DevOps Lifecycle ○ DevOps Delivery Pipeline ● Continuous Integration/ Continuous Delivery (CI/CD) ○ Introduction to CI/CD ○ Continuous Delivery v/s Continuous Deployment ○ Case study of any one CI/CD tool(CircleCI/Jenkins, etc). Case study should include architecture, pipeline and plugin management ● Configuration Management ○ Introduction to Configuration Management ○ Case study of any one Configuration Management(e.g. Ansible, Chef, etc). Case study should include Infrastructure as Code, Inventory Management, playbooks/cookbooks ● Containerization ○ Introduction to Containerization ○ Container Lifecycle ○ Case study of any one containerization tool (e.g. Docker, etc) which should include namespaces, commands,CLI, image creation, image registry ● Continuous Monitoring ○ Introduction to continuous monitoring ○ Types: Infrastructure Monitoring, Application Monitoring and Network Monitoring ○ Case study on one continuous monitoring tool(e.g. Nagios, Prometheus, etc)	18 hours
	Mini Project *Ideally done in a group. Concepts and tools (or similar) learnt in the course will need to be implemented/incorporated.*	12 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching / pair programming / presentations / mini-project	

References/ Readings	1. Frank W. Zammetti, "Modern Full-Stack Development", Apress 2. Nader Dabit, "Full Stack Serverless", O'Reilly 3. Joakim Verona, "Practical DevOps" 4. https://www.elastic.co/guide/index.html 5. https://docs.aws.amazon.com/ 6. https://cloud.google.com/docs 7. https://docs.microsoft.com/enus/azure/?product=featured 8. https://docs.docker.com	
Learning Outcomes	1. Learner will learn about the latest tools and platforms used in the software industry 2. Learner will have fair idea on the popular cloud services used 3. Learner will appreciate the different devops tools and why devops is important	

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Programme: MCA
Course Code: CSA-529
Title of Course: Ethical Hacking
Number of Credits: 4 (4L-0T-0P)
Contact Hours: 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Internet Technologies, Operating System, Database Management, Programming Skills	
Objectives	To introduce the students to ethical hacking tools and practices used to protect systems from the wide-ranging impact of data breaches and cybersecurity incidents.	
Content	**Introduction:** The importance of security, The various phases involved in hacking, An overview of attacks and exploit categories, The legal implications. **Footprinting:** Introduced to footprinting, Information gathering methodology, Tools used for the reconnaissance phase, countermeasures. **Scanning:** Detecting 'live' systems on target network, Discovering services running/ listening on target systems, port scanning techniques, active and passive fingerprinting, Automated discovery tools. **Enumeration:** Identifying valid user accounts or poorly protected resource shares, active connections to systems and directed queries, Null Session, NetBIOS Enumeration, SNMP enumeration, Applications and Banners. **System Hacking:** Remote password guessing, Eavesdropping, Denial of Service, Buffer overflows, Privilege escalation, Password cracking, keystroke loggers, sniffers, Remote control and backdoors, Port redirection, Covering tracks, Hiding files **Trojans and Backdoors:** Defining Trojans and Backdoors, Understanding the various backdoor genres, Trojan tools, Prevention methods and countermeasures, Anti-Trojan software.	2 hours 3 hours 3 hours 3 hours 5 hours 2 hours 4 hours

	Sniffers: Active and Passive Sniffing, ARP Spoofing and Redirection, DNS and IP Sniffing and Spoofing.	
	Denial of Service: DOS and Distributed DOS Attacks, Types of denial of service attacks, Tools for running DOS attacks, Tools for running DDOS attacks, Denial of Service Countermeasures	3 hours
	Social Engineering: Common Types of Attacks, Online Social Engineering, Reverse Social Engineering, Policies and Procedures, Employee awareness.	3 hours 4 hours
	Session Hijacking: Spoofing Vs Hijacking, Types of session hijacking, TCP/IP concepts, Performing Sequence prediction, ACK Storms, Session Hijacking Tools.	3 hours
	Web Server Hacking: Web Servers and Common Vulnerabilities, Apache Web Server Security, IIS Server Security, Attacks against Web Servers, Countermeasures	5 hours
	Web Application Vulnerabilities: Common Web Application Security Vulnerabilities, Penetration Methodologies, Input Manipulation, Authentication And Session Management, Tools and Countermeasure.	3 hours
	Password cracking: HTTP Authentication Basic & Digest, NTLM Authentication, Certificate Based Authentication, Forms Based Authentication, Password Guessing, Password cracking Tools.	
	SQL injection: Exploiting the weakness of Server Side Scripting, Using SQL Injection techniques to gain access to a system, SQL Injection Scripts, Prevention and Countermeasures	3 hours
	Buffer Overflow: What is a Buffer Overflow, Exploitation, CPU / OS Dependency, Understanding Stacks, Stack Based Buffer Overflow, Defense against Buffer Overflows	4 hours
	Hacking wireless networks: Introduction to 802.1, WEP, Cracking WEP Keys, WPA, WLAN Scanners, WLAN Sniffers, Securing Wireless Networks.	4 hours
	Viruses: Types of viruses, virus signatures, Anti-virus software, few examples.	2 hours
	Evading Firewalls, IDS and Honeypots: Intrusion Detection System, Integrity Verifiers, Intrusions Detection, Anomaly Detection, Signature Recognition, Protocol Stack Verification, Application Protocol Verification, Hacking Through Firewalls, Honey Pots.	4 hours
Pedagogy		
References/ Readings	**Main Reading** 1. "Hacking Exposed", Osborne/ Mc Graw Hill. 2. "Hacking Exposed: Network Security Secrets and solutions", Osborne/ Mc Graw Hill. 3. "Hacking Exposed: Linux Security Secrets and Solutions", Mc Graw Hill. 4. "Hacking Exposed: Windows Security Secrets and Solutions", Mc Graw Hill. 5. "Hacking Exposed: Web Application Security Secrets and	

	Solutions", Mc Graw Hill/Osborne.	
Learning Outcomes	3. Discover the elements of a four-phase penetration test and how the four phases help successfully identify system vulnerability. 4. Learn about the different tools and techniques that hackers—including ethical hackers—employ.	

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Programme: MCA
Course Code: CSA-530 **Title of Course:** Advanced Unix Programming
Number of Credits: 4 (4L-0T-0P) **Contact Hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Basic knowledge of Programming in C and Operating systems	
Objectives	● Introduces system administration tasks, including software installation, system configuration, and managing user accounts. ● Introduce the concept of UNIX system programming including process, signals and interprocess communication.	
Content	Introduction: Organization of UNIX interface, Programmer interfaces. System call API , Error handling. UNIX standardization. UNIX implementations. Relationship of standards and implementation. File I/O and Directories : File descriptor and basic file I/O calls. Duplicating file descriptors. File Types, File access permissions, Set-user-id and set-group-id bits. Setting file permissions. Changing file ownership. Soft and hard links. Reading directories. Synchronising file contents. Standard I/O library.	15 hours
	Process : Environment of UNIX process. Command Line arguments. Environment variables. Memory allocation. Process relationship, Process groups, sessions, Controlling Terminal, Process related system calls. Foreground, Background Processes and Job control. Orphaned process groups.	15 hours
	Signals: Signal concept, Reliable and unreliable signals, Signal sets, Signal related system calls. Non local jumps. Job control using signals.	10 hours
	Terminal I/O: Special Input Characters. Canonical and Non canonical modes. Terminal Option flags. Getting and setting terminal attributes. Pseudo terminals. Opening and using pseudo Terminals. Advanced I/O: Nonbloking I/O, Record locking. Stream, I/O multiplexing, Memory mapped I/O, Asynchronous I/O.	10 hours
	Inter-process communication: Pipes, Message queues, Semaphores and shared memory.	10 hours
Pedagogy	lectures/ tutorials/Hands-on assignments/self-study	
References/ Readings	1. Steven W R, Advanced Programming in UNIX Environment, Addison Wesley.	

	2. Unix man pages and Standard C library (libc) Documentation	
Learning Outcomes	After completing the course, students will be able to: ● Manage UNIX users, file systems, and devices using root powers. ● Access UNIX file management and process management functions via system calls. ● Develop complex system-level software in the C programming language	

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Programme: MCA
Course Code: CSA-531
Title of Course: Theory of Computation
Number of Credits: 4 (4L-0T-0P)
Contact Hours: 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programme Prerequisites	
Objectives	1. To give an overview of the theoretical foundations of computer science from the perspective of formal languages 2. To illustrate finite state machines to solve problems in computing.	
Content	General Concepts of Automata Theory: Alphabets Strings, Languages, Grammars, Applications of Automata Theory.	3 hours
	Finite Automata (FA): Introduction, Deterministic Finite Automata (DFA) - definition and notations, language of a DFA. Nondeterministic Finite Automata (NFA)- Definition, language of an NFA, Equivalence of DFA and NFA, Applications of FA. Finite Automata with Epsilon Transitions, Eliminating Epsilon transitions, Minimization of DFA. Finite automata with output (Moore and Mealy machines) and inter-conversion.	12 hours
	Regular Expressions (RE): Introduction, Identities of RE. Finite Automata and Regular Expressions - conversions, Algebraic Laws for Regular Expressions, applications of RE. Regular grammars: Definition, regular grammars, and FA, Proving languages to be non-regular (Pumping lemma), Properties of Regular Language, applications.	10 hours
	Context-Free Grammar (CFG): Definition, Derivations Using a Grammar- Leftmost and rightmost derivation, Parse tree, Applications, Ambiguity in CFG. Minimization of CFG, CNF, GNF, Pumping Lemma for CFL's.	10 hours
	Pushdown Automata (PDA): Definition, Language of PDA- Acceptance by Final State and Acceptance by Empty stack, Equivalence of CFG and PDA, Deterministic PDA, Chmosky normal form of CFG Turing Machines (TM): Formal definition and behavior, Languages of a TM, TM as accepters, and TM as a computer of	15 hours

	integer functions, Types of TMs.	
	Recursive And Recursively Enumerable Languages (REL): Properties of recursive and recursively enumerable languages, Universal Turing machine, The Halting problem, Undecidable problems about TMs. Context-sensitive language and linear bounded automata (LBA), Chomsky hierarchy, Decidability.	10 hours
Pedagogy	lectures/ tutorials/assignments/self-study	
References/ Readings	1. John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, Introduction to Automata Theory Languages and Computation, Pearson Education, India (latest edition) 2. H.R.Lewis and C.H.Papadimitriou, Elements of the Theory of Computation, PHI, (latest edition) 3. J.Martin, Introduction to Languages and the Theory of Computation, TMH (latest edition)	
Learning Outcomes	At the end of the course students will be able to: ● use basic concepts of formal languages of finite automata techniques ● design Finite Automata for different Regular Expressions and Languages ● Construct context-free grammar for various languages	

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MCA SEMESTER III & IV COURSES

Programme: MCA
Course Code: CSA-600 **Title of the Course:** Speech Processing
Number of Credits: 4 (2L-0T-2P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	CSA521-Mathematics for Computer Science and CSA-509 Machine Learning	
Objectives:	The objective of the course is to study fundamental concepts of automatic speech recognition.	
Content:	Anatomy & Physiology of Speech Organs, The process of Speech Production, The Acoustic Theory of Speech Production, Digital models for speech signals.	6 hours
	Formants of vowels, spectrogram of vowels, Acoustic analysis of vowels.	6 hours
	Basic pattern recognition approaches, Parametric representation of speech, Evaluating the similarity of speech patterns, Isolated digit Recognition System, Continuous digit Recognition System.	6 hours
	Hidden Markov Model (HMM) for speech recognition, Viterbi algorithm, Training and testing using HMMs, Adapting to variability in speech (DTW), Language models.	6 hours
	Issues in speaker recognition and speech synthesis of different	6 hours

	speakers. Text to speech conversion, Speech to text system. End-to-end systems.	
	Basic tools ● Installation of speech processing tools eg. Praat audacity etc. ● Spectrogram visualization	10 hours
	Phonetics and speech signals ● Introduction to International phonetic alphabets ● Audio signal processing and cleaning ● Annotation of speech signal	15 hours
	Formant analysis ● Formant analysis of vowels ● Nasalisation of vowels	15 hours
	Advance concepts ● Installation of kaldi for building ASR ● Creation of phonetic dictionary ● Creation of language model ● Building ASR system	20 hours
Pedagogy:	Lab assignments/ research paper reading/ discussion/ tools demonstration/ mini project.	
References/ Readings	1. Digital processing of speech signals - L.R Rabiner and S.W. Schafer. Pearson Education. 2. Speech Communications: Human & Machine - Douglas O'Shaughnessy, 2nd ed., IEEE Press. 3. Fundamentals of Speech Recognition. L.R Rabinar and B.H. Juang.	
Learning Outcomes	After completion of this course, students will be able to ● Have a good understanding of human speech production system ● Understand the basics of pattern recognition approaches. ● Have knowledge of the concepts in speech recognition.	

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Programme: MCA
Course Code: CSA-601 **Title of Course:** Machine Translation
Number of Credits: 4 (2L-0T-2P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Knowledge of Mathematics for Computer Science and Machine Learning will prove beneficial, A previous course on Artificial Intelligence and Natural Language Processing will help; Exposure to Linguistics is useful, though not mandatory	
Objectives:	The objective of the course is to understand and get an insight into the different approaches used for Machine Translation (MT).	
Content:	Introduction: Data-driven MT, MT Approaches, Language divergence, three major paradigms of MT, MT Evaluation,	8 hours
	Bilingual Word Mappings: Combinatorial Argument, One-to-One	4 hours

	Alignment, Heuristic and Iterative bases computation, Mathematics of Alignment, Expectation Maximization, IBM models of Alignment	
	Phrase-Based Machine Translation (PBMT): Need, Examples, Phrase Table, Mathematics of Phrase-Based SMT, Decoding.	10 hours
	Rule-Based Machine Translation (RBMT): Kinds, UNL, Interlingua and Word Knowledge, UNL conversion, Transfer-based MT.	5 hours
	Example-Based Machine Translation (EBMT): Essential steps of EBMT, Text similarity computation, Translation memory, Statistical Machine Translation	3 hours
	<u>Practical</u>	
	Assignment 1: Data-driven MT, MT Approaches, Language divergence, three major paradigms of MT, MT Evaluation,	16 hours
	Assignment 2: Bilingual Word Mappings: Combinatorial Argument, One-to-One Alignment, Heuristic and Iterative bases computation, Mathematics of Alignment, Expectation Maximization, IBM models of Alignment	8 hours
	Assignment 3: Phrase-Based Machine Translation (PBMT): Need, Examples, Phrase Table, Mathematics of Phrase-Based SMT, Decoding.	20 hours
	Assignment 4: Rule-Based Machine Translation (RBMT): Kinds, UNL, Interlingua and Word Knowledge, UNL conversion, Transfer-based MT.	10 hours
	Assignment 5: Example-Based Machine Translation (EBMT): Essential steps of EBMT, Text similarity computation, Translation memory, Statistical Machine Translation	6 hours
<u>Pedagogy:</u>	lectures/ tutorials/assignments/self-learning/ flipped classroom	
<u>References/ Readings</u>	1. Machine Translation by Pushpak Bhattacharyya, Chapman and Hall/CRC, February 2015 2. Machine Translation on Coursera by Prof. Alexander Waibel and Jan Niehues https://www.coursera.org/learn/machinetranslation 3. An Open Source Neural Machine Translation System https://opennmt.net/ 4. Bhashini Project – https://bhashini.gov.in/bhashadaan/en/likho-india	
<u>Learning Outcomes</u>	After completion of this course, students will - • Understand the Machine Translation Approaches • Understand the differences between Phrase-Based, Rule-Based, and Example-Based Machine Translation • explain, apply, and assess evaluation methods for machine translation; • describe and critically discuss the architecture of machine translation systems; • build their own translation model using existing tools for machine	

	translation and evaluate and analyse the translation results; • compare different types of machine translation strategies, such as rule-based, statistical, and neural machine translation; • implement components of machine translation systems or components used in evaluation or pre-processing

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Programme: MCA
Course code: CSA-602 **Title of course:** Educational Technology
Number of Credits: 4 (2L-0T-2P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Web Technology	
Objectives	Course aims at Software Developers who wish to develop technology solutions for using Educational Technology in classroom and online mode. Course will offer students an overview of the theories and practices involved in Educational Technology Students will present examples showing the use of technology for classroom management, administration, teaching and learning. Students will select and evaluate appropriate software and hardware for application in the classroom Students will demonstrate legal and ethical use of technology in the classroom. Students will apply technology to develop higher-order skills and creativity	
Content	Learning theories. Learning objectives and Bloom's taxonomy; constructivist and situated theories of learning; factors affecting and facilitating learning; learning styles	8 hours
	Technologies for creating new resources. Examples include video, multimedia, animations and simulations, Web 2.0/3.0.	4 hours
	Instructional Design (ID). Basic ID models (eg ADDIE model), ID models for e-learning and blended learning (eg Dick and Carey model), online course development using ID. Digital Storytelling	8 hours
	Technologies for content delivery. Examples include Learning Management Systems (e.g. Moodle) classroom management systems (e.g. Jhoomla), Open Education Resources, intelligent tutoring systems.	5 hours
	Case Studies: MOOC such as EdX/Coursera, Swayam-NPTEL	5 hours
	Introduction to various types of Education Technology tools.	4 hours
	Content Authoring Tools: eg Raptivity, Articulate	6 hours
	Assessment Tools: Hot Potato,	4 hours

	Concept Mapping Tools: e.g. CMAP, MindMap, Compendium	4 hours
	Visualization Tools: e.g. R, Highcharts	6 hours
	Analytics Tools: e.g. SPSS, R-language, CAQDAS	6 hours
	Learning Management System: e.g. Moodle, Sakai	8 hours
	Educational Data Mining: e.g. Weka, Rapidminer, KNIME	4 hours
	MOOC: e.g. EdX	8 hours
	Collaboration Tools: e.g. Wiki	2 hours
	Tutoring system development. e.g. CTAT, ASPIRE	2 hours
	Animation tools. E.g. Flash, Gimp, Others: Camstudio for the screencast, image editing, audio editing (audacity), video management, etc	6 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching /active learning	
References/ Readings	• **Foundations of Educational Technology: Integrative Approaches and Interdisciplinary Perspectives (Interdisciplinary Approaches to Educational Technology) BY J. Michael Spector, Routledge; 2nd edition** • **Websites/tutorials for the tools**	
Learning Outcomes	• Create a portfolio-like presentation with samples reflecting ways technology can support classroom management, administration, and teaching. • Create and evaluate products that critique various software and hardware tools for instructional purposes • List and describe legal and ethical issues for using technology in the classroom	

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Programme: MCA
Course code: CSA-603 **Title of course:** Computer Graphics
Number of credits: 4 (2L-0T-2P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of linear algebra, geometry and programming	
Objectives	This course will introduce the learner to various concepts in 3D modeling and computer graphics	
Content	**Fundamentals** history of computer graphics, applications, graphics pipeline, physical and synthetic images, synthetic camera, modeling,	6 hours

	animation, rendering, relation to computer vision and image processing, review of basic mathematical objects (Points, Vectors, Matrix methods).	
	Exploring OpenGL/WebGL architecture, primitives and attributes, simple modeling and rendering of two- and three-dimensional geometric objects, indexed and RGB color models, frame buffer, double buffering, GLUT, interaction, events and callbacks,picking	6 hours
	Geometric Transformations homogeneous coordinates, affine transformations (translation, rotation, scaling, shear), concatenation, matrix stacks and use of model-view matrix in OpenGL/WebGL for these operations	6 hours
	Viewing classical three dimensional viewing, computer viewing, specifying views, parallel and perspective projective transformations	4 hours
	Shading light sources, illumination model, Gouraud and Phong shading for polygons. Rasterization- Line segment and polygon clipping, 3D clipping, scan conversion, polygonal fill	4 hours
	Discrete Techniques texture mapping, compositing, textures in OpenGL; Ray Tracing-Recursive ray tracer, ray-sphere intersection	4 hours
	Suggested Sample List of Assignments:- 1) Explore a 3D programming IDE (e.g. Alice 3D). Understand basic graphic concepts like objects, camera, direction, projection, etc. 2) Using OpenGL/WebGL/Canvas, write a program to create basic 2D/3D geometric shapes. Use RGB colors. 3) Using OpenGL/WebGL/Canvas, write a program to work around with basic shape transformations (translate, rotate, scale, skew, etc.). 4) Using OpenGL/WebGL/Canvas, write a program to animate objects/shapes (e.g. bouncing ball). Try to incorporate basic physics laws. 5) Using OpenGL/WebGL/Canvas, write a program to import object models. 6) Using OpenGL/WebGL/Canvas, write a program to show object collision. 7) Using OpenGL/WebGL/Canvas, write a program to add texture to objects. 8) Using OpenGL/WebGL/Canvas, write a program to add a light source and implement shadows. 9) Using a 3D modeling tool (e.g. Blender), explore creating complex objects like pillars, cars, etc.	40 hours
	Mini-Project Ideally done in a group. The project should include design and	20 hours

	development of a graphic simulation. There should be some interactivity involved. Objects in simulations should be in 3D. Objects could be designed in 3D modeling tools like blender. The texture to those objects could be added programmatically in the simulation before rendering. (e.g. simulation of solar system)	
Pedagogy	Hands-on assignments / tutorials / peer-learning / flip classroom / analysis of research (or white) papers	
References/ Readings	● Edward Angel, Interactive Computer Graphics. A Top-Down Approach Using OpenGL (fifth edition), Pearson Education, 2008 ● Donald Hearn and Pauline Baker, Computer Graphics with OpenGL (third edition), Prentice Hall, 2003 ● F. S. Hill Jr. and S. M. Kelley, Computer Graphics using OpenGL (third edition), Prentice Hall, 2006 ● Peter Shirley and Steve Marschner, Computer Graphics (first edition), A. K. Peters, 2010. ● James D Foley, Andries Van Dam, Steven K Feiner, John F Huges, Computer graphics with OpenGL: pearson education ● Xiang, Plastock, Computer Graphics, 2nd edition, Tata McGraw ● Kelvin Sung, Peter Shirley, Steven Baer, Interactive Computer Graphics, Concepts and Applications, Cengage Learning ● M M Raiker, Computer Graphics using OpenGL, Elsevier	
Learning Outcomes	Learner will 1. understand and apply fundamental concepts within computer graphics 2. compare and evaluate the ideas in some fundamental algorithms for computer graphics 3. apply fundamental principles within interaction programming 4. understand fundamental concepts of information and scientific visualization	

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Programme: MCA
Course Code: CSA-604 **Title of the Course:** Data science
Number of Credits: 4 (2L-0T-2P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Statistics and probability theory and python programming. Python programming and Data science theory fundamentals.	
Objectives	To get started with basics of data science and learn all aspects of data science in its entirety. Learning Objectives ● Basic process of data science	

	● Python and Jupyter notebooks ● An applied understanding of how to manipulate and analyze uncurated datasets ● Basic statistical analysis and basic machine learning methods like linear regression . ● How to effectively visualize results using python APIs or tools.	
Content	**Unit -1:** Basics of Data Science: Introduction; Typology of problems**-Data science in a big data world:** Benefits and uses of data science and big data-Facets of data-The data science process-The big data ecosystem and data science-**The data science process:** Overview of the data science process- Defining research goals and creating a project charter- Retrieving data-Cleansing, integrating, and transforming data-Exploratory data analysis-Build the models- Presenting findings and building applications on top of them.	4 hours
	Unit -2 Mathematics for Data science ● Importance of linear algebra, statistics and optimization from a data science perspective; Structured thinking for solving data science problems. ● Linear Algebra: Matrices and their properties (determinants, traces, rank, nullity, etc.); Eigenvalues and eigenvectors; Matrix factorizations; Inner products; Distance measures; Projections; Notion of hyperplanes; half-planes. ● Probability, Statistics and Random Processes: Probability theory and axioms; Random variables; Probability distributions and density functions (univariate and multivariate); Expectations and moments; Covariance and correlation; Statistics and sampling distributions; Hypothesis testing of means, proportions, variances and correlations; Confidence (statistical) intervals; Correlation functions; White-noise process.	2 hours
	Unit -3 Introduction to Data Science Methods: Linear regression as an exemplar function approximation problem; Linear classification problems.	2 hours
	Unit -4 Handling large data on a single computer ● The problems you face when handling large data-General techniques for handling large volumes of data-General programming tips for dealing with large data sets-Case study 1: Predicting malicious URLs-**First steps in big data-**Distributing data storage and processing with frameworks	2 hours
	Unit 5: Join the NoSQL movement-Introduction to NoSQL **Unit 6: The rise of graph databases**	4 hours

	• Introducing connected data and graph databases • Introducing Neo4j: a graph database **Unit 7: Data visualization to the end user** • Data visualization options • Crossfilter, the JavaScript MapReduce library • Creating an interactive dashboard with dc.js • Dashboard development tools • Data science Story telling.	4 hours 4 hours 4 hours 4 hours
	1. Python libraries – Numpy, Matplotlib, seaborn, pandas. 2. Write program to do Exploratory data analysis using the libraries above.- Data collection(Kaggle, github and Machine learning repository),data cleaning (removing missing values, reformatting data etc. 3. Write program to do univariate analysis using tools like Box plot, histogram etc. 4. Write program to do bivariate analysis using tools like scatter plots, box plots. 5. Demo on business intelligence tools -Business intelligence tools help an organization analyze huge chunks of data; they provide insights with actionable recommendations - Tableau, Qlik,splunk,Trillium,Logi analytics, powerBI 6. Write program to implement PCA. 7. Write program to implement SVD 8. Use tools like tableau/Power BI to do Visualizatiation for large data set and create dashboard 9. Mini Project: With the tools of Jupyter notebooks, numpy, pandas, and Visualization, you're ready to do sophisticated analysis on your own. You'll pick a dataset we've worked with already and perform an analysis for this first project 10. Machine Learning: To take your data analysis skills one step further, write program to do basics of machine learning and how to use sci-kit learn - a powerful library for machine learning. 11. Working with Text and Databases: You'll find yourself often working with text data or data from databases. This week will give you the skills to access that data. For text data, we'll also give you a preview of how to analyze text data using ideas from the field of Natural Language Processing and how to apply those ideas using the Natural Language Processing Toolkit (NLTK) library. 12. Final Project: These weeks let you showcase all your new skills in an end-to-end data analysis project. You'll pick the dataset, do the data munging, ask the research questions, visualize the data, draw conclusions, and present your results.	2 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 4 hours 15 hours 5 hours 6 hours 10 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study. Lab assignments/ research paper reading/ discussion/ tools	

	demonstration/ mini project.	
References/ Readings	1. Practical statistics for data science by peter bruce and andrew bruce 2. Naked statistics by charles wheelon 3. Business data science by matt taddy 4. Elements of statistical learning by Trevor Hastie, Robert and jerome 5. Python for data analysis 6. Data science and big data analytics -EMC2 7. Hands-On Data Structures and Algorithms with Python — By Dr. Basant Agarwal. 8. 3. The Art of Data Science — by Roger D. Peng and Elizabeth Matsui. 9. . Automate the Boring Stuff With Python: Practical Programming— by Al Sweigart.	
Learning Outcomes	Enrich one's knowledge with overall basics of data science and appreciate data science with this introduction to be able to get started in the direction. Students should be able to carry out mini data science projects using python libraries.	

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Programme: MCA
Course Code:CSA-605 **Title of Course:** IoT architecture and protocols
Number of Credits: 4 (3L-0T-1P) **Contact Hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Internet Technologies, Computer Organization and architecture, Operating Systems.	
Objectives	To understand the fundamentals of Internet of Things and the protocols and standards designed for IoT	
Content	Introduction to IoT: Introduction, IoT ecosystem, Applications, Challenges.	4 hours
	Fundamentals: IoT Devices - Sensors, Actuators, and gateways, Basics of the wireless sensor network.	6 hours
	IoT Architecture & Design: oneM2M, IoTWF, Additional Reference Models, Core functional stack, Data Management and compute stack.	8 hours
	Communicating smart objects: Communication criteria, communication models, IoT access technologies – 3GPP MTC, IEEE 802.11, IEEE 802.15, WirelessHART, ZWave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7	12 hours
	IoT Network Layer: IP as IoT network layer, IPv6, 6LoWPAN, 6TiSCH, RPL, CORPL, CARP	10 hours
	IoT Transport and Application protocols: Transport Layer: TCP, UDP, DCCP, SCTP, TLS, DTLS IoT application transport methods, HTTP, CoAP, XMPP, MQTT,	12 hours

	AMQP, DDS	
	Security in IoT: MAC802.15.4, 6LoWPAN, RPL, Application Layer security.	4 hours
	IoT Application case study: Discuss any 3 applications of IoT	4 hours
Pedagogy	lectures/ tutorials/Hands-on assignments/self-study	
References/ Readings	1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press, 2017 2. Hersent, Olivier, David Boswarthick, and Omar Elloumi, The internet of things: Key applications and protocols. John Wiley & Sons, 2011. 3. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and Paradigms. Elsevier, 2016.	
Learning Outcomes	After completing the course, students will be able to: ● Understand the concepts of the IoT Architecture Reference model ● Identify the IoT networking components and protocols.	

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Programme: MCA
Course code: CSA-606 **Title of course:** Mobile App Development
Number of Credits: 4 (2L-0T-2P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of OS and networking; and web development basics	
Objectives	On completion of this course, the learner should be able to successfully build, debug and deploy android apps.	
Content	**Android OS, Ecosystem & Basics** ● Mobile Platforms & OSs; Approaches to mobile development; Android OS; Android System Architecture; Android App Lifecycle; Play Store ● Intro; Create Your First Android App; Layouts, Views and Resources; Text and Scrolling Views; Resources to Help You Learn ● Debugging your apps; Testing your app; Support libraries, and Backwards Compatibility.	6 hours
	User Interface & Lifecycle ● Screen Sizes; User Interaction - User Input Controls, Menus; Screen Navigation; RecyclerView ● Delightful User Experience; Drawables, Themes and Styles; Material Design; Providing Resources for adaptive layouts ● Testing the User Interface ● Activities and Intents; The Activity Lifecycle and Managing State; Starting Activities with Implicit Intents	14 hours
	Background Tasks & Notifications ● Background Tasks; AsyncTask and AsyncTaskLoader; Connecting to the Internet; Broadcast Receivers; Services	4 hours

	● Triggering, Scheduling, and Optimizing Background Tasks; Notifications; Alarm Manager; Transferring Data Efficiently.	
	Data Saving, Retrieving, Loading ● Overview to storing data ● Shared Preferences; App Settings ● SQLite; Firebase ● Sharing Data: Content Resolvers and Content Providers ● Using Loaders to Load and Display Data ● Connecting with API service endpoints.	6 hours
	Suggested Sample List of Assignments:- 1) Build an OO system (like elevators in a building, EVM, etc.). Employ use of design patterns (like Adapter, Singleton, Observer, etc.) 2) Creating a Java/Kotlin project using build tool (e.g. Gradle, Maven) 3) Create a hello world android app using IDE (preferably Android Studio). Try deploying on emulator/mobile. Debug using logcat. 4) Create a calculator app (similar to the app installed in the device used during development) 5) Using intents create a game (like a maze). Explore having raster images & vector graphics in the app. 6) Create a CRUD app. Explore the use of various form elements/widgets and fragments. 7) Create a To-Do app. Explore adding the views/view-groups programmatically (e.g. using inflate, recycler view). Use material design in the UI. 8) Create an app accessing data exposed by another app/ service. Explore BroadcastReceiver, services, etc. 9) Create an app that will run in background and communicate information through status bar/ push-notifications. 10) Create a CRUD app using data stored locally. Explore ROOM, SQLite 11) Create an app to consume an API and populate the layout with appropriate views. 12) Create an app to contain a webapp.	40 hours
	Mini-project Ideally done in a group. It should include design and implementation of an android application. Project implementation should mandatorily use at least 2 mobile-specific functionality (to justify as a mobile app and not web app). The GUI of the app should follow design guidelines (e.g. Material/ Flat Design). Conduct and progress of the project could follow industry practices (e.g. UX mocks, git, scrum, etc.).	20 hours
Pedagogy	Assignments / tutorials / peer-learning / troubleshooting/ case	

	studies	
References/ Readings	● Bill Philips & Brian Hardy, "Android Programming: The Big Nerd Ranch Guide" ● Dawn Griffiths & David Griffiths, "Head First Android Development" ● Ian F. Darwin, "Android Cookbook" ● https://developer.android.com ● https://kotlinlang.org ● https://material.io	
Learning Outcomes	1. Learner will understand the android ecosystem, android versions & compatibility across them. 2. Learner will be able to design user interfaces specifically to be run native android devices. 3. Learner will be able to evaluate which type of views & widgets are preferable for various use cases. 4. Learner will be able to build and design navigation flows in an app. 5. Learner will be able to connect the app to Android services or apps already available on the device. 6. Learner will be able to build apps that can store data locally or remotely.	

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Programme: M.C.A
Course Code: CSA-607 **Title of the Course:** Research Methodology
Number of Credits: 4 (4L-0T-0P) **Contact Hours:** 60 hours (60L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Nil	
Objectives:	The objective of the course is to introduce the theoretical as well as practical aspects of Research	
	Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process Problem Identification & Formulation – Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance Research Design: Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of	15 hours

	Independent & Dependent variables.	
	Qualitative and Quantitative Research: Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches. Measurement: Concept of measurement– what is measured? Problems in measurement in research – Validity and Reliability. Levels of measurement – Nominal, Ordinal, Interval, Ratio. Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample – Practical considerations in sampling and sample size.	15 hours
	Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association. Interpretation of Data and results	15 hours
	Paper Writing – Layout of a Research Paper, Software for paper formatting like LaTeX/MS Office. Journals in Computer Science, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Software for detection of Plagiarism . Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases for Computer Science Discipline. Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley	15 hours
Pedagogy:	Lecture/Presentations/Assignments/Case Study/	
References/ Readings	1. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition 2. Business Research Methods – Alan Bryman & Emma Bell, Sixth Edition, Oxford University Press. 3. Research Methodology: Methods and Techniques, C.R.Kothari, Second Revised Edition, New Age International Publishers 4. Social Science Research: Principles, Methods, and Practices, Anol Bhattacharjee, University of South Florida, Scholar Commons. https://digitalcommons.usf.edu/cgi/viewcontent.cgi?article=1002&context=oa_textbooks	
Learning Outcomes	After completion of this course, students will – • Understand how to formulate a research problem	

	• Understand data collection and analysis techniques • Understand all aspects related to publishing research papers

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Programme: MCA
Course Code: CSA-608 **Title of the Course:** Deep Learning
Number of Credits: 4(2L+0T+2P) **Contact hours:** 90 hours(30L + 0T + 60 P)
Effective from AY: 2023-24

Prerequisites for the course	Familiarity with linear algebra, probability theory, machine learning , familiarity with python	
Objectives:	This course is aimed at any one who wishes to explore deep learning from scratch. This course offers a practical hands on exploration of deep learning, avoiding mathematical notation,preferring instead to explain quantitative concepts through programming using python API	
Content:	Introduction :- what is deep learning ?- Artificial Intelligence, machine learning and deep learning -learning representation from data-"the deep " in deep learning -understanding how deep learning works -what deep learning has achieved so far. Revision of Fundamentals of machine learning- probabilistic modeling – early neural networks- kernel methods-decision tree, random forest and gradient boosting machines -back to neural networks- what makes deep learning different-the modern machine learning landscape . Four branches of machine learning -supervised -unsupervised-self-supervised – reinforcement learning – evaluating machine learning models – data processing, feature engineering-overfitting and underfitting -universal workflow of machine learning The mathematical building block of neural networks – a first look at neural networks – data representation for neural networks- the gears of neural networks :Tensor operations- the engine of neural networks : Gradient -based optimization. Neural networks – anatomy of neural networks- building blocks of deep learning -models of layers -loss functions and optimizers-keys to configuring the learning process.-introduction to keras -keras,tensor flow, theoano and CNTK – developing with keras -setting up a deep learning workstation -case studies – classification movie reviews – classification newswires -predicting house prices. Deep Learning for computer vision – Introduction to convnets – training convnets from scratch on small data sets – using pre trained convnet – visualizing what convnets learn	2 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 5 hours

	Deep learning for text and sequences – working with text -one-hot encoding of words and characters -using word embeddings-understanding recurrent neural networks – A recurrent layer in Keras -understanding LSTM and GRU layers- A concrete LSTM example in Keras. Advanced use of recurrent neural networks- A temperature-forecasting problem – preparing the data – a common-sense, non machine learning baseline-using recurrent drop out to fight overfitting- stacking recurrent layers-using bidirectional RNNs – sequences processing with convnets Generative deep learning – text generation with LSTM- deep Dream – neural style transfer-generative images with variational autoencoders- introduction to generative adversarial networks. **Practical** ● Assignment 1 - Logistic Regression with a Neural Network mindset ● Assignment 2 - Planar data classification with one hidden layer ● Assignment 3 - Building your Deep Neural Network: Step by Step ● Assignment 4 - Deep Neural Network for Image Classification: Application ● Assignment 5 – Initialization and performance of model, Regularization and whether it helps eliminate overfitting, Gradient Checking with model used, Optimization Methods used for every model ● Assignment 6- TensorFlow Tutorial ● Assignment 7 - Convolution model Step by Step demo ● Assignment 8 - Convolution model Application for image classification ● Assignment 9- Keras Tutorial - Autonomous driving application - Car Detection, Face Recognition ● Assignment 10 - Art Generation with Neural Style transfer	5 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours
Pedagogy:	Lectures/ tutorials/lab assignments/self-study	
References/ Readings	Main Reading :- 1. Introduction to Statistical Learning, Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Springer, 2013. 2. EthemAlpaydin, Introduction to Machine Learning, MIT Press. 3. Richard O. Duda, Peter E. Hart, David G. Stork Pattern Classification,. 4. Peter Flach , Machine Learning , Cambridge 5. Christopher M. Bishop,Pattern recognition and machine Learning, springer.	

	6. Deep Learning, Ian Good fellow, MIT press 7. Tom Michele, Machine Learning, McGraw-Hill.	
Learning Outcomes	By the end of the course , students should: • Develop an appreciation for what is involved in learning from data. • Revision of machine learning fundamentals • understand a wide variety of deep learning algorithms. • understand how to apply a variety of learning algorithms to data. • understand how to perform evaluation of learning algorithms and model selection. • Equips them with a general understanding of deep learning.	

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Programme: MCA
Course code: CSA-609 **Title of course:** Programming Paradigms
Number of credits: 4 (4L-0T-0P) **Contact hours:** 60 hours
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of programming	
Objectives	To learn and understand various programming paradigms.	
Content	**Understanding Programming Paradigm** • Programming paradigm concept, motivation, types and classification of paradigms. • Factors with respect to programming languages: Binding times and flexibility; Scoping; First class values; Abstraction; Typing; Storage Allocation & Dynamic Memory	4 hours
	Imperative Programming • Variables and data types; Operators and expressions; Input/Output operations, Decision constructs; Looping constructs • Procedural (*in Python/C*) -- blocks & scope; procedures (functions) • Object Oriented (*in Java/C++*) -- classes & objects, object-oriented principles (encapsulation, abstraction, inheritance, polymorphism)	4 hours
	Functional Programming (*in Haskell/Clojure/Scala*) • Revision of mathematical Functions' concepts • Side effects; Pure functions • Type induction • Defining functions • Currying; Function composition • Recursion • Lazy evaluation; infinite lists • List comprehensions • Higher order functions; Folds	20 hours

	Logic Programming (*in Prolog/ECLiPSe Constraint language*) ● Revision of mathematical Logic concepts ● Programming "without algorithms" ● Logic programming with facts, rules and goals ● Recursion; Lists ● Constraint logic programming; constraints as relationship between variables; solving puzzles (like sudoku)	12 hours
	Event-driven Programming (*in Python/.NET*) ● Events ● Main loop & callback ● Scheduler & Event handlers; Triggers ● Exception handling ● Reliable eventing ● Asynchronous triggers	8 hours
	Multi-Paradigms and more ● Language support for multi paradigms; Benefits & issues ● Parallel programming -- Data Parallelism (*in OpenMP*) and Message Passing (*in MPI*) ● Reactive programming (*in Elm/ReactiveX for Java, JS*) ● Meta programming (*in Lisp*) ● Natural Language Programming (*in SciLab/MATLAB*)	12 hours
Pedagogy	Hands-on assignments / tutorials / peer-learning / pair programming/ analysis of research (or white) papers	
References/ Readings	● Terrance W. Pratt, Marvin V. Zelkowitz, "Programming Languages - Design & Implementation" ● Robert L. Sebesta, "Concepts of Programming Languages" ● Ravi Sethi, "Programming Languages Concepts & Constructs" ● Bruce J. Mac Lennan, "Principles of Programming Languages: Design, Evaluation, and Implementation" ● Kenneth C. Louden, "Programming Languages: Principles and Practice" ● Allen Tucker, Robert Noonan, "Programming Languages: Principles and Paradigms" ● Graham Hutton, "Programming in Haskell" ● W. Clocksin, "Programming in Prolog" ● Slim Abdennadher, Thom Frühwirth, "Essentials of Constraint Programming" ● Roland Kuhn, Brian Hanafee, Jamie Allen, "Reactive Design Patterns"	
Learning Outcomes	1. Learner will be able to distinguish between different programming paradigms 2. Learner will be able to choose an adequate programming paradigm in solving specific software engineering problems	

	3. Learner will be able to recognize the similar concepts implemented in a different way across different programming languages and paradigms	

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Programme: MCA
Course code: CSA-610 **Title of course:** Software Testing
Number of Credits: 4 (2L-0T-2P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Software Engineering, OOT, Web Technology, Agile Methodology Software Engineering, OOT, Web Technology	
Objectives	Inculcate the concepts and skills related to testing and quality assurance To empower the learner to evaluate and select appropriate testing methods and tools Develop Test first approach to software development. Inculcate the concepts and skills related to testing and quality assurance. Use various tools for testing and test automation To empower the learner to evaluate and select appropriate testing methods and tools.	
Content	Fundamentals of testing: Test, test case, test case design Levels of testing: Unit, Integration, system, Acceptance Testing Types of testing: White box and black box, various techniques – Cyclomatic complexity, equivalence class partitioning, boundary value analysis Functional and non-functional testing.	8 hours
	Test Driven Development: TDD frameworks and refactoring using Junit, pair programming	8 hours
	Debugging approaches and principles, debugging guidelines	4 hours
	Testing tools and frameworks for Web and App development: Selenium, Jmeter, Jira, Bugzilla, API testing, DB testing,	4 hours
	Continuous Integrations and DevOPs	2 hours
	Quality Assurance: Reviews, walkthroughs, quality frameworks	4 hours
	Test management tool: keep track of all the testing activity, fast data analysis, manage manual and automation test cases, various environments, and plan and maintain manual testing	6 hours
	Bug tracking tool: commonly used bug tracking tools such as: Jira, Bugzilla	6 hours
	Automated testing tool: how to change the manual test cases into a test script with the help of some automation tools. commonly used automation testing tools: Selenium	6 hours

	Performance testing tool: test the performance of the software or an application. Performance testing tools such as Apache JMeter, LoadRunner	6 hours
	Cross-browser testing tool: to test application on multiple browsers , perform compatibility testing through various browsers by using cross-browser testing tools such as LambdaTest, Sauce Labs	6 hours
	Integration testing tool: test the interface between modules and find the bugs. Some of the most used integration testing tools : Citrus, FitNesse	6 hours
	Unit testing tool using Junit/NUnit/phpunit and refactoring tools	6 hours
	Mobile/android testing tool to check the usability, functionality, security, and consistency of the application. Use of tools of mobile testing such as Appium	6 hours
	GUI testing tool GUI testing:Navigation validation, verify the check screens, data integrity validation, verification of usability situations, and also check the numeric, date field formats.	6 hours
	Security testing tool authorization, confidentiality, authentication, and availability types of aspect SonarQube ZAP	6 hours
Pedagogy	Classroom/handson instructions, assignments, mini projects. Demo of tools, Classroom/handson instructions, assignments, mini projects	
References/ Readings	1. Agile Java: Crafting Code with Test-Driven Development, Prentice Hall; 1st edition, 2005 2.A Practitioner's Guide to Software Test Design, Lee Copeland, Artech House 3. Refactoring: Improving the Design of Existing Code by Martin Fowler, Pearson, 2009 4. Code Complete- Steve McConnel, Microsoft Press US; 2nd edition, 2004 Websites and online tutorials	
Learning Outcomes	1. Learner will be able to design test cases 2. Learner will be able to apply agile and lean principles in software design 3. Learner will be able to configure and use various test automation tools 4. Learner will be able to adopt best practices in software testing and quality assurance 5. Learner will be able to use testing tools for all aspects of software testing 6. Learner will be able to evaluate and select appropriate tool 7. Learner will apply the tools on a software project	

Programme: MCA

Course Code: CSA-611 **Title of the Course:** Artificial Intelligence
Number of Credits: 4 (2L-0T-2P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	a)Strong knowledge of Mathematics. b)Good command over programming languages. c) Good Analytical Skills. d)Ability to understand complex algorithms. e) Basic knowledge of Statistics and modeling.	
Objectives:	This course provides students with an in-depth introduction to Five main tribes of Artificial Intelligence-namely Symbolists,Connectionists,Bayesians,Evolutionariesand Analogizers. symbolist systems include Decision trees,Random decision forests,Production rule systems,inductive programming. connectionist include Artificial neural nets,Reinforcement learning,Deep learning Bayseaian include Hidden Markov chains-Graphical models-Causal inference Evolutionary -biologist - biologically inspired computing Analogizers (psychologists) include k nearest neighbor algorithm and svm. This course is aimed at exploring all facets of AI and obtain in-depth understanding of this facilitating field.	
Content:	Unit 1 :-Introduction to AI :- The roots of Artificial Intelligence -Five tribe of AI -The symbolist - connectionist -Evolutionaries-The Bayseians-Analogizer	1 hours
	Unit2:-Symbolic Tribe (Symbolic AI) Problem-solving-Solving Problems by Searching -Search in Complex Environments -Adversarial Search and Games -Constraint Satisfaction Problems . Knowledge, reasoning, and planning Logical Agents - First-Order Logic - Inference in First-Order Logic - Knowledge Representation -Automated Planning .	5 hours
	Unit -3 :-Bayesian Tribe :- Uncertain knowledge and reasoning - Quantifying Uncertainty -Probabilistic Reasoning-Probabilistic Reasoning over Time -Probabilistic Programming -Making Simple Decisions -Making Complex Decisions -Multiagent Decision Making	5 hours
	Unit 4:- Connectionism tribe :- Machine Learning - supervised learning -unsupervised learning-Artificial neural networks-perceptron-MLP-deep neural network -CNN-RNN-LSTM -hop	5 hours

	field neural network Unit 5 :- Evolutionaries tribe:- An Overview of Combinatorial Optimization-An Introduction to Genetic Algorithms-Theoretical Foundations of Genetic Algorithms-Genetic Algorithms in Engineering and Optimization-Genetic Algorithms in Natural Evolution-Simulated Annealing and Tabu Search GALib-Genetic Algorithm Optimization Toolbox (GAOT) under Matlab.	5 hours
	Unit 6 :- Analogizers :- constrained optimization ,Margin and SVM- hard margin and soft margin, non-linearity - kernel- different types of kernels-k nearest neighbors	5 hours
	Unit 7 :- Communicating, perceiving, and acting-Natural Language Processing -Deep Learning for Natural Language Processing -Computer Vision -Robotics	4 hours
	Conclusions- Philosophy, Ethics, and Safety of AI - Explainable AI - The Future of AI	
	Practical ● Real-world path planning for pedestrians. In the first part, students implement A* over a map that includes roads/paths as well as elevations. In the second part, students collect actual data through walking around the real world, and the cost model is then learned via regression techniques.	5 hours
	● Solve maze via search -this assignment involves formulating maze-solving as a search problem, image processing (via OpenCV) as a step in maze-solving, as well as guided performance/quality analysis of representational parameters.	5 hours
	● Within the context of an artificial intelligence course, students are taught to identify ethical issues within technical projects and to engage in moral problem solving with regard to such issues.	5 hours
	● Neural network for face recognition using tensor flow -build feedforward neural networks for face recognition using TensorFlow. Students then visualize the weights of the neural networks they train. The visualization allows students to understand feedforward one-hidden layer neural networks in terms of template matching, and allows students to explore overfitting.	5 hours
	● Organic path finding -Students develop a “human-like” pathfinding technique by specializing a generic search algorithm with custom action cost and heuristic cost functions. Students apply classical search algorithms and reflect on example organic paths to achieve “human-like” pathfinding.	5 hours

	● Implement a genetic algorithm in Python to evolve strategies for Robby the Robot to collect empty soda cans that lie scattered around his rectangular grid world. ● Compare the performances of a brute-force search and a search employing the Minimum Remaining Values (MRV) heuristic in solving Sudoku puzzles. ● The students need to understand and extend an existing implementation of the back-propagation algorithm and use it to recognize static hand gestures in images. ● Students learn about feedforward neural networks and the backpropagation algorithm by implementing a perceptron network for AND and XOR Boolean functions and, given an implementation of a feedforward network, learn digit recognition using the MNIST data set. ● In this assignment students extend a Tic Tac Toe program to Ultimate Tic Tac Toe and implement a different search strategy than the example code.	5 hours 5 hours 10 hours 10 hours 5 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study.	
References/ Readings	Main Reading :- 1. Master algorithm by pedro domingos 2. Artificial Intelligence -Modern approach -Russel and Norvig- 4th Edition 3. Hands on Machine learning with sci-kit learn and tensorflow-Orellie 4. Deep learning with python by Francois - 5. Elements of statistical learning - Trevor Hastie,Robert and Jerome -springer. 6. Bayesian reasoning and machine learning - David barber 7. Genetic algorithm by David E Goldberg. 8. Artificial Intelligence- A Modern Approach (3rd edition) by norvig , russel 9. Artificial Intelligence By Example-2nd edition by Denies Rothman,PACKT 10. Artificial Intelligence Engines: A Tutorial Introduction to the Mathematics of Deep Learning 11. Human Compatible: Artificial Intelligence and the Problem of Control by Stuart Russel References 12. Artificial Intelligence - A guide for thinking humans by Melaine Mitchell. 13. A world without work - by Daniel susskind. 14. Genius Makers -Cade Metz 15. what computer still cannot do by Hubert Dreyfus 16. The alignment problem -Brian Christian 17. Clara and sun by Kazuo Ishiguro 18. Rebooting AI by Gary Marcus and Ernest Davis	

	19. Four futures -Peter Frase 20. Flake, The Computational Beauty of Nature, MIT Press, 1998. 21. von Neumann, The Computer and the Brain. Yale University Press, 1958 22. https://formtek.com/blog/artificial-intelligence-the-five-tribes-of-ai/	
Learning Outcomes	By the end of the course , students should: • develop an appreciation for what is involved in AI systems • understand a wide variety of AI algorithms. • learning to apply different tribes in different applications. • understand how to apply a variety of learning algorithms to data. • understand how to perform evaluation of learning algorithms and model selection. • further learn to understand the need to understand Master algorithm - unification of all algorithms to solve complex problems. • to carry out the mini project work with respect to symbolic paradigm. • To carry out the mini project work with respect to connectionsim paradigm. • To carry out the mini project work with respect to bayseian paradigm. • To carry out the mini project work with respect to analogiser paradigm. • To carry out the mini project work with respect to Evolutionary paradigm.	

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Programme: MCA
Course Code: CSA-612 **Title of the Course:**MLOps
Number of Credits: 4 (2L+0T+2P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Familiarity with linear algebra, probability theory, machine learning , familiarity with python.	
Objectives:	This course is aimed at any one who wishes to explore deep learning from scratch. This course offers a practical hands on exploration of deep learning, avoiding mathematical notation,preferring instead to explain quantitative concepts through programming using python API	
Content:	Unit 1. Introduction to MLOps Rise of the Machine Learning Engineer and MLOps-What Is MLOps?-DevOps and MLOps-An MLOps Hierarchy of Needs-Implementing DevOps-Configuring-Continuous Integration with GitHub Actions-DataOps and Data Engineering-Platform Automation-MLOps	3 hours

	Unit 2. MLOps Foundations-Bash and the Linux Command Line-Cloud Shell Development Environments-Bash Shell and Commands-List Files Run CommandsFiles and Navigation-Input/Output-Configuration-Writing a Script-Cloud Computing Foundations and Building Blocks-Getting Started with Cloud Computing- minimalistic python revision-Descriptive Statistics and Normal Distributions-Optimization-Machine Learning Key Concepts-Doing Data Science-Build an MLOps Pipeline from Zero Unit 3. MLOps for Containers and Edge Devices Containers-Container Runtime-Creating a Container Running a Container-Best Practices-Serving a Trained Model Over HTTP-Edge Devices-Coral Azure Percept-TFHub-Porting Over Non-TPU Models-Containers for Managed ML Systems-Containers in Monetizing MLOps-Build Once, Run Many MLOps Workflow Unit 4. Continuous Delivery for Machine Learning Models-Packaging for ML Models-Infrastructure as Code for Continuous Delivery of ML Models-Using Cloud Pipelines-Controlled Rollout of Models-Testing Techniques for Model Deployment Unit 5. AutoML and KaizenML-AutoML-MLOps Industrial Revolution-Kaizen Versus KaizenML-Feature Stores-Apple’s Ecosystem-Apple’s AutoML: Create ML-Apple’s Core ML Tools orGoogle’s AutoML and Edge Computer Vision or Azure’s AutoMLor AWS AutoML-Open Source AutoML Solutions-Ludwig-FLAML-Model Explainability Unit 6. Monitoring and Logging-Observability for Cloud MLOps-Introduction to Logging-Logging in Python-Modifying Log Levels-Logging Different Applications-Monitoring and Observability-Basics of Model Monitoring-Monitoring Drift with AWS SageMaker-Monitoring Drift with Azure ML Unit 7. MLOps for AWS-Introduction to AWS-Getting Started with AWS Services-MLOps on AWS-MLOps Cookbook on AWS-CLI Tools-Flask Microservice-AWS Lambda Recipes-AWS Lambda-SAM Local-AWS Lambda-SAM Containerized Deploy-Applying AWS Machine Learning to the Real World Unit 8. Machine Learning Interoperability-Why Interoperability Is Critical-ONNX: Open Neural Network Exchange-ONNX Model Zoo-Convert PyTorch into ONNX -Convert TensorFlow into ONNX-Deploy ONNX to Azure-Apple Core ML-Edge Integration Unit 9: Building MLOps Command Line Tools and Microservices-Python Packaging-The Requirements File-Command Line Tools-Creating a Dataset Linter Modularizing a Command Line Tool-Microservices-Creating a Serverless Function-Authenticating to Cloud Functions-Building a Cloud-Based CLI-Machine Learning CLI Workflows	3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours

	Unit 10. Machine Learning Engineering and MLOps Case StudiesUnlikely Benefits of Ignorance in Building Machine Learning Models-MLOps Projects at Sqor Sports Social Network-Mechanical Turk Data Labeling-Influencer Rank-Athlete intelligence (AI product)-The perfect techniques versus the real world-critical challenges in MLops- Ethical and unintended consequences-lack of operational excellences- focus on prediction accuracy vs the big picture	
	Practical: ● Perfect Project Structure – Cookiecutter & readme.so ● Speed Exploratory Data Analysis to Minutes – Pandas Profiling, SweetViz ● Track Data Science Projects with CI, CD, CT, CM –Data Version Control (DVC) ● Explainable AI / XAI – SHAP, LIME, SHAPASH ● Deploy ML Projects in minutes – Docker, FastAPI ● End to End Machine Learning – MLflow ● Building Production Ready ML Pipelines - Model Registry, Feature Store (Feast, ButterFlow) ● Big Data using Python, instead of PySpark – DASK ● Build a Chatbot and Deploy it (open-source) ● FaaS Framework implementation – Apache OpenWhisk, OpenFaas	 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours
Pedagogy:	lectures/ tutorials/lab assignments/self-study	
References/ Readings	Main Reading :- Practical MLops – Noah Gift and AlfredoDeza Introduction to MLOps – Noah Gift and AlfredoDeza 1| Machine Learning Engineering By Andriy Burkov 2.ML Ops: Operationalizing Data Science By David Sweenor, Dev Kannabiran, Thomas Hill, Steven Hillion, Dan Rope and Michael O'Connell-O'Reilly 3. Building Machine Learning Pipelines By Hannes Hapke, Catherine Nelson 4. Practical MLOps by Noah Gift, Alfredo Deza. O'Reilly 5. Introducing MLOps By Mark Treveil & Dataiku Team 6.Beginning MLOps with MLFlow: Deploy Models in AWS SageMaker, Google Cloud, and Microsoft Azure By Sridhar Alla, Suman Kalyan Adari, O'Reilly	
Learning Outcomes	Students will be able to handle deployment challenges in ML project carried out in the lab and would develop technical competence to deploy the Machine learning projects.	

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Std. Com.X AC-6
15 & 22.05.2023

Programme: MCA
Course code: CSA-613 **Title of course:** IoT application development
Number of Credits: 4 (2L-0T-2P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2022-23

Prerequisites for the course	Programming skills, basic knowledge of electronics, Basics of networking	
Objectives	The basic objectives are: ● To introduce the concept of the Internet of Things and its applications in various domains ● To explore the different protocols and communication methods used in IoT systems ● To provide a working knowledge of Node-RED, a popular programming tool for developing IoT applications ● To equip students with the skills to design and build IoT systems for a variety of use cases	
Content	Fundamentals of IoT ● Understanding IoT and its applications ● IoT architecture and components ● Introduction to sensors and actuators	8 hours
	IoT protocols and communication ● Wired and wireless communication protocols ● Overview of IoT protocols: MQTT, CoAP, HTTP, WebSocket, etc. ● LoRaWAN and its applications	8 hours
	Cloud Computing for IoT ● Cloud computing fundamentals ● Cloud services for IoT ● Cloud platforms for IoT ● IoT data management and storage on the cloud	8 hours
	IoT Security and Privacy ● IoT security risks and challenges ● IoT security protocols and practices ● IoT privacy concerns and regulations	6 hours
	Practical Introduction to Node-RED ● features, architecture, and installation ● Building the flow: understanding nodes, messages, and flows ● Debugging the flows: using the debug node, logging, and error handling	12 hours
	Data acquisition and visualization ● Using sensors and actuators in Node-RED ● Connecting to sensors and devices: using input nodes and protocols (MQTT, HTTP, WebSocket, etc.) ● Data processing and manipulation: using function nodes and JavaScript ● Building dashboards: using the Node-RED Dashboard module for data visualization and control	16 hours

	● Using APIs and cloud services in Node-RED	
	IoT protocols and communication ● Overview of IoT protocols: MQTT, CoAP, HTTP, WebSocket, etc. ● Setting up an MQTT broker: installation, configuration, and security ● MQTT publishing and subscribing: using MQTT nodes in Node-RED ● Building an MQTT-based IoT system: integrating sensors, actuators, and applications	16 hours
	Advanced topics in IoT and Node-RED ● Node-RED extensions and plugins ● Deploying and scaling Node-RED: hosting Node-RED flows on cloud platforms like AWS ● IoT Project Development with Node-RED ● Developing IoT projects using Node-RED and sensors, actuators, and communication protocols	16 hours
Pedagogy	Assignments / tutorials / peer-learning / troubleshooting/ case studies	
References/ Readings	1. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. *Internet of Things: Principles and paradigms*. Elsevier, 2016. 2. Raj, Pethuru, and Anupama C. Raman. The Internet of Things: Enabling technologies, platforms, and use cases. CRC press, 2017. 3. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press) 4. Research papers 5. Hagino, Taiji. Practical Node-RED Programming: Learn powerful visual programming techniques and best practices for the web and IoT. Packt Publishing Ltd, 2021. 6. https://cookbook.nodered.org/	
Learning Outcomes	After completion of the course, the learner will be able to: 1. will be able to design some IOT-based prototypes 2. Understand the various protocols and communication methods used in IoT systems, including MQTT, CoAP, and HTTP. 3. Implement various protocols and communication methods used in IoT systems, including MQTT in NodeRED 4. Design and build IoT systems for a variety of use cases, including smart home automation,	

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Programme: MCA
Course Code: CSA-621 **Title of Course:** Corporate Skills
Number of Credits: 4 (4L-0T-0P) **Total contact hours:** 60 hours
Effective from AY: 2022-23

Prerequisites for the course	Programme prerequisites	
Objectives	The course is aimed at learners to gain practical and essential skills to work effectively in the industry.	
Content	Understanding the Industry and Companies ● Understanding the evolution of the industry and technology and methods used ● Understanding Innovation and how new Impactful ideas have evolved ● Types of companies and typical organization - Who does What ● Understanding companies - Domain, Offering, Customers, Strategy ● Company Culture & Professionalism ● Understanding companies financially	8 hours
	Understanding Execution and day to day work in organizations ● Product Solutioning and Development - Understanding beyond the theory ● Product Management - Understanding beyond the theory ● Quality - Understanding beyond the theory ● Solutioning and Design - A key step between requirements and delivery ● Site Reliability, Devops, Support - Understanding beyond the theory ● Common Metrics and Measurements ● Key Tools in a Product Life Cycle ● Issues Management and Lifecycle - A key aspect of customer Satisfaction ● Software delivery models and Release cycles - how they work in the real world ● Usability by end user - UI/UX and other key concepts and its importance ● Understanding Data engineering and Data science ● Writing good product or service specifications which can be translated to building a good product ● Understanding data from collection to modeling to usage ● How to do effective product, competition or technical research and use it effectively ● testing and testing automation - understand beyond the theory ● what is effective program management and scrum management ● Designing for performance, scalability and reliability in products ● Effective root cause analysis and building products which can allow quicker RCA ● Understanding dev ops and its importance and role in a company ● Understanding product architecture with respect to a monolith or modularity and its pros and cons ● Governance, alerts and monitoring and its importance	20 hours

	Useful skills to work effectively in a organization ● Continuous learning and improvement - An essential skill ● Ownership and Leadership ● Analyzing one's career path and making educated judgements ● Time management and multi-tasking model ● Being an effective Mentee and Mentor ● Being Inquisitive: Why is asking questions more difficult than giving answers? ● Effective Articulation and Communication ● Introducing yourself & Making Effective Presentations ● Problem breakdown and resolving model ● Effective project Management ● Mind Mapping - A powerful technique to learn ● Must have tips to succeed in any career	20 hours
	Mini-Project	12 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching / mini-project / case studies	
References/ Readings	All the course material is based on real life industry practices, experiences and case studies and focused on application of skills and knowledge. The course is being imparted by experienced industry professionals who are still working in the industry and leading critical functions and teams and have the pedigree of building products, managing and delivering to customers, managing teams, entrepreneurs or being part of core teams in software product or services organization.	
Learning Outcomes	1. Know and recall core knowledge of the syllabus. (To measure this outcome, questions may be in the form of the situations, simulations, case studies) 2. Understand core concepts. (To measure this outcome, Question and Answers, Situations analysis, case studies would be used) 3. Analyze the problem and apply the appropriate concept. (To measure this outcome, Projects and Case studies would be used) 4. Give reasoning. (To measure this outcome, Problem analysis and solving techniques would be taught and used, Question and answers and use cases would be utilized) 5. Apply core concepts to new situations. (To measure this outcome, Group projects and Case studies based homework would be used)	**(Back to Index) (Back to Agenda)**

Annexure V

Masters in Data Science to be effective from Academic Year 2023-24

Eligibility:

Bachelor degree in Computer Science/Computer Applications/Engineering (Computer Science/Information Technology) or equivalent degree with atleast 55% marks (relaxation in minimum percentage for reserved categories shall be applicable as per existing state government rules)

OR

Bachelor degree in Mathematics/Statistics/Electronics with atleast 55% marks (relaxation in minimum percentage for reserved categories shall be applicable as per existing state government rules). Such candidates shall be provisionally admitted until successful completion of Bridge Courses as specified by the **Admission Committee for Masters in Data Science** at the time of admission.

Admission:

Procedure for admission to the Masters in Data Science will be decided by the Admission Committee for Masters in Data Science appointed by the Vice-Chancellor for the Academic Year

SEMESTER – 1

Course-Code	**Course Title**	**L**	**T**	**P**	**Credits**
	Discipline Specific Core Courses(DSCC)				
DSC-500	Fundamentals of Data science (Theory)	2	0	0	**2**
DSC-501	Fundamentals of Data science (Practical)	0	0	4	**2**
DSC-502	Machine learning (Theory)	2	0	0	**2**
DSC-503	Machine learning (Practical)	0	0	4	**2**
DSC-504	Mathematical Foundations for Data Science (Theory)	2	0	0	**2**
DSC-505	Mathematical Foundations for Data Science (Practical)	0	0	4	**2**
DSC-506	Fundamentals of Artificial Intelligence (Theory)	2	0	0	**2**
DSC-507	Fundamentals of Artificial Intelligence (Practical)	0	0	4	**2**
	Total Credits for DSCC				**16**

Discipline Specific Elective Courses(DSEC)					
DSC-521	Domain specific Predictive Analytics	2	0	4	**4**
DSC-522	Design thinking for Data-Driven App Development	2	0	4	**4**
	Total Minimum Credits for DSEC				**4**
Total Minimum Credits Semester – 1					**20**
Skill Enhancement Course(SEC), Students to be encouraged / made mandatory to go through the courses, but not considered for GPA Calculation, will appear on Grade Card					
	Yoga and Meditation	0	0	4	**2**
	Any Community Engagement Course like - Swachh Bharat Student Internship(SBSI) or Community Engagement and Rural Development (CERD) Course (Practical)	0	0	4	**2**

MSc In Data Science COURSE STRUCTURE to be effective from Academic Year 2023-24					
SEMESTER – 2					
Course-Code	**Course Title**	**L**	**T**	**P**	**Credits**
DSC-508	Reinforcement learning (Theory)	2	0	0	**2**
DSC-509	Reinforcement learning (Practical)	0	0	4	**2**
DSC-510	Optimization techniques	4	0	0	**4**
DSC-511	MLOps (Theory)	2	0	0	**2**
DSC-512	MLOps (Practical)	0	0	4	**2**
DSC-513	Software Engineering for AI Enabled systems (Theory)	2	0	0	**2**
DSC-514	Software Engineering for AI Enabled systems (Practical)	0	0	4	**2**
Total Credits for DSCC					**16**
Discipline Specific Elective Courses (DSEC)					
DSC-523	Signal processing	2	0	4	**4**
DSC-524	Regression Analytics and Predictive Models	2	0	4	**4**
Total Minimum Credits for DSEC					**4**
Total Minimum Credits Semester – 2					**20**

Masters in Data Science COURSE STRUCTURE to be effective from Academic Year 2023-24					
SEMESTER – 3					
Course-Code	**Course Title**	**L**	**T**	**P**	**Credits**
The following Research Specific Elective Courses(RSEC) to be opted in consultation with the Mentor based on the Dissertation type to be opted by the student for Semester 4.					
DSC-600	Speech Processing	2	0	4	**4**
DSC-601	NLP	2	0	4	**4**
DSC-602	Simulation and Modelling	2	0	4	**4**
DSC-603	Deep Learning Models	2	0	4	**4**
DSC-604	Data Engineering	2	0	4	**4**
DSC-605	Sensors , Actuators and Signal Conditioning	2	0	4	**4**
DSC-606	Cloud Computing	2	0	4	**4**
DSC-607	Research Methodology	4	0	0	**4**
Total Minimum Credits for RSEC					**8**
Generic Elective Courses(GEC)- total 12 credits to be opted					
DSC-621	Corporate Skills	4	0	0	4
DSC-622	Seminar Course	4	0	0	**4**
	Value Added Course / Skill Enhancement Courses / Community Engagement Course / Multidisciplinary Course	2	0	4	4
	Any one offered by Commerce Discipline for that semester can be opted	4	0	0	**4**
	Any one offered by Economics Discipline for that semester can be opted	4	0	0	**4**
	Any one offered by Management Studies Discipline for that semester can be opted	4	0	0	**4**
	Foreign or Indian Language Course	4	0	0	**4**
Total Minimum Credits for GEC					**12**
SWAYAM / MOOC Courses **can be opted over and above the regular prescribed as Audit Courses**					

Total Minimum Credits for Semester 3	**20**

MSc in Data Science to be effective from Academic Year 2023-24
SEMESTER – 4
Anyone Research Specific Elective Courses(RSEC) to be opted in consultation with the Mentor based on the Dissertation type to be opted by the student for Semester 4. It could be completed in Semester 3 before going for Internship.

DSC-608	Financial Machine Learning	2	0	4	**4**
DSC-609	Data Science for Atmospheric Science	2	0	4	**4**
DSC-610	Pragmatic AI	2	0	4	**4**
DSC-611	AI for Medical Specialization	2	0	4	**4**
DSC-612	Recommender Systems	2	0	4	**4**
DSC-613	Text Mining and Sentiment Analysis	2	0	4	**4**

Total Minimum Credits for RSEC	4

Dissertation Type	**Credits**
DSC-652: Industry Internship OR Software Project Development OR DSC-651: Research Project in Academic or Research Institutes	16
Total Credits for Dissertation	**16**
Total Minimum Credits for Semester-4	**20**
Total Minimum Credits for two-year MSc in Data Science degree Programme	**80**

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SEMESTER I

Programme: MSc. in Data Science
Course Code: DSC-500 **Title of the Course:** Fundamentals of Data Science (Theory)
Number of Credits: 2(2L-0T- 0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Statistics and probability theory and python programming	
Objectives	To get started with basics of data science and learn all aspects of data science in its entirety	

Content	Introduction: Typology of problems - Data science in a big data world: Benefits and uses of data science and big data-Facets of data-The data science process-The big data ecosystem and data science-The data science process: Overview of the data science process- Defining research goals and creating a project charter-Retrieving data-Cleansing, integrating, and transforming data-Exploratory data analysis-Build the models- Presenting findings and building applications on top of them.	4 hours
	Mathematics for Data Science – A quick Review: Importance of linear algebra, statistics and optimization from a data science perspective; Structured thinking for solving data science problems. Linear Algebra: Matrices and their properties (determinants, traces, rank, nullity, etc.); Eigenvalues and eigenvectors; Matrix factorizations; Inner products; Distance measures; Projections; Notion of hyperplanes; half-planes. Probability, Statistics and Random Processes: Probability theory and axioms; Random variables; Probability distributions and density functions (univariate and multivariate); Expectations and moments; Covariance and correlation; Statistics and sampling distributions; Hypothesis testing of means, proportions, variances and correlations; Confidence (statistical) intervals; Correlation functions; White-noise process. Data clearing (EDA)	6 hours
	Introduction to Data Science Methods: Linear regression as an exemplar function approximation problem; Linear classification problems-PCA	4 hours
	Handling large data on a single computer - The problems you face when handling large data-General techniques for handling large volumes of data-General programming tips for dealing with large data sets - Case study 1: Predicting malicious URLs - First steps in big data-Distributing data storage and processing with frameworks	4 hours
	Introduction to NoSQL The rise of graph databases Introducing connected data and graph databases Introducing Neo4j: a graph database	4 hours
	Data visualization to the end user	4 hours
	Data visualization options Cross filter, the JavaScript MapReduce library Creating an interactive dashboard with dc.js Dashboard development tools	4 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References / Readings	1. Practical statistics for data science by peter bruce and andrew bruce 2. Naked statistics by charles wheelon 3. Business data science by matt taddy	

	4. Elements of statistical learning by Trevor Hastie, Robert and jerome 5. Python for data analysis 6. Data science and big data analytics -EMC2	
Learning Outcomes	The students will be able to • Enrich one's knowledge with overall basics of data science • Appreciate data science with this introduction to be able to get started in the direction.	

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Programme: Masters in Data Science
Course code: DSC-501 **Title of course:** Fundamentals of Data Science (Practical)
Number of credits: 2(0L-0T-2P) **Total contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Basic programming skills, Statistics	
Objectives	• To introduce Basic process of data science, Python and Jupyter notebooks. • To understanding how to manipulate and analyse uncurated datasets • To learn basic statistical analysis and machine learning methods and effectively visualize results	
Content	Jupyter and Numpy: Jupyter notebooks are one of the most commonly used tools in data science as they allow you to combine your research notes with the code for the analysis. After getting started in Jupyter, we'll learn how to use numpy for data analysis. numpy offers many useful functions for processing data as well as data structures which are time and space efficient.	10 hours
	Pandas: Pandas, built on top of numpy, adds data frames which offer critical data analysis functionality and features.	10 hours
	Visualization: When working with large datasets, you often need to visualize your data to gain a better understanding of it. Also, when you reach conclusions about the data, you'll often wish to use visualizations to present your results.	10 hours
	Mini Project: With the tools of Jupyter notebooks, numpy, pandas, and Visualization, you're ready to do sophisticated analysis on your own. You'll pick a dataset we've worked with already and perform an analysis for this first project.	10 hours
	Machine Learning: To take your data analysis skills one step further, we'll introduce you to the basics of machine learning and how to use sci-kit learn - a powerful library for machine learning.	10 hours

	Working with Text and Databases: You'll find yourself often working with text data or data from databases. This week will give you the skills to access that data. For text data, we'll also give you a preview of how to analyse text data using ideas from the field of Natural Language Processing and how to apply those ideas using the Natural Language Processing Toolkit (NLTK) library.	5 hours
	Final Project: These weeks let you showcase all your new skills in an end-to-end data analysis project. You'll pick the dataset, do the data munging, ask the research questions, visualize the data, draw conclusions, and present your results.	5 hours
Pedagogy	Tutorials/ Lab assignments/ Project work	
References/ Readings	1. Practical statistics for data science by Peter bruce and andrew bruce 2. Naked statistics by charles wheelon 3. Business data science by matt taddy 4. Elements of statistical learning by Trevor Hastie, Robert and jerome 5. Python for data analysis 6. Data science and big data analytics -EMC2	
Learning Outcomes	The student will be able to: • To understanding how to manipulate and analyse uncurated datasets • To learn basic statistical analysis and machine learning methods and effectively visualize results	

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Programme: Masters in Data Science
Course Code: DSC-502 **Title of the Course: Machine Learning (Theory)**
Number of Credits: 2(2L-0T-0P) **Total Contact Hours: 30 hours (30L-0T-0P) Effective from AY:** 2023-24

Prerequisites for the course:	Familiarity with linear algebra, statistics & probability theory	
Objectives:	This course provides students with • In-depth introduction to three main areas of Machine Learning: supervised and unsupervised and reinforcement learning. • This course will cover some of the main models and algorithms for regression, classification, clustering and Markov decision processes. Topics will include linear and logistic regression, regularisation, SVMs and kernel methods, ANNs, clustering, and dimensionality reduction ,sequential learning Like HMM and deep learning CNN and	

	RNN	
Content:	**1. Introduction:** well posed learning problem, designing a learning system, perspectives and issues in machine learning-types of learning - supervised, unsupervised and reinforcement learning	3 hours
	2. Concept learning: concept learning task , notation, inductive learning hypothesis, concept learning as search, version space and candidate elimination algorithm, decision tree, random forest.	3 hours
	3. Linear regression: logistic regression-Support vector machine kernel, Model selection and feature selection-Ensemble methods: Bagging, boosting, Evaluating and debugging learning algorithms.	3 hours
	4. Continuous Latent Variables: Principal Component Analysis, Maximum variance formulation, Minimum error formulation, Applications of PCA, PCA for high-dimensional data.	3 hours
	5. Neural Networks: -Feed-forward Network, Functions, perceptron, -Weight-space symmetries, Network Training, Parameter optimization, Local quadratic approximation, Use of gradient information, Gradient descent optimization, Error Backpropagation, Evaluation of error-function derivatives, Efficiency of backpropagation.	3 hours
	6. Deep learning: Deep Feedforward Networks, Gradient-Based Learning, Hidden Units, -Architecture Design, CNN and RNN (simple RNN and LSTM).	4 hours
	7. Unsupervised learning; Clustering, K-means, EM.Mixture of Gaussians.	4 hours
	8. Sequential Data: Markov Models, Hidden Markov Models, Maximum likelihood for the HMM, The forward-backward algorithm, The sum-product algorithm for the HMM, Scaling factors, -The Viterbi algorithm.	4 hours
	9. Reinforcement learning: introduction- learning task-Q learning, non-deterministic rewards and actions-temporal difference learning.	3 hours
Pedagogy:	lectures/ tutorials/assignments/self-study/lab assignment/ project work	
References/ Readings	Main Reading:- 1. James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013. 2. Alpaydin, Ethem. Introduction to machine learning. MIT press, 2020. 3. Hart, Peter E., David G. Stork, and Richard O. Duda. Pattern classification. Hoboken: Wiley, 2000. 4. Flach, Peter. Machine learning: the art and science of algorithms that make sense of data. Cambridge University	

	Press, 2012. 5. Bishop, Christopher M. "Pattern recognition and machine learning: springer New York." (2006). 6. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016. 7. Mitchell, Tom, and Machine Learning McGraw-Hill. "Edition." (1997). 8. machine learning and AI online google course by cassie kozyrkov	
Learning Outcomes	By the end of the course, students will be able to: • Develop an appreciation for what is involved in learning from data. • Understand a wide variety of learning algorithms. • Understand how to apply a variety of learning algorithms to data. • Understand how to perform evaluation of learning algorithms and model selection. • Have a basic understanding of deep learning.	

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Programme: Masters in Data Science
Course Code: DSC-503 **Title of the Course: Machine Learning Lab**
Number of Credits: 2(0L-0T-4P) **Total Contact Hours: 60 hours (0L-0T-60P)**
Effective from AY: 2023-24

Prerequisites for the course:	Machine learning theory and programming in python	
Objective:	This course provides students with • Aimed at imparting implementation of machine learning algorithms using python and its APIs	
Content:	**Suggested Lab assignments/work with respect to the following using python (scikit /keras libraries) /amazon sage maker/matlab toolbox - each assignment with duration of 4 hrs. and 8 hrs. for project work**	
	1. Write a program to implement version space.	5 hours
	2. Write a program to implement a decision tree for given data.	5 hours
	3. Write a program to implement linear regression for given data.	5 hours
	4. Write a program to implement logistic regression.	5 hours
	5. Write a program to implement SVM.	5 hours
	6. Write a program to implement perceptron.	5 hours
	7. Write a program to implement a multilayer perceptron.	5 hours

	8. Write a program to implement RNN.	5 hours
	9. Write a program to implement CNN.	5 hours
	10. Write a program to implement HMM.	5 hours
	Capstone Mini Project work to assess the overall learning.	10 hours
Pedagogy:	Lab Assignments / Mini Project	
References/ Readings	Main Reading:- 1. James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013. 2. Alpaydin, Ethem. Introduction to machine learning. MIT press, 2020. 3. Hart, Peter E., David G. Stork, and Richard O. Duda. Pattern classification. Hoboken: Wiley, 2000. 4. Flach, Peter. Machine learning: the art and science of algorithms that make sense of data. Cambridge University Press, 2012. 5. Bishop, Christopher M. "Pattern recognition and machine learning: springer New York." (2006). 6. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016. 7. Mitchell, Tom, and Machine Learning McGraw-Hill. "Edition." (1997). 8. machine learning and AI online google course by cassie kozyrkov	
Learning Outcomes	Students should be able to • write program in python for implementing Machine learning algorithms using different libraries like scikit learn, keras and pytorch	

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Programme: MSc. in Data Science
Course code: DSC-504 **Title of course:** Mathematics foundation for Data Science (Theory)
Number of credits: 2 (2L-0T-0P) **Total contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Basic mathematics	
Objectives	• To build a strong foundation in maths required for learning computer science/data science subjects. • To understand fundamental concepts and tools in calculus, linear algebra etc. with emphasis on their applications to computer science in particular data science/machine learning	
Content	**Introduction** Importance of mathematics and their applications for computer science/machine learning/data science/deep learning Functions, variables, equations, graphs revision	5 hours

	Probability and Statistics: Probability Rules & Axioms, Bayes' Theorem, Random Variables, Variance and Expectation, Conditional and Joint Distributions, Standard Distributions (Bernoulli, Binomial, Multinomial, Uniform and Gaussian), Moment Generating Functions, Maximum Likelihood Estimation (MLE), Prior and Posterior, Maximum a Posteriori Estimation (MAP) and Sampling Methods-confidence intervals, Hypothesis testing, p-values, A/B testing-ANOVA, t-test, Linear regression, regularization	5 hours
	Calculus Overview of Differential and Integral Calculus, Partial Derivatives Product and chain rule-Taylor's series, infinite series summation/integration concepts-Fundamental and mean value-theorems of integral calculus, evaluation of definite and improper integrals-Beta and Gamma functions, Functions of multiple variables, limit, continuity, partial derivatives-Basics of ordinary and partial differential equations -Applications of Calculus	5 hours
	Linear Algebra: Systems of Linear Equations-Matrices-Solving Systems of Linear Equations-Vector Spaces-Linear Independence-Basis and Rank-Linear Mappings Affine Spaces	5 hours
	Analytic Geometry Norms-(Inner Products-Lengths and Distances Angles and Orthogonality-Orthonormal Basis Orthogonal Complement-Inner Product of Functions-Orthogonal Projections-Rotations) - Eigen value decomposition and SVD	5 hours
	Optimization Differentiation of Univariate Functions-Partial Differentiation and Gradients-Gradients of Vector-Valued Functions-Gradients of Matrices Useful Identities for ComputingGradients-Backpropagation and Automatic Differentiation-Higher-Order Derivatives-Linearization and Multivariate Taylor Series-Gradient Descent-Constrained Optimization -Lagrange Multipliers-Convex Optimization,	5 hours
Pedagogy	Problem solving approach and carrying out small project work using matlab tools	
References/ Readings	1. Statistics Written, Robert S. Witte and John S. Witte 2. Barron's AP Statistics, 8th Edition, Martin Sternstein, PhD. 3. Statistics for Business and Economics by- James T. McClave, P. George Benson and Terry T Sincich 4. Naked Statistics: Stripping the Dread from the Data, Charles Wheelan 5. Introduction to Linear Algebra, Gilbert Strang	

	6. Linear Algebra and Its Applications, David C. Lay 7. No bullshit guide to Linear algebra, Ivon Savov 8. Functions and Graphs by I M Gelfand 9. Cartoon guide to calculus, Larry Gonick 10. Optimization Methods in Business Analytics — *edX, MIT*	
Learning Outcomes	Students will be able to: • Apply the concepts of mathematics in the modelling and design of computational problems and deeper understanding of subjects like machine learning / deep learning and other computer science subjects.	

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Programme: MSc. in Data Science
Course code: DSC-505 **Title of course:** Mathematical foundation for Data Science (Practical)
Number of credits: 2 (0L-0T-4P) **Total contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Mathematical foundation theory and programming background	
Objectives	The lab assignment are aimed at demonstration of the following regarding statistics	
Content	Recap of following – A. NumPy is a third-party library for numerical computing, optimized for working with single- and multi-dimensional arrays. Its primary type is the array type called ndarray. This library contains many routines for statistical analysis. B. SciPy is a third-party library for scientific computing based on NumPy. It offers additional functionality compared to NumPy, including scipy.stats for statistical analysis. C. Pandas is a third-party library for numerical computing based on NumPy. It excels in handling labelled one-dimensional (1D) data with Series objects and two-dimensional (2D) data with Data Frame objects. D. Matplotlib is a third-party library for data visualization. It works well in combination with NumPy, SciPy, and Pandas.	3 hours
	Assignment 1 - Write program to implement the EDA concepts using python libraries -Numpy,Pandas, matplotlib, seaborn,scipy, scrapy and beautiful soup, and tensor flow ,keras and pytorch etc.	3 hours
	Assignment -2 - Sampling, Variables in Statistics, Frequency Distributions. Generate frequency distribution tables, Generate grouped frequency distribution tables and -Visualizing Frequency Distributions -Generate bar plots, pie charts, and	6 hours

	histograms ,Employ bar plots, pie charts and histograms.	
	Assignment-3-Comparing Frequency Distributions -grouped bar plots- step-type histogram-kernel density estimate plots- strip plots and box plots	6 hours
	Assignment-4 -Multidimensional image operations, Solving differential equations and the Fourier transform using scipy	6 hours
	Assignment-5 -Optimization algorithms using scipy.	6 hours
	Assignment -6 -Linear algebra using scipy	6 hours
	Assignment- 7-Program in python to implement the concepts such as Vector space, subspace, span, column space, row space, null space, left-null space, rank, basis, orthogonal matrix, symmetric matrix.	6 hours
	Assignment -8 – Implement Eigen value decomposition in python.	6 hours
	Assignment-9 – implement SVD using python.	6 hours
	Assignment -10 – implements some of optimization algorithm using the python library.	6 hours
Pedagogy	lab assignments /Project	
References/ Readings	1. Statistics Written, Robert S. Witte and John S. Witte 2. Barron's AP Statistics, 8th Edition, Martin Sternstein, PhD. 3. Statistics for Business and Economics by- James T. McClave, P. George Benson and Terry T Sincich 4. Naked Statistics: Stripping the Dread from the Data, Charles Wheelan 5. Introduction to Linear Algebra, Gilbert Strang 6. Linear Algebra and Its Applications, David C. Lay 7. No bullshit guide to Linear algebra, Ivon Savov 8. Functions and Graphs by I M Gelfand 9. Cartoon guide to calculus, Larry Gonick 10. Optimization Methods in Business Analytics — *edX, MIT*	
Learning Outcomes	Students will be able to: • Apply the concepts of mathematics in the modelling and design of computational problems. • Deeper understanding of subjects like machine learning / deep learning and other computer science subjects.	

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Programme: Masters in Data Science
Course code: DSC-506
Title of course: Fundamentals of AI (Theory)
Number of credits: 2(2L-0T-0P)
Total contact hours: 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Programming back programming and probability and statistics and linear algebra	
Objectives	To develop a basic understanding of • Problem solving • Knowledge representation • Reasoning and learning methods of AI.	
Content	Artificial Intelligence Introduction -Intelligent Agents, Problem-solving Solving Problems by Searching -Search in Complex Environments -Adversarial Search and Games- Constraint Satisfaction Problems Knowledge, reasoning, and planning Knowledge Representation-First-Order Predicate Logic -Unification Forward and Backward Chaining - Resolution -Ontological Engineering Categories and Objects - Events-Mental Events and Mental Objects - Reasoning Systems for Categories - Reasoning with Default Information Uncertain knowledge and reasoning	5 hours
	Quantifying Uncertainty - Probabilistic Reasoning - Probabilistic Reasoning over Time Probabilistic Programming -Making Simple Decisions - Making Complex Decisions -Multiagent Decision Making	4 hours
	Machine Learning, Learning from Examples - Learning Probabilistic Models - Deep Learning - Reinforcement Learning Communicating, perceiving, and acting	4 hours
	Natural Language Processing - Deep Learning for Natural Language Processing - Computer Vision - Robotics.	5 hours
	Artificial Intelligence applications Language Models -Information Retrieval - Information Extraction	4 hours
	Natural Language Processing - Machine Translation - Speech Recognition	4 hours
	Robotics-Hardware and Software for Robots - Planning and Perception Explainable AI - Definitions and concepts such as black-box models, transparency, interpretable machine learning and explanations. - Decision-making and decision support, Human-Computer Interaction (HCI) and AI. - Explainable AI. - Methods for Explainable AI. - Applications and examples. - Trust and acceptance.-Evaluation methods and metrics. - Ethical, legal and social issues of explainable AI. Contemporary issues in AI-Philosophy, Ethics, and Safety of AI -The Future of AI	4 hours
Pedagogy	Tutorials / Hands-on-assignments / Self-study	
References/	1. A Classical Approach to Artificial Intelligence, M.C. Trivedi,	

Readings	Khanna Book Publishing, 2019. 2. Artificial Intelligence: A modern approach by Stuart Russel, Pearson Education, 2010. 3. Artificial Intelligence by Rich and Knight, The McGraw Hill, 2017. 4. Artificial Intelligence: A new synthesis by Nils and Nilson, Elsevier, 1997. 5. Artificial Intelligence by Luger, Pearson Education, 2002. 6. Artificial Intelligence by Padhy, Oxford Press, 2005. 7. https://www.edx.org/course/artificial-intelligence-ai 8. https://www.udemy.com/course/artificial-intelligence-az/	
Learning Outcomes	The students will be able to: 1. Understand the basic concepts and techniques of Artificial Intelligence. 2. Apply AI algorithms for solving practical problems. 3. Describe human intelligence and AI. 4. Explain how the intelligent system works. 5. Apply basics of Fuzzy logic and neural networks. 6. Explain Expert System and implementation.	

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Programme: Masters in Data Science
Course Code: DSC-507 Title of the Course: Fundamentals of Artificial Intelligence (Practical)
Number of Credits: 2 (0L-0T-4P) **Total Contact Hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course:	Artificial Intelligence theory, probability and statistics , linear algebra and Python programming	
Objectives:	To develop a basic understanding of • Problem solving • Knowledge representation • Reasoning and learning methods of AI • Implement AI algorithms	
Content:	Assignment-1 -Real-world path planning for pedestrians. In the first part, students implement A* over a map that includes roads/paths as well as elevations. In the second part, students collect actual data through walking around the real world, and the cost model is then learned via regression techniques.	10 hours
	Assignment-2 -Solve maze via search -this assignment involves formulating maze-solving as a search problem, image processing (via OpenCV) as a step in maze-solving, as well as guided performance/quality analysis of representational parameters	10 hours

	Assignment 3-Within the context of an artificial intelligence course, students are taught to identify ethical issues within technical projects and to engage in moral problem solving with regard to such issues.	10 hours
	Assignment 4-Neural network for face recognition using tensor flow -build feedforward neural networks for face recognition using TensorFlow. Students then visualize the weights of the neural networks they train. The visualization allows students to understand feedforward one-hidden layer neural networks in terms of template matching, and allows students to explore overfitting.	10 hours
	Assignment -5 -Organic path finding -Students develop a “human-like” pathfinding technique by specializing a generic search algorithm with custom action cost and heuristic cost functions. Students apply classical search algorithms and reflect on example organic paths to achieve “human-like” pathfinding.	10 hours
	Assignment - 6 -Implement a genetic algorithm in Python to evolve strategies for Robby the Robot to collect empty soda cans that lie scattered around his rectangular grid world. And also Compare the performances of a brute-force search and a search employing the Minimum Remaining Values (MRV) heuristic in solving Sudoku puzzles.	10 hours
Pedagogy:	lectures/practical/ tutorials/assignments/self-study	
References /Readings:	1. A Classical Approach to Artificial Intelligence, M.C. Trivedi, Khanna Book Publishing, 2019. 2. Artificial Intelligence: A modern approach by Stuart Russel, Pearson Education, 2010. 3. Artificial Intelligence by Rich and Knight, The McGraw Hill, 2017. 4. Artificial Intelligence: A new synthesis by Nils and Nilson, Elsevier, 1997. 5. Artificial Intelligence by Luger, Pearson Education, 2002. 6. Artificial Intelligence by Padhy, Oxford Press, 2005. 7. https://www.edx.org/course/artificial-intelligence-ai 8. https://www.udemy.com/course/artificial-intelligence-az/	

Learning Outcomes:	• The students need to understand and extend an existing implementation of the back-propagation algorithm and use it to recognize static hand gestures in images. • Students learn about feedforward neural networks and the backpropagation algorithm by implementing a perceptron network for AND and XOR Boolean functions and, given an implementation of a feedforward network, learn digit recognition using the MNIST data set. • In this assignment students extend a Tic Tac Toe program to Ultimate Tic Tac Toe and implement a different search strategy than the example code.	

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Programme: Masters in Data Science
Course Code: DSC-508 **Title of the Course:** Reinforcement Learning(Theory)
Number of Credits: 2(2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Linear algebra, multivariable calculus Basic machine learning knowledge	
Objectives	To enable the student to understand • The reinforcement learning paradigm • Identify when an RL formulation is appropriate • Understand the basic solution approaches in RL • Implement and evaluate various RL algorithms.	
Content	Review of ML fundamentals – Classification, Regression. Review of probability theory and optimization concepts.	2 hours
	RL Framework; Supervised learning vs. RL; Explore-Exploit Dilemma; Examples.	2 hours
	MAB: Definition, Uses, Algorithms, Contextual Bandits, Transition to full RL, Intro to full RL problem	2 hours
	Intro to MDPs: Definitions, Returns, Value function, Q-function.	2 hours
	Bellman Equation, DP, Value Iteration, Policy Iteration, Generalized Policy Iteration.	2 hours
	Evaluation and Control: TD learning, SARSA, Q-learning, Monte Carlo, TD Lambda, Eligibility Traces.	2 hours
	Maximization-Bias & Representations: Double Q learning, Tabular learning vs. Parameterized, Q-learning with NNs	2 hours
	Function approximation: Semi-gradient methods, SGD, DQNs, Replay Buffer.	2 hours
	Policy Gradients: Introduction, Motivation, REINFORCE, PG theorem, Introduction to AC methods	3 hours

	Actor-Critic Methods, Baselines, Advantage AC, A3C Advanced Value-Based Methods: Double DQN, Prioritized Experience Replay, Dueling Architectures, Expected SARSA.	3 hours
	Advanced PG/A-C methods: Deterministic PG and DDPG, Soft Actor-Critic (SAC) HRL: Introduction to hierarchies, types of optimality, SMDPs, Options, HRL algorithms POMDPS: Intro, Definitions, Belief states, Solution Methods; History-based methods, LSTMS, Q-MDPs, Direct Solutions, PSR.	4 hours
	Model-Based RL: Introduction, Motivation, Connections to Planning, Types of MBRL, Benefits, RL with a Learnt Model, Dyna-style models, Latent variable models, Examples, Implicit MBRL. Case study on design of RL solution for real-world problems.	4 hours
Pedagogy	Hands-on assignments / tutorials / peer-teaching / flip classroom/ presentations.	
References/ Readings	1. Reinforcement learning -Introduction by Richard sutton and Andrew barto, 2nd edition, MIT press. 2. Algorithms for reinforcement learning by Csaba Szepesvari, Ronald Brachman, et al,2010.	
Learning Outcomes	Understanding the fundamentals of reinforcement learning and its role in building gaming applications and in turn helps to understand the challenges of real world problems, how RL will help them.	

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Programme: Masters in Data Science
Course Code: DSC-509 **Title of the Course:** Reinforcement Learning(Practical)
Number of Credits: 2 (0L-0T-4P) **Contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Linear algebra, multivariable calculus, Basic machine learning knowledge and programming background.	
Objectives	To understand the theory by carrying out the lab assignment based on the key ideas of reinforcement learning.	
Content	1. RL task formulation (action space, state space, environment definition)	7 hours
	2. Tabular based solutions (dynamic programming, Monte Carlo, temporal-difference)	7 hours
	3. Function approximation solutions (Deep Q-networks)	7 hours
	4. Policy gradient from basic (REINFORCE) towards advanced topics (proximal policy optimization, deep deterministic policy gradient, etc.)	7 hours
	5. Model-based reinforcement learning	7 hours

	6. Imitation learning (behavioral cloning, inverse RL, generative adversarial imitation learning)	7 hours
	7. Meta-learning	8 hours
	8. Multi-agent learning, partial observable environments	10 hours
Pedagogy	Lab assignments/ mini project	
References/ Readings	1. Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", Second Edition, MIT Press, 2019. 2. Li, Yuxi. "Deep reinforcement learning." arXiv preprint arXiv:1810.06339 (2018). 3. Wiering, Marco, and Martijn Van Otterlo. "Reinforcement learning." Adaptation, learning, and optimization 12 (2012): 3. 4. Russell, Stuart J., and Peter Norvig. "Artificial intelligence: a modern approach."Pearson Education Limited, 2016. 5. Goodfellow, Ian, YoshuaBengio, and Aaron Courville. "Deep learning." MIT press, 2016. 6. David Silver's course on Reinforcement Learning (link).	
Learning Outcomes	• Understanding the fundamentals of reinforcement • Learning role in building gaming applications • Understand the challenges of real world problems, how RL will help them.	

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Programme: Masters in Data Science
Course Code: DSC-510
Title of the Course: Optimization Techniques
Number of Credits: 2(2L-0T-0P)
Contact Hours: 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	NIL	
Objectives	• To familiarize the students with some basic concepts of optimization techniques and approaches. • To formulate a real-world problem as a mathematical programming model. • To develop the model formulation and applications are used in solving decision problems. • To solve specialized linear programming problems like the transportation and assignment problems.	
Content:	**Introduction to Operations Research** Introduction-Mathematical models of Operation Research - Scope and applications of Operation Research - Phases of Operation Research study - Characteristics of Operation Research - Limitations of Operation Research.	4 hours
	Linear Programming Introduction –Properties of Linear Programming-Basic	4 hours

	assumptions-Mathematical formulation of Linear Programming-Limitations or constraints-Methods for the solution of LP Problem-Graphical analysis of LP-Graphical LP Maximization problem-Graphical LP Minimization problem.	
	Linear Programming Models Simplex Method-Basics of Simplex Method - Formulating the Simplex Method-Simplex Method with two variables - Simplex Method with more than two variables - Big M Method.	4 hours
	Dual Linear Programming Introduction- Primal and Dual problem - Dual problem properties-Solution techniques of Dual problem - Dual Simplex method-Relations between direct and dual problem-Economic interpretation of Duality.	4 hours
	Transportation and Assignment Models Introduction: Transportation problem - Balanced - Unbalanced - Methods of basic feasible solution Optimal solution-MODI method. Assignment problem-Hungarian Method.	4 hours
	Network Analysis Basic concepts-Construction of Network-Rules and precautions-CPM and PERT Networks Obtaining of critical path. Probability and cost consideration. Advantages of Network.	5 hours
	Theory of Games Introduction-Terminology-Two Person Zero-Sum game-Solution of games with saddle points and without saddle points-2X2 games-dominance principle – mX2 and 2Xn games-Graphical method.	5 hours
Pedagogy:	Assignment / Quiz / invited talks on current issues/ Research and Analytical problems on various applications of the industrial issues.	
References/ Readings	**Text Book(s)** • HamdyTaha, Operations Research, 10th edition, Prentice Hall India, 2019. • P. K. Gupta and D. S. Hira, Operations Research, S. Chand & co., 2007.2 **Reference Books** • S.D. Sharma (2000), Operations Research, Nath& Co., Meerut. • Maurice Solient, Arthur Yaspen, Lawrence Fridman, (2003), OR methods and Problems, New Age International Edition. • J K Sharma (2007), Operations Research Theory & Applications, 3e, Macmillan India Ltd. • P. SankaraIyer, (2008), Operations Research, Tata McGraw-Hill. • A Ravindran, Don T Philips and James J Solberg, Operations Research: Principles and practice, 2nd edition, John Wiley and sons, 2007	
Learning	Student will be able to	

Outcomes	• Apply operations research techniques like linear programming problem in industrial optimization problems. • Solve allocation problems using various OR methods. • Understand the characteristics of different types of decision making environment and the appropriate decision making approaches and tools to be used in each type. • Recognize competitive forces in the marketplace and develop appropriate reactions based on existing constraints and resources.	

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Programme: Masters in Data Science
Course Code: DSC-511 **Title of the Course:** MLOps(Theory)
Number of Credits: 2(2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Familiarity with linear algebra, probability theory, machine learning , familiarity with python.	
Objectives	This course is aimed at anyone who wishes to • Explore deep learning from scratch. • This course offers a practical hand on exploration of deep learning, avoiding mathematical notation, preferring instead to explain quantitative concepts through programming using python API	
Content	Introduction to MLOps Rise of the Machine Learning Engineer and MLOps-What Is MLOps?-DevOps and MLOps-An MLOps Hierarchy of Needs-Implementing DevOps-Configuring-Continuous Integration with GitHub Actions-DataOps and Data Engineering-Platform Automation-MLOps	3 hours
	MLOps Foundations-Bash and the Linux Command Line-Cloud Shell Development Environments-Bash Shell and Commands-List Files Run Commands Files and Navigation-Input/output-Configuration-Writing a Script-Cloud Computing Foundations and Building Blocks-Getting Started with Cloud Computing-minimalistic python revision-Descriptive Statistics and Normal Distributions-Optimization-Machine Learning Key Concepts-Doing Data Science-Build an MLOps Pipeline from Zero	3 hours
	MLOps for Containers and Edge Devices Containers-Container Runtime-Creating a Container Running a Container-Best Practices-Serving a Trained Model Over HTTP-Edge Devices-Coral Azure Percept-TFHub-Porting Over Non-TPU Models-Containers for Managed ML Systems-Containers in Monetizing MLOps-Build Once, Run Many MLOps Workflow	3 hours
	Continuous Delivery for Machine Learning Models-Packaging for ML Models-Infrastructure as Code for Continuous Delivery of ML Models-Using Cloud Pipelines-Controlled Rollout of Models-	3 hours

	Testing Techniques for Model Deployment	
	AutoML and Kaizen ML-Auto ML-MLOps Industrial Revolution-Kaizen Versus Kaizen ML-Feature Stores-Apple's Ecosystem-Apple's AutoML: Create ML-Apple's Core ML Tools or Google's AutoML and Edge Computer Vision or Azure's AutoML or AWS AutoML-Open Source AutoML Solutions-Ludwig-FLAML-Model Explainability	3 hours
	Monitoring and Logging-Observability for Cloud MLOps-Introduction to Logging-Logging in Python-Modifying Log Levels-Logging Different Applications-Monitoring and Observability-Basics of Model Monitoring-Monitoring Drift with AWS SageMaker-Monitoring Drift with Azure ML	3 hours
	MLOps for AWS-Introduction to AWS-Getting Started with AWS Services-MLOps on AWS-MLOps Cookbook on AWS-CLI Tools-Flask Microservice-AWS Lambda Recipes-AWS Lambda-SAM Local-AWS Lambda-SAM Containerized Deploy-Applying AWS Machine Learning to the Real World	3 hours
	Machine Learning Interoperability-Why Interoperability Is Critical-ONNX: Open Neural Network Exchange-ONNX Model Zoo-Convert PyTorch into ONNX -Convert TensorFlow into ONNX-Deploy ONNX to Azure-Apple Core ML-Edge Integration.	3 hours
	Building MLOps Command Line Tools and Microservices-Python Packaging-The Requirements File-Command Line Tools-Creating a Dataset Linter Modularizing a Command Line Tool-Microservices-Creating a Serverless Function-Authenticating to Cloud Functions-Building a Cloud-Based CLI-Machine Learning CLI Workflows	3 hours
	Machine Learning Engineering and MLOps Case StudiesUnlikely Benefits of Ignorance in Building Machine Learning Models-MLOps Projects at Sqor Sports Social Network-Mechanical Turk Data Labeling-Influencer Rank-Athlete intelligence (AI product)-The perfect techniques versus the real world-critical challenges in MLops- Ethical and unintended consequences-lack of operational excellences- focus on prediction accuracy vs the big picture	3 hours
Pedagogy	Lectures/ tutorials/lab assignments/self-study	
References/ Readings	Main Reading :- • Practical MLops – Noah Gift and AlfredoDeza • Introduction to MLOps – Noah Gift and AlfredoDeza	
Learning Outcomes	Student will be able to • Deploy ML models and test the same.	

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Std. Com.X AC-6
15 & 22.05.2023

Programme: Masters in Data Science
Course Code: DSC-512 **Title of the Course:** MLOps(Practical)
Number of Credits: 2(0L-0T-4P) **Contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Machine Learning and programming	
Objectives	Aimed at imparting the knowledge required to deploy ML models	
Content	• Perfect Project Structure – Cookiecutter& readme.so	6 hours
	• Speed Exploratory Data Analysis to Minutes – Pandas Profiling, SweetViz	6 hours
	• Track Data Science Projects with CI, CD, CT, CM –Data Version Control (DVC)	6 hours
	• Explainable AI / XAI – SHAP, LIME, SHAPASH	6 hours
	• Deploy ML Projects in minutes – Docker, FastAPI	6 hours
	• End to End Machine Learning – MLflow	6 hours
	• Building Production Ready ML Pipelines - Model Registry, Feature Store (Feast, ButterFlow)	6 hours
	• Big Data using Python, instead of PySpark – DASK	6 hours
	• Build a Chat bot and Deploy it (open-source)	6 hours
	• FaaS Framework implementation – Apache OpenWhisk, OpenFaas	6 hours
Pedagogy	Lab Assignments / mini project	
References/ Readings	1. Machine Learning Engineering By AndriyBurkov Publisher : True Positive Inc. (8 September 2020) 2. ML Ops: Operationalizing Data Science By David Sweenor, DevKannabiran, Thomas Hill, Steven Hillion, Dan Rope and Michael O'Connell-O'Reilly 3. Building Machine Learning Pipelines By HannesHapke, Catherine Nelson 4. Practical MLOps by Noah Gift, Alfredo Deza. O'Reilly 5. Introducing MLOps By Mark Treveil&Dataiku Team 6. Beginning MLOps with MLFlow: Deploy Models in AWS SageMaker, Google Cloud, and Microsoft AzureBy Sridhar Alla, SumanKalyanAdari, O'Reilly	
Learning Outcomes	Student should be able to • Deploy ML models • Test the issues related to scaling etc.	

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Programme: Masters in Data Science
Course code: DSC-513 **Title of course:** Software Engineering for AI Enabled Systems (Theory)
Number of credits: 2 (2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Programming & Data Structures, Python	
Objectives	• Gain an in-depth understanding of Software Engineering including its importance. • Learn Scrum, Kanban, Agile, Waterfall, Prototyping, Incremental, RAD and Spiral Software Process Models. • Learn to perform systematic Software Requirement Engineering. • Applying SE approach to developing AI solutions	
Content	Software Engineering: Software Processes, SDLC, agile approaches to SE	5 hours
	Requirements Engineering: elicitation techniques, specification. SCRUM and user stories.	5 hours
	Test Driven Development: Refactoring and Unit testing	5 hours
	Use of frameworks and APIS and handling of big data	5 marks
	Configuration management, continuous integration, and automated software engineering	5 hours
	Cloud based software development, DevOps	5 hours
Pedagogy	Classroom/hands-on instructions, assignments, mini projects	
References/ Readings	1. Hands-On Software Engineering with Python: Move beyond basic programming and construct reliable and efficient software with complex code, Brian Allbee, Packt Publishing. 2. A concise Introduction to Software Engineering, Pankaj Jalote- 2008n- Springer. 3. Agile Estimating and Scrum, Mike Cohn, Prentice Hall.	
Learning Outcomes	1. Application of SE principles for AI and Data Science projects 2. How to work in self organizing teams 3. Use of tools and techniques for automating and managing software development	

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Programme: Masters in Data Science
Course code: DSC-514 **Title of course:** Software Engineering for AI Enabled Systems(Practical)
Number of credits: 2 (0L-0T-4P) **Contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Programming & Data Structures, Python	
Objectives	Applying SE approach to developing AI solutions Use of modern software engineering tools and frameworks	
Content	1 Version Control Tools- Git and Github	12 hours
	2 TDD –Unit testing and refactoring with Python	12 hours

	3 Working with Python libraries and frameworks	12 hours
	4 Use of testing tools- selenium, Jmeter	12 hours
	5 Cloud based software development &DevOps	12 hours
Pedagogy	Lab sessions and projects	
References/ Readings	1. Hands-On Software Engineering with Python: Move beyond basic programming and construct reliable and efficient software with complex code, Brian Allbee, Packt Publishing. 2. A concise Introduction to Software Engineering, Pankaj Jalote-2008n- Springer. 3. Agile Estimating and Scrum, Mike Cohn, Prentice Hall.	
Learning Outcomes	1. Application of SE principles for AI and Data Science projects 2. How to work in self-organizing teams 3. Use of tools and techniques for automating and managing software development	

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Programme: MSc in Data Science
Course Code: DSC-521
Title of the Course: Domain Specific Predictive Analytics
Number of Credits: 4(2L-0T-4P)
Contact hours: 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Data science fundamentals and programming background	
Objectives	• It introduces theoretical foundations • Algorithms, Methodologies for analysing data in various domains such Retail, Finance, Risk and Healthcare.	
Content for Theory	**Retail Analytics** Understanding Customer: Profiling and Segmentation, Modelling Churn. Modelling Lifetime Value, Modelling Risk, Market Basket Analysis.	4 hours
	Risk Analytics Risk Management and Operational Hedging: An Overview, Supply Chain Risk Management, A Bayesian Framework for Supply Chain Risk Management, Credit Scoring and Bankruptcy Prediction	4 hours
	Financial Data Analytics Financial News analytics: Framework, techniques, and metrics, News events impact market sentiment, Relating news analytics to stock returns	4 hours
	Financial Time Series Analytics Financial Time Series and Their Characteristics, Common Financial Time Series models, Autoregressive models, Markov chain models, Time series models with leading indicators, Long term forecasting	4 hours

	Introduction Healthcare Analytics An Introduction to Healthcare Data Analytics, Electronic Health Records, Privacy-Preserving Data Publishing Methods in Healthcare, Clinical Decision Support Systems	4 hours
	Healthcare Data Analytics Natural Language Processing and Data Mining for Clinical Text: Core NLP Components, Information Extraction and Named Entity Recognition, Social Media Analytics for Healthcare: Tracking of Infectious Disease Outbreaks, Readmission risk Prediction	4 hours
	Genomic Data Analytics Microarray Data, Microarray Data Analysis , Genomic Data Analysis for Personalized Medicine , Patient Survival Prediction from Gene Expression Data , Genome Sequence Analysis	6 hours
Content for Practical	• Finance: a) Stock Market Prediction: Develop a predictive model to forecast stock prices based on historical data, using techniques such as time series analysis and machine learning algorithms.	6 hours
	b) Credit Risk Assessment: Build a model to predict the creditworthiness of individuals or businesses, incorporating relevant financial and non-financial factors to assess default probabilities.	6 hours
	c) Fraud Detection: Create an algorithm to identify fraudulent transactions or activities in financial systems by analysing patterns, anomalies, and historical data.	6 hours
	• Medical Science: a) Disease Diagnosis: Develop a predictive model to diagnose diseases based on patient symptoms, medical history, and test results, using techniques like classification algorithms and medical data analysis.	6 hours
	b) Patient Readmission Prediction: Build a model to predict the likelihood of a patient being readmitted to the hospital within a certain time frame, considering factors such as demographics, medical conditions, and treatment history.	6 hours
	c) Drug Effectiveness Prediction: Create a model to predict the effectiveness of a particular drug for a specific patient or group of patients, utilizing genetic information, clinical data, and treatment outcomes.	6 hours

	• Genomic Science: Predictive analytics in the domain of genomics can be highly beneficial for various applications, such as disease prediction, drug discovery, personalized medicine, and genetic engineering. Here are a few examples of predictive analytics techniques that can be applied in genomics a) Disease Risk Prediction: By analyzing an individual's genomic data, predictive analytics can be used to assess the risk of developing specific diseases. Machine learning algorithms can identify patterns and genetic markers associated with various diseases, allowing for early detection and preventive measures. For example, predictive models can be built to predict the risk of developing conditions like cancer, cardiovascular diseases, or genetic disorders.	6 hours
	b) Pharmacogenomics: Predictive analytics can aid in predicting an individual's response to specific drugs based on their genetic makeup. By analyzing genomic data along with clinical information, machine learning models can predict drug efficacy, potential side effects, and optimal dosage. This information can be used to develop personalized treatment plans and improve patient outcomes.	6 hours
	c) Genomic Variant Interpretation: Genomic variants play a crucial role in determining an individual's susceptibility to diseases. Predictive analytics can be used to interpret the functional consequences of these variants. Machine learning algorithms can predict the impact of genetic mutations on protein structure and function, helping researchers and clinicians understand the underlying mechanisms of diseases and develop targeted therapies.	6 hours
	d) Gene Expression Analysis: Predictive analytics can analyze gene expression data to identify patterns and correlations between genes and specific traits or diseases. By using machine learning algorithms, it is possible to predict gene expression levels based on genomic features and environmental factors. This can provide valuable insights into gene regulatory networks and help in understanding disease mechanisms and identifying potential therapeutic	6 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. Chris Chapman, Elea McDonnell Feit "R for Marketing Research and Analytics", Springer, 2015. 2. Olivia Parr Rud “Data Mining Cookbook: Modeling Data for Marketing, Risk, and Customer Relationship Management”, Wiley, 2001.	

	3. Chandan K. Reddy, Charu C. Aggarwal "Healthcare Data Analytics", CRC Press, 2015. 4. Rene Carmona "Statistical Analysis of Financial Data in R", Springer, 2014. 5. James B. Ayers "Handbook Of Supply Chain Management" Auerbach Publications, 2006. 6. PanosKouvelis, Lingxiu Dong, OnurBoyabatli, Rong Li "The Handbook of Integrated Risk Management in Global Supply Chains", Wiley, 2012.	
Learning Outcomes	Students will be able to understand • Retail Analytics, Risk Analytics, Financial Data Analytics, Financial Time Series Analytics, Healthcare Analytics, Healthcare Data Analytics and Genomic Data Analytics.	

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Programme: MSc in Data Science
Course Code: DSC-522 **Title of the Course:** Design Thinking for Data-Driven App Development
Number of Credits: 4(4L-0T-0P) **Contact hours:** 60 hours (60L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	None	
Objectives	This course helps you learn • The basics of Design Thinking in an experiential way. • This course aims at an empathy-led data-driven app development approach for data scientists. • The learners will launch a fully functioning app in a real app store at the end of the course.	
Content	Introduction to Design Thinking – Course outline and projects, Intro to the Design of Everyday Things, Intro to Design Thinking in software apps, Project management. Empathize phase (Iteration #1)-- Emotional and intellectual map of the user stories from interviews, User story creation and Customer Journey Mapping	15 hours
	Analyse phase (Iteration #1) - Stated needs and unsaid/latent needs, Root cause analysis, Multiple perspectives of customers and manufacturers, Frame conflicts from popular movies. Solve phase (Iteration #1)Structured and unstructured creativity, Dynamics of group thinking, Optimal conditions of creativity, Natural creativity, Concept creation via group activities, Silent brainstorming, inventive principles and concept consolidation	15 hours
	Test phase (Iteration #1)/ Empathize phase (Iteration #2) - Basics of prototyping, Assumptions in creation of new concepts, Features rather than ideas. Basics of Digital Marketing, User Experience Design, Website Development	15 hours
	Analyse phase (Iteration #2) Solve phase (Iteration #2) - Introduced problems via the solution	15 hours

	from iteration #1, the subsequent ideation process in iteration #2, apply solutioning and analysis tools in iteration #2, subsequent testing and field trial skills required for iteration #3, analytical tools and data oriented tools on iteration #3. Test (Iteration #2) / Empathize (Iteration #3) - Basics of obtaining insights from feedback from a live audience. Analyse (Iteration #3). Test phase (Iteration #3) - Launch of the App.	
Pedagogy	Hands-on assignments / Tutorials / Peer-teaching /Presentations	
References/ Readings	1. Design of everyday things by Don A. Norman, 2013. 2. This is Service Design thinking- basics, tools and cases by Marc Stickdorn, 1st edition, John Wiley & Sons Inc., 2012.	
Learning Outcomes	Students will be able to: • Recall the basics of Design Thinking • Apply Agile method to developing software • Design an App using the principles of Design Thinking • Develop an App for Android • Collaborate with other developers using git version control method • Learn the basics of marketing and customer support through their website	

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Programme: Masters in Data Science
Course Code: DSC-523 **Title of the Course:** Signal Processing
Number of Credits: 2(2L-0T-2P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	1. Linear algebra, 2. Calculus and multivariable calculus, 3. At least high school math on trigonometry, 4. Complex number 5. A little bit familiarity with programming, especially for numerical computation, such as GNU Octave.	
Objectives	1. To study various types of signals and its characteristics. 2. To study various operations on the signals. 3. To analyse the signals using Fourier transform and Laplace Transform. 4. To learn the fundamentals of robotics and sensor technology. 5. To understand the controlling applications of robotics using sensor responses.	
Content for Theory	**Module:1** Introduction to Signals Continuous-time and Discrete-time Signals: Representation of signals, Signal classification, Types of Signals, Operations on signals - Scaling, Shifting	4 hours

	Module: 2 Fourier Analysis of Continuous-time Signals Introduction to Fourier series, Gibbs Phenomenon, and Continuous-time Fourier transform (CTFT), Existence, Magnitude and phase response, Parseval's theorem, Inverse Fourier transform. Relation between Laplace and Fourier transforms, Laplace Transform, Magnitude and phase response	4 hours
	Module: 3 signal conditioning Sensing - Pre-processing – Noise reduction, enhancement of details. Signal Conversion – Sampling, Quantization, Encoding	4 hours
	Module:4 Data Acquisition and sensing in Robotics Data Acquisition: Analogy and digital data acquisition, single channel and multi-channel data acquisition Image processing in Robotics: Vision sensor, Introduction to computer vision, Point operators, Linear Filters, More neighbourhood operators, Fourier transforms, Pyramids and wavelets, Geometric transformations.	4 hours
	Module: 5 Fundamentals of Robotics Basic components of robotic system. Basic terminology- Accuracy, Repeatability, Resolution, Degree of freedom. Mechanisms and transmission, End effectors, Grippers-different methods of gripping, Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, Cam type gripper, Magnetic grippers, Vacuum grippers, Air operated grippers; Specifications of robot.	4 hours
	Module: 6 Drive Systems and Sensors in Robotics Drive system- hydraulic, pneumatic and electric systems. Sensors in robot – Touch sensors, Tactile sensor, Proximity and range sensors, Robotic vision sensor, Force sensor, Light sensors, and Pressure sensors.	4 hours
	Module: 7 Signal processing application in Robotics Robot applications: Application of robots in surgery, Manufacturing industries, space and underwater. Humanoid robots, Micro robots, Social issues and Future of robotics.	6 hours
Content for Practical:	• To find Discrete Fourier Transform and Inverse Discrete Fourier Transform of given digital signal using MATLAB software.	7 hours
	• To obtain Linear Convolution of two finite length sequences using MATLAB software.	7 hours
	• To compute auto correlation between two sequences using MATLAB software.	7 hours
	• AIM: To find frequency response of a given system in differential equation form using MATLAB software.	7 hours

	• AIM: To find the FFT of a given sequence using MATLAB software.	7 hours
	• Determination of Power Spectrum of a given signal using MATLAB software.	7 hours
	• To implement LP FIR filter for a given sequence using MATLAB software.	9 hours
	• To implement HP FIR filter for a given sequence using MATLAB software.	9 hours
Pedagogy	ISA/Assignments/seminar	
References/ Readings	**Text Book(s)** 1. Signals and Systems, second edition-P. Rama Krishna Rao and Shankar Prakriya- Mc-Graw Hill, 2013. 2. Groover. M.P. Industrial Robotics, technology, programming and application Mc-Graw Hill 2012. 3. S. R.Deb, "Robotics technology and flexible automation", Tata McGraw Hill publishing company limited, 1994. **Reference Books** 1. Signals and systems, second edition-Alan. V. Oppenheim, Alan. S. Willsk,S. Hamid Nawab, PHI learning Pvt ltd, 1997 2. Signals and systems, second edition - Simon Haykin, Barry VanVeen, Wiley, Wiley India, 2007. 3. S. K. Saha, "Introduction to Robotics", Tata McGraw-Hill Publishing Company Ltd. (2008). 4. Ramon Pallas-Areny, John G. Webster, "Sensors and Signal Conditioning", 2nd Edition, Wiley India Pvt.Ltd., India, 2012. Mode of Evaluation: Assignments / Assignments / Quiz	
Learning Outcomes	After the completion of the course, student will be able to: 1. To differentiate continuous and discrete time signals 2. To analyse the sensor response using Fourier transform 3. To analyse the trajectory of sensor signal using Laplace transform 4. To understand the signal conditioning and acquisition mechanism 5. To learn the fundamentals and peripherals of robots 6. To explore sensor responses in controlling robots 7. To explore various real-time application of sensor signal in robotics	

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Programme: Masters in Data Science
Course Code: DSC-524 **Title of the Course:** Regression Analytics and Predictive Models
Number of Credits: 2 (2L-0T-2P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Probability Theory and Distributions	
Objectives	• Develop an understanding of regression analysis and model building. • Provide the ability to develop relationship between variables • Investigate possible diagnostics in regression techniques • Formulate feasible solutions using a regression model for real-life problems.	
Content (Theory)	**Simple Regression Analysis** Introduction to a linear and nonlinear model. Ordinary Least Square methods. Simple linear regression model, using simple regression to describe a linear relationship. Fitting a linear trend to time series data, Validating simple regression model using t, F and p test. Developing confidence interval. Precautions in interpreting regression results.	4 hours
	Multiple Regression Analysis Concept of Multiple regression model to describe a linear relationship, Assessing the fit of the regression line, inferences from multiple regression analysis, problem of over fitting of a model, comparing two regression model, prediction with multiple regression equation.	4 hours
	Fitting Curves and Model Adequacy Checking Introduction, fitting curvilinear relationship, residual analysis, PRESS statistics, detection and treatment of outliers, lack of fit of the regression model, test of lack of fit, Problem of autocorrelation and heteroscedasticity. Estimation of pure errors from near neighbors.	4 hours
	Transformation techniques Introduction, variance stabilizing transformations, transformations to linearize the model, Box Cox methods, transformations on the repressors variables, Generalized and weighted least squares, Some practical applications.	4 hours
	Multicollinearity Introduction, sources of multicollinearity, effects of multicollinearity. Multicollinearity diagnostics: examination of correlation matrix, variance Inflation factors (VIF), Eigen system analysis of X1X. Methods of dealing with Multicollinearity: collecting additional data, model re-specification, and ridge regression.	4 hours
	Generalized Linear Models Generalized linear model: link functions and linear predictors, parameter estimation and inference in the GLM, prediction and estimation with the GLM, Residual Analysis, and concept of over dispersion.	4 hours

	Model building and Nonlinear Regression Variable selection, model building, model misspecification. Model validation techniques: Analysis of model coefficients, and predicted values, data splitting method. Nonlinear regression model, nonlinear least squares, transformation to linear model, parameter estimation in nonlinear system, statistical inference in nonlinear regression.	6 hours
Content for Practical:	1. Linear Regression	5 hours
	2. Minimum Least Square Method	5 hours
	3. Calculating coefficients values	5 hours
	4. Ascombe's Quartet	5 hours
	5. Regression Equations- x on y & y on x	5 hours
	6. Predicting mom's height based on daughter's height	5 hours
	7. Regression-Solved problem-2	5 hours
	8. Probable Error- Calculating correlation coefficient of POPULATION	5 hours
	9. Predictive modelling project for credit card fraud detection	5 hours
	10. Predictive modelling project for customer value prediction	5 hours
	11. Predictive modelling project for stock market forecasting	5 hours
	12. Predictive modelling project for corporate bankruptcy prediction	5 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, Introduction to Linear Regression Analysis, Third Ed., Wiley India Pvt. Ltd., 2016. Norman R. 2. Draper, Harry Smith; Applied Regression Analysis, WILEY India Pvt. Ltd. New Delhi; Third Edition, 2015. 3. Johnson, R A., Wichern, D. W., Applied Multivariate Statistical Analysis, Sixth Ed., PHI learning Pvt., Ltd., 2013. 4. Iain Pardoe, Applied Regression Modeling, John Wiley and Sons, Inc, 2012.	
Learning Outcomes	At the end of the course students will be able to: • Develop in-depth understanding of the linear and nonlinear regression model. • Demonstrate the knowledge of regression modelling and model selection techniques.	

	• Examine the relationships between dependent and independent variables. • Estimate the parameters and fit a model. • Investigate possible diagnostics in regression modelling and analysis. • Validate the model using hypothesis testing and confidence interval approach. • Understand the generalizations of the linear model to binary and count data.	

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Annexure VI

Masters in Artificial Intelligence to be effective from Academic Year 2023-24

Eligibility:

Bachelor degree in Computer Science/Computer Applications/Engineering (Computer Science/Information Technology) or equivalent degree with atleast 55% marks (relaxation in minimum percentage for reserved categories shall be applicable as per existing state government rules)

OR

Bachelor degree in Mathematics/Statistics/Electronics with atleast 55% marks (relaxation in minimum percentage for reserved categories shall be applicable as per existing state government rules). Such candidates shall be provisionally admitted until successful completion of Bridge Courses as specified by the ***Admission Committee for Masters in Artificial Intelligence*** *at the time of admission.*

Admission:

Procedure for admission to the Masters in Artificial Intelligence will be decided by the Admission Committee for Masters in Artificial Intelligence appointed by the Vice-Chancellor for the Academic Year

Masters in Artificial Intelligence Programme Specific Outcomes:

The course is aimed at imparting the following core things

1. *Core programming skills and techniques, including designing and coding applications, and the important principles of code design and development.*
2. *Data science tools and techniques, including the principles of data science, data analysis, visualisation and interpretation, and the use of "big data".*
3. *Artificial intelligence tools and techniques, including problem-solving, knowledge representation, machine learning, computer vision, human-computer interactions and (mis) information diffusion.*
4. *Ethical computing and data science, exploring the ethical, legal, social and professional frameworks in which data scientists must operate, in business and society.*
5. *The application of AI and data science in research and industry*

Pathway

Fundamentals (Mathematics and Problem Solving, Programming) -→ Core Courses (AI, Machine Learning, Deep Learning, etc.,) → Specialization (Natural Language Processing, Computer Vision) → Research and Dissertation (Core Research – Language Models, or Application Oriented Research or Product Based Research (MLOps, DevOps, Design Thinking , Pragmatic AI)

As per the above pathway vision, the structure for programme has been designed as follows -

Masters in Artificial Intelligence COURSE STRUCTURE to be effective from Academic Year 2023-24					
SEMESTER – 1					
Course-Code	***Course Title***	***L***	***T***	***P***	***Credits***
Discipline Specific Core Courses(DSCC)					

CSI-500	*Fundamentals of Artificial Intelligence*	*2*	*0*	*0*	***2***
CSI-501	*Fundamentals of Artificial Intelligence Lab*	*0*	*0*	*4*	***2***
CSI-502	*Algorithms and Data structures*	*2*	*0*	*0*	***2***
CSI-503	*Algorithms and Data structures Lab*	*0*	*0*	*4*	***2***
CSI-504	*Mathematical Foundations for Artificial Intelligence*	*2*	*0*	*0*	***2***
CSI-505	*Mathematical Foundations for Artificial Intelligence Lab*	*0*	*0*	*4*	***2***
CSI-506	*Data Science Fundamentals*	*2*	*0*	*0*	***2***
CSI-507	*Data Science Fundamentals Lab*	*0*	*0*	*4*	***2***
	Total Credits for DSCC				***16***
Discipline Specific Elective Courses(DSEC) – Any One to be selected…					
CSI-521	*Natural Language Processing*	*2*	*0*	*4*	***4***
CSI-522	*Computer Vision*	*2*	*0*	*4*	***4***
CSI-523	*Robotics*	*2*	*0*	*4*	***4***
CSI-524	*IoT Architecture and Protocols*	*2*	*0*	*4*	***4***
	Total Minimum Credits for DSEC				***4***
Total Minimum Credits Semester – 1					***20***
Skill Enhancement Course(SEC), Students to be encouraged / made mandatory to go through the courses, but not considered for GPA Calculation, will appear on Grade Card					
	Yoga and Meditation	*1*	*1*	*0*	*2*
	Any Community Engagement Course like - Swachh Bharat Student Internship(SBSI)	*0*	*0*	*4*	*2*

Masters in Artificial Intelligence *Programme Structure to be effective from Academic Year 2023-24*					
SEMESTER – 2					
Course-Code	*Course Title*	*L*	*T*	*P*	*Credits*
CSI-508	*Deep Learning*	*2*	*0*	*0*	*2*
CSI-509	*Deep Learning Lab*	*0*	*0*	*4*	*2*
CSI-510	*Big Data Frameworks*	*2*	*0*	*0*	*2*
CSI-511	*Big Data Frameworks Lab*	*0*	*0*	*4*	*2*
CSI-512	*Reinforcement Learning*	*2*	*0*	*0*	*2*
CSI-513	*Reinforcement Learning Lab*	*0*	*0*	*4*	*2*
CSI-514	*Software Engineering for AI Enabled systems*	*2*	*0*	*0*	*2*
CSI-515	*Software Engineering for AI Enabled systems*	*0*	*0*	*4*	*2*

	Lab				
Total Credits for DSCC					*16*
Discipline Specific Elective Courses (DSEC) – Any one to be opted for…					
CSI-525	*Machine Translation*	*2*	*0*	*4*	*4*
CSI-526	*Mathematics for Computer Vision and Robotics*	*2*	*0*	*4*	*4*
CSI-527	*Soft computing*	*2*	*0*	*4*	*4*
CSI-528	*Regression Analytics and Predictive Models*	*2*	*0*	*4*	*4*
CSI-529	*Essentials of Data Analytics*	*2*	*0*	*4*	*4*
Total Minimum Credits for DSEC					*4*
Total Minimum Credits Semester – 2					*20*

Masters in Artificial Intelligence ***Programme Structure to be effective from Academic Year 2023-24***					
SEMESTER – 3					
Course-Code	***Course Title***	***L***	***T***	***P***	***Credits***
Any two Research Specific Elective Courses(RSEC) to be opted in consultation with the Mentor based on the Dissertation type to be opted by the student for Semester 4.					
CSI-600	*Speech Processing*	*2*	*0*	*4*	***4***
CSI-601	*Advanced Machine Translation*	*2*	*0*	*4*	***4***
CSI-602	*Simulation and Modelling*	*2*	*0*	*4*	***4***
CSI-603	*MLOps*	*2*	*0*	*4*	***4***
CSI-604	*Generative Deep Learning Models*	*2*	*0*	*4*	***4***
CSI-605	*Data Engineering*	*2*	*0*	*4*	***4***
CSI-606	*Sensors , Actuators and Signal Conditioning*	*2*	*0*	*4*	***4***
CSI-607	*Signal Processing*	*2*	*0*	*4*	***4***
CSI-608	*Image Processing*	*2*	*0*	*4*	***4***
Total Minimum Credits for RSEC					***8***
Generic Elective Courses(GEC) – Any three to be opted…					
CSA-621	Corporate Skills	4	0	*0*	4
CSI-621	Seminar Course	*4*	*0*	*0*	***4***

CSI-623	Research Methodology	*4*	*0*	*0*	***4***
	Value Added Course / Skill Enhancement Courses / Community Engagement Course / Multidisciplinary Course	2	0	*4*	4
	Any one offered by Commerce Discipline during that semester can be opted	*4*	*0*	*0*	***4***
	Any one offered by Economics Discipline during that semester can be opted	*4*	*0*	*0*	***4***
	Any one offered by Management Studies Discipline during that semester can be opted	*4*	*0*	*0*	***4***
	Foreign or Indian Language Course under AEC could be opted	*4*	*0*	*0*	***4***
Total Minimum Credits for GEC					***12***
Total Minimum Credits for Semester 3					***20***

Masters in Artificial Intelligence ***Programme Structure to be effective from Academic Year 2023-24***					
SEMESTER – 4					
Research Specific Elective Courses(RSEC) – Any one to be opted in consultation with the Mentor based on the Dissertation type to be opted by the student for Semester 4. It could be completed in Semester 3 before going for the Dissertation.					
CSI-609	*Financial Machine Learning*	*2*	*0*	*4*	***4***
CSI-610	*AI for Atmospheric Science*	*2*	*0*	*4*	***4***
CSI-611	*Pragmatic AI*	*2*	*0*	*4*	***4***
CSI-612	*AI for Medical Specialization*	*2*	*0*	*4*	***4***
CSI-613	*Design thinking for AI*	*2*	*0*	*4*	***4***
CSI-614	*Recommender Systems*	*2*	*0*	*4*	***4***
CSI-615	*Text Mining and Sentiment Analysis*	*2*	*0*	*4*	***4***
CSI-616	*Digital Twin*	*2*	*0*	*4*	***4***
Total Minimum Credits for RSOC					***4***
Dissertation Type					***Credits***

CSI-652: Industry Internship / Software Project Development *OR* *CSI-651: Research Project in Academic or Research Institutes*	*16*
Total Credits for Dissertation	***16***
Total Minimum Credits for Semester-4	***20***
Total Minimum Credits for two-year* M.Sc. in Artificial Intelligence *degree Programme	***80***

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Semester I (Core Papers)

Programme: M.Sc. in Artificial Intelligence
Course code: CSI-500 **Title of course:** Fundamentals of Artificial Intelligence
Number of credits: 2(2L+0T+0P) **Total contact hours:** 30 hours(30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Programming back programming and probability and statistics and linear algebra	
Objectives	To develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI.	
Content	Artificial Intelligence Introduction -Intelligent Agents, Problem-solving Solving Problems by Searching -Search in Complex Environments - Adversarial Search and Games-Constraint Satisfaction Problems	5 hours
	Knowledge, reasoning, and planning Knowledge Representation-First-Order Predicate Logic - Unification Forward and Backward Chaining - Resolution - Ontological Engineering Categories and Objects - Events-Mental Events and Mental Objects - Reasoning Systems for Categories - Reasoning with Default Information	3 hours
	Uncertain knowledge and reasoning Quantifying Uncertainty - Probabilistic Reasoning - Probabilistic Reasoning over Time Probabilistic Programming -Making Simple Decisions - Making Complex Decisions -Multiagent Decision Making	3 hours
	Machine Learning Learning from Examples - Learning Probabilistic Models - Deep Learning - Reinforcement Learning Communicating, perceiving, and acting	6 hours
	Natural Language Processing - Deep Learning for Natural Language Processing - Computer Vision - Robotics .	2 hours

	Artificial Intelligence applications Language Models - Information Retrieval - Information Extraction Natural Language Processing - Machine Translation - Speech Recognition Robotics-Hardware and Software for Robots - Planning and Perception Explainable AI - Definitions and concepts such as black-box models, transparency, interpretable machine learning and explanations. - Decision-making and decision support, Human-Computer Interaction (HCI) and AI. - Explainable AI. - Methods for Explainable AI. - Applications and examples. - Trust and acceptance.-Evaluation methods and metrics. - Ethical, legal and social issues of explainable AI. Contemporary issues in AI- Philosophy, Ethics, and Safety of AI -The Future of AI	7 hours 4 hours
Pedagogy	Tutorials / Hands-on-assignments / Self-study	
References/ Reading	1. A Classical Approach to Artificial Intelligence, M.C. Trivedi, Khanna Book Publishing, 2019. 2. Artificial Intelligence: A modern approach by Stuart Russel, Pearson Education, 2010. 3. Artificial Intelligence by Rich and Knight, The McGraw Hill, 2017. 4. Artificial Intelligence: A new synthesis by Nils and Nilson, Elsevier, 1997. 5. Artificial Intelligence by Luger, Pearson Education, 2002. 6. Artificial Intelligence by Padhy, Oxford Press, 2005. 7.https://www.edx.org/course/artificial-intelligence-ai 8.https://www.udemy.com/course/artificial-intelligence-az/	
Learning Outcomes	The students will be able to: 1. Understand the basic concepts and techniques of Artificial Intelligence. 2. Apply AI algorithms for solving practical problems. 3. Describe human intelligence and AI. 4. Explain how the intelligent system works. 5. Apply basics of Fuzzy logic and neural networks. 6. Explain Expert System and implementation.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-501 **Title of the Course:** Fundamentals of Artificial Intelligence Lab
Number of Credits: 2 (0L+0T+2P) **Total Contact Hours:** 60 hours (0L+0T+2P)
Effective from AY: 2023-24

Prerequisites for the course:	Artificial Intelligence theory, probability and statistics , linear algebra and Python programming	
Objectives:	To develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI and implement AI algorithms	
Content:	Assignment-1 -Real-world path planning for pedestrians. In the first part, students implement A* over a map that includes roads/paths as well as elevations. In the second part, students collect actual data through walking around the real world, and the cost model is then learned via regression techniques.	10 hours
	Assignment-2 -Solve maze via search -this assignment involves formulating maze-solving as a search problem, image processing (via OpenCV) as a step in maze-solving, as well as guided performance/quality analysis of representational parameters.	10 hours
	Assignment 3-Within the context of an artificial intelligence course, students are taught to identify ethical issues within technical projects and to engage in moral problem solving with regard to such issues.	10 hours
	Assignment 4-Neural network for face recognition using tensor flow -build feedforward neural networks for face recognition using TensorFlow. Students then visualize the weights of the neural networks they train. The visualization allows students to understand feedforward one-hidden layer neural networks in terms of template matching, and allows students to explore overfitting.	10 hours
	Assignment -5 -Organic path finding -Students develop a “human-like” pathfinding technique by specializing a generic search algorithm with custom action cost and heuristic cost functions. Students apply classical search algorithms and reflect on example organic paths to achieve “human-like” pathfinding.	10 hours
	Assignment - 6 -Implement a genetic algorithm in Python to evolve strategies for Robby the Robot to collect empty soda cans that lie scattered around his rectangular grid world. And also Compare the performances of a brute-	10 hours

	force search and a search employing the Minimum Remaining Values (MRV) heuristic in solving Sudoku puzzles.	
Pedagogy:	lectures/practical/ tutorials/assignments/self-study	
References /Readings:	1. A Classical Approach to Artificial Intelligence, M.C. Trivedi, Khanna Book Publishing, 2019. 2. Artificial Intelligence: A modern approach by Stuart Russel, Pearson Education, 2010. 3. Artificial Intelligence by Rich and Knight, The McGraw Hill, 2017. 4. Artificial Intelligence: A new synthesis by Nils and Nilson, Elsevier, 1997. 5. Artificial Intelligence by Luger, Pearson Education, 2002. 6. Artificial Intelligence by Padhy, Oxford Press, 2005. 7.https://www.edx.org/course/artificial-intelligence-ai 8.https://www.udemy.com/course/artificial-intelligence-az/	
Learning Outcomes:	The students need to understand and extend an existing implementation of the back-propagation algorithm and use it to recognize static hand gestures in images. Students learn about feedforward neural networks and the backpropagation algorithm by implementing a perceptron network for AND and XOR Boolean functions and, given an implementation of a feedforward network, learn digit recognition using the MNIST data set. In this assignment students extend a Tic Tac Toe program to Ultimate Tic Tac Toe and implement a different search strategy than the example code.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-502 **Title of the Course:** Algorithms and Data Structure
Number of Credits: 2 (2L+0T+0P) **Total Contact Hours:** 30 hours(30L+0T+0P)
Effective from AY: 2023-24

Prerequisites for the course:	Programming in Python	

Objectives:	The aim of the course is to introduce the fundamental concept of data structures and to emphasize the importance of data structures in developing and implementing efficient algorithms. It provides an exposure to various data structures and algorithm analysis including lists, stacks, queues, trees, and various sorting and searching algorithms.	
Content:	Introduction: Three level Approach - Application/User level, Abstract/Logical level, Physical/Implementation level; Concept of Abstract Data Types (ADTs), Data Structure definition, Data type vs. data structure, Applications of data structures, Algorithms analysis and its complexity, Best case, worst case , and Average case performance, time-space tradeoff, Asymptotic Analysis, Big-O notation. Linear Data Structures: Array and its application: Polynomials, Sparse matrices, String-pattern Matching. Linked Lists, Doubly linked list, Circular linked list, Stack and Queues. Nonlinear Data Structures: Trees: Binary tree representation, Binary Search Trees, AVL Trees, M-way Search Trees, B-trees. B tree algorithms, Heap Structures.	3 hours 3 hours 5 hours 5 hours
	Graphs: Graph representations; Graph Traversals Complexity of Searching & Sorting algorithms: Bubble sort, Quick sort, Selection sort, Insertion sort, Merge sort and Heap sort. An Empirical Comparison of Sorting Algorithms, Lower bounds for Sorting. Linear search, binary search. Dynamic programming and Greedy algorithms: Assembly line scheduling, Matrix-chain multiplication; Prim‟s Algorithm, Kruskal‟s Algorithm	2 hours 8 hours 4 hours
Pedagogy:	Practical/ tutorials/assignments/self-study	
References /Readings:	1. Horowitz, Ellis, Sartaj Sahni, and Susan Anderson-Freed. Fundamentals of data structures in C. WH Freeman & Co., 1992. 2. Benjamin Baka, Basant Agarwal, “Hands on Data Structure and Algorithms with Python”, Second Edition, O‟Reilly, 2018 3. Cormen Thomas, L. Charles, R. Ronald, S. Clifford, “Introduction to Algorithms”, Second Edition,EEE, PHI. 4. Allen, Weiss Mark. Data structures and algorithm	

	analysis in C. Pearson Education India, 2011. 5. Algorithms, by Dasgupta, Papadimitriou, and Vazirani, McGraw-Hill.	
Learning Outcomes:	1. Upon successful completion of the course, a student will bE able to 2. ● Implement common data structures such as lists, stacks, queues, graphs, and binary trees for solving programming problems. 3. ● Identify and use appropriate data structures in the context of a solution to a given problem.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-503 **Title of the Course:** Algorithms and Data Structure Lab
Number of Credits: 2 (0L+0T+2P) **Total Contact Hours:** 60 hours (0L+0T+2P)
Effective from AY: 2023-24

Prerequisites for the course:	Programming in Python	
Objectives:	The aim of the course is to introduce the fundamental concept of data structures and to emphasize the importance of data structures in developing and implementing efficient algorithms. It provides an exposure to various data structures and algorithm analysis including lists, stacks, queues, trees, and various sorting and searching algorithms.	
Content:	Object-Oriented Design Goals, Object-Oriented Design Principles. 1. The programming assignment should introduce and enforce the concepts of encapsulation, polymorphism and Inheritance. ADT Specifications and Implementation of following basic data structures	
	2. Singly Linked Linear Lists	

	3. Singly Linked Circular Lists	2 hours
	4. Doubly Linked Linear Lists	2 hours
	5. Doubly Linked circular Lists	2 hours
	6. Stack using linked list	2 hours
	7. Queue using linked list	2 hours
	ADT Specifications and Implementation of following non-linear data structures 8. Binary Trees	4 hours
	9. Binary Search Trees	3 hours
	10. AVL Trees	4 hours
	11. B-Trees and its variants	3 hours
	Application of stack 12. Program to convert the given infix expression to postfix expression using stack	3 hours
	13. Program to evaluate a postfix expression using stack.	2 hours
	14. Program to traverse a binary tree in the following way: Pre-order, In-order, Post-order	3 hours
	Applications of Binary Trees 15. Write a program to implement Huffman encoding using Binary tree.	2 hours

	16. Write a program to create a binary tree for the given infix expression.	2 hours
	Applications of AVL Trees 17. Write a program that reads a list of names and telephone number from a text file and inserts them into an AVL tree. Write a function to allow the user to search the tree. Searching and sorting	3 hours
	18. Program to implement Binary search technique using Iterative method and Recursive methods.	3 hours
	19. Programs to implement following sorting algorithm-Bubble sort, Selection sort, Insertion sort, Quicksort, Merge sort and Heap sort	3 hours
	Implementation of Dynamic programming 20. Assembly line scheduling	4 hours
	21. Matrix-chain multiplication	3 hours
	Implementation of Greedy algorithms 22. Prim‟s Algorithm	3 hours
	23. Kruskal‟s Algorithm	
Pedagogy:	Lectures/Practical/ tutorials/assignments/self-study	

References/Readings:	1. Horowitz, Ellis, Sartaj Sahni, and Susan Anderson-Freed. Fundamentals of data structures in C. WH Freeman & Co., 1992. 2. Benjamin Baka, Basant Agarwal, "Hands on Data Structure and Algorithms with Python", Second Edition, O"Reilly, 2018 3. Cormen Thomas, L. Charles, R. Ronald, S. Clifford, "Introduction to Algorithms", Second Edition,EEE, PHI. 4. Allen, Weiss Mark. Data structures and algorithm analysis in C. Pearson Education India, 2011. 5. Algorithms, by Dasgupta, Papadimitriou, and Vazirani, McGraw-Hill.	
Learning Outcomes:	A student will be able to : 1. Implement common data structures such as lists, stacks, queues, graphs, and binary trees for solving programming problems. 2. Identify and use appropriate data structures in the context of a solution to a given problem.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-504 **Title of course:** Mathematics foundation for Artificial Intelligence
Number of credits: 2 (2L-0T-0P) **Total contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Basic mathematics	
Objectives	To build a strong foundation in maths required for learning computer science/data science subjects. To understand fundamental concepts and tools in calculus, linear algebra etc with emphasis on their applications to computer science in particular data science/machine learning	
Content	**Introduction** Importance of mathematics and their applications for computer science/machine learning/data science/deep learning Functions, variables, equations, graphs revision **Probability and Statistics:** Probability Rules & Axioms, Bayes' Theorem, Random Variables, Variance and Expectation, Conditional and Joint Distributions, Standard Distributions (Bernoulli, Binomial, Multinomial,	3 hours 7 hours

	Uniform and Gaussian), Moment Generating Functions, Maximum Likelihood Estimation (MLE), Prior and Posterior, Maximum a Posteriori Estimation (MAP) and Sampling Methods-confidence intervals, Hypothesis testing, p-values, A/B testing-ANOVA, t-test,Linear regression, regularization **Calculus** Overview of Differential and Integral Calculus, Partial Derivatives Product and chain rule-Taylor's series, infinite series summation/integration concepts-Fundamental and mean value-theorems of integral calculus, evaluation of definite and improper integrals-Beta and Gamma functions, Functions of multiple variables, limit, continuity, partial derivatives-Basics of ordinary and partial differential equations -Applications of Calculus **Linear Algebra:** Systems of Linear Equations-Matrices-Solving Systems of Linear Equations-Vector Spaces-Linear Independence-Basis and Rank-Linear Mappings Affine Spaces **Analytic Geometry** Norms-(Inner Products-Lengths and Distances Angles and Orthogonality-Orthonormal Basis Orthogonal Complement-Inner Product of Functions-Orthogonal Projections-Rotations) -Eigen value decomposition and SVD **Optimization** Differentiation of Univariate Functions-Partial Differentiation and Gradients-Gradients of Vector-Valued Functions-Gradients of Matrices Useful Identities for Computing Gradients-Backpropagation and Automatic Differentiation-Higher-Order Derivatives-Linearization and Multivariate Taylor Series-Gradient Descent-Constrained Optimization -Lagrange Multipliers-Convex Optimization,	4 hours 3 hours 6 hours 7 hours
Pedagogy	Problem solving approach and carrying out small project work using matlab tools	
References/ Readings	1. Statistics Written, Robert S. Witte and John S. Witte	

	2. Barron's AP Statistics, 8th Edition, Martin Sternstein, PhD. 3. Statistics for Business and Economics by- James T. McClave, P. George Benson and Terry T Sincich 4. Naked Statistics: Stripping the Dread from the Data, Charles Wheelan 5. Introduction to Linear Algebra, Gilbert Strang 6. Linear Algebra and Its Applications, David C. Lay 7. No bullshit guide to Linear algebra, Ivon Savov 8. Functions and Graphs by I M Gelfand 9. Cartoon guide to calculus, Larry Gonick 10. Optimization Methods in Business Analytics — *edX, MIT*	
Learning Outcomes	Students will be able to: Apply the concepts of mathematics in the modeling and design of computational problems and deeper understanding of subjects like machine learning / deep learning and other computer science subjects.	

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Programme: M.Sc. in Artificial Intelligence
Course code: CSI-505 **Title of course:** Mathematics Foundation for AI using Matlab
Number of credits: 2 (0L-0T-2P) **Total contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Mathematical foundation theory and programming background	
Objectives	The lab assignment are aimed at demonstration of the following regarding statistics	

Content	Revision of the following : NumPy is a third-party library for numerical computing, optimized for working with single- and multi-dimensional arrays. Its primary type is the array type called ndarray. This library contains many routines for statistical analysis. SciPy is a third-party library for scientific computing based on NumPy. It offers additional functionality compared to NumPy, including scipy.stats for statistical analysis. Pandas is a third-party library for numerical computing based on NumPy. It excels in handling labeled one-dimensional (1D) data with Series objects and two-dimensional (2D) data with DataFrame objects. Matplotlib is a third-party library for data visualization. It works well in combination with NumPy, SciPy, and Pandas.	6 hours
	Assignment 1 - Write program to implement the following concepts using python libraries - Numpy,Pandas, matplotlib, seaborn,scipy, scrapy and beautiful soup, and tensor flow ,keras and pytorch etc	
	Assignment -2 - Sampling ,Variables in Statistics, Frequency Distributions.	6 hours
	Generate frequency distribution tables,Generate grouped frequency distribution tables and -Visualizing Frequency Distributions -Generate bar plots, pie charts, and histograms ,Employ bar plots, pie charts and histograms.	6 hours
	Assignment-3-Comparing Frequency Distributions -grouped bar plots- step-type histogram-kernel density estimate plots- strip plots and box plots	6 hours
	Assignment-4 -Multidimensional image operations,Solving differential equations and the Fourier transform using scipy	6 hours
	Assignment-5 -Optimization algorithms using scipy.	6 hours
	Assignment -6 -Linear algebra using scipy	6 hours

	Assignment- 7-Program in python to implement the concepts such as Vector space, subspace, span, coumn space, row space, null space, left-null space, rank, basis, orthogonal matrix, symmetric matrix	6 hours
	Assignment -8 – Implement Eigen value decomposition in python.	6 hours
	Assignment-9 – implement SVD using python.	6 hours
	Assignment -10 – implement some of optimization algorithm using the python library	6 hours
Pedagogy	lab assignments /Project	
References/ Readings	1. Statistics Written, Robert S. Witte and John S. Witte 2. Barron's AP Statistics, 8th Edition, Martin Sternstein, PhD. 3. Statistics for Business and Economics 4. Naked Statistics: Stripping the Dread from the Data, Charles Wheelan 5. Introduction to Linear Algebra, Gilbert Strangsss	
Learning Outcomes	Students will be able to: • Apply the concepts of mathematics in the modeling and design of computational problems and deeper understanding of subjects like machine learning / deep learning and other computer science subjects.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-506 **Title of the Course:** Data Science Fundamentals
Number of Credits: 2(2L+ 0P) **Contact hours:** 30 hours (30L+0T+0P)
Effective from AY: 2023-24

Prerequisites for the course	Statistics and Probability theory and Python Programming	
Objectives	To get started with basics of Data Science and learn all aspects of Data Science in its entirety	

Content	Introduction: Typology of problems - Data science in a big data world: Benefits and uses of data science and big data-Facets of data-The data science process-The big data ecosystem and data science-The data science process: Overview of the data science process-Defining research goals and creating a project charter-Retrieving data-Cleansing, integrating, and transforming data-Exploratory data analysis-Build the models- Presenting findings and building applications on top of them.	4 hours
	Mathematics for Data science (Revision) Importance of linear algebra, statistics and optimization from a data science perspective; Structured thinking for solving data science problems. Linear Algebra: Matrices and their properties (determinants, traces, rank, nullity, etc.); Eigenvalues and eigenvectors; Matrix factorizations; Inner products; Distance measures; Projections; Notion of hyperplanes; half-planes. Probability, Statistics and Random Processes: Probability theory and axioms; Random variables; Probability distributions and density functions (univariate and multivariate); Expectations and moments; Covariance and correlation; Statistics and sampling distributions; Hypothesis testing of means, proportions, variances and correlations; Confidence (statistical) intervals; Correlation functions; White-noise process.Data clearing (EDA)	8 hours 3 hours
	Introduction to Data Science Methods: Linear regression as an exemplar function approximation problem; Linear classification problems-PCA	4 hours
	Handling large data on a single computer The problems you face when handling large data-General techniques for handling large volumes of data-General programming tips for dealing with large data sets - Case study 1: Predicting malicious URLs - First steps in big data-Distributing data storage and processing with frameworks	4 hours

	Introduction to NoSQL The rise of graph databases Introducing connected data and graph databases Introducing Neo4j: a graph database Data visualization to the end user Data visualization options Crossfilter, the JavaScript MapReduce library Creating an interactive dashboard with dc.js Dashboard development tools	3 hours 4 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References / Readings	1. Practical statistics for data science by peter bruce and andrew bruce 2. Naked statistics by charles wheelon 3. Business data science by matt taddy 4. Elements of statistical learning by Trevor Hastie, Robert and jerome 5. Python for data analysis 6. Data science and big data analytics -EMC2	
Learning Outcomes	The students will be able to enrich one's knowledge with overall basics of data science and appreciate data science with this introduction to be able to get started in the direction.	

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Programme: M.Sc. in Artificial Intelligence
Course code: CSI-507 **Title of course:** Data Science Fundamentals Lab
Number of credits: 2(0L+0T+4P) **Total contact hours:** 60 hours(0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Basic programming skills, Statistics	
Objectives	To introduce Basic process of data science, Python and Jupyter notebooks. To understanding how to manipulate and analyze uncurated datasets To learn basic statistical analysis and machine learning methods and effectively visualize results	

Content	Jupyter and Numpy: Jupyter notebooks are one of the most commonly used tools in data science as they allow you to combine your research notes with the code for the analysis. After getting started in Jupyter, we'll learn how to use numpy for data analysis. numpy offers many useful functions for processing data as well as data structures which are time and space efficient.	10 hours
	Pandas: Pandas, built on top of numpy, adds data frames which offer critical data analysis functionality and features.	10 hours
	Visualization: When working with large data sets you often need to visualize your data to gain a better understanding of it. Also, when you reach conclusions about the data, you'll often wish to use visualizations to present your results.	10 hours
	Mini Project: With the tools of Jupyter notebooks, numpy, pandas, and Visualization, you're ready to do sophisticated analysis on your own. You'll pick a dataset we've worked with already and perform an analysis for this first project.	10 hours
	Machine Learning: To take your data analysis skills one step further, we'll introduce you to the basics of machine learning and how to use sci-kit learn - a powerful library for machine learning.	10 hours
	Working with Text and Databases: You'll find yourself often working with text data or data from databases. This week will give you the skills to access that data. For text data, we'll also give you a preview of how to analyze text data using ideas from the field of Natural Language Processing and how to apply those ideas using the Natural Language Processing Toolkit (NLTK) library.	5 hours
	Mini-Project	5 hours
Pedagogy	Tutorials/ Lab assignments/ Project work	
References/ Readings	1. Practical statistics for data science by Peter Bruce and Andrew Bruce 2. Naked statistics by Charles Wheelon 3. Business data science by Matt Taddy 4. Elements of statistical learning by Trevor	

	Hastie, Robert and jerome 5. Python for data analysis 6. Data science and big data analytics -EMC2	
Learning Outcomes	• The student will be able to: • To understanding how to manipulate and analyze uncurated datasets • To learn basic statistical analysis and machine learning methods and effectively visualize results	

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Semester II (Core Papers)

Programme: MSc AI
Course Code: CSI-508 **Title of the Course:** Deep Learning
Number of Credits: 2(2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Programme prerequisites	
Objectives	To study the basics of Neural Networks and their various variants such as the Convolutional Neural Networks and Recurrent Neural Networks, to study the different ways in which they can be used to solve problems in various domains such as Computer Vision, Speech and NLP.	
Content	History of Deep Learning, McCulloch Pitts Neuron, Thresholding Logic, Perceptron Learning Algorithm and Convergence	1 hours
	Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent	1 hours
	Feedforward Neural Networks, Representation Power of Feedforward Neural Networks, Backpropagation	2 hours
	Gradient Descent(GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Adagrad, AdaDelta,RMSProp, Adam,AdaMax,NAdam, learning rate schedulers	2 hours
	Autoencoders and relation to PCA , Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders	3 hours
	Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout	3 hours
	Greedy Layer Wise Pre-training, Better activation functions,	

	Better weight initialization methods, Batch Normalization Learning Vectorial Representations Of Words, Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT Gated Recurrent Units (GRUs), Long Short Term Memory (LSTM) Cells, Solving the vanishing gradient problem with LSTM Encoder Decoder Models, Attention Mechanism, Attention over images, Hierarchical Attention, Transformers.	3 hours 3 hours 3 hours 3 hours 3 hours 3 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. An MIT Press book. 2016. 2. Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019. 3. Dive into Deep Learning by Ashton Zang. 4. Introduction to Deep Learning by Sandro Skansi.	
Learning Outcomes	● A brief history of deep learning and its success stories. ● Perceptrons, Sigmoid neurons and Multi-Layer Perceptrons (MLP) with specific emphasis on their representation power and algorithms used for training them (such as Perceptron Learning Algorithm and Backpropagation). ● Gradient Descent (GD) algorithm and its variants like Momentum based GD,AdaGrad, Adam etc Principal Component Analysis and its relation to modern Autoencoders. ● The bias variance tradeoff and regularisation techniques used in DNNs (such as L2 regularisation, noisy data augmentation, dropout, etc). ● Different activation functions and weight initialization strategies ● Convolutional Neural Networks (CNNs) such as AlexNet, ZFNet, VGGNet, InceptionNet and ResNet. ● Recurrent Neural Network (RNNs) and their variants such as LSTMs and GRUs (in particular, understanding the	

	vanishing/exploding gradient problem and how LSTMs overcome the vanishing gradient problem) ● Applications of CNN and RNN models for various computer vision and Natural Language Processing (NLP) problems.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-509 **Title of the Course:** Deep Learning Lab
Number of Credits: 2(0L-0T-4P) **Contact hours:**60 hours(0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Programming, Machine Learning Skills. Statistics,Calculus,Linear Algebra.Probability.	
Objectives	1. To make students comfortable with tools and techniques required in handling large amounts of datasets. 2. They will also uncover various deep learning methods in NLP, Neural Networks etc.	
Content	**Tensorflow with Python** Introducing Tensorflow - Tensorflow as an Interface - Tensorflow as an environment - Tensors - Computation Graph - Installing Tensorflow - Tensorflow training - Prepare Data - Tensor types - Loss and Optimization - Running tensorflow programs.	5 hours
	Building Neural Networks using Tensorflow Building Neural Networks using Tensorflow - Tensorflow data types - CPU vs GPU vs TPU - Tensorflow methods - Introduction to Neural Networks - Neural Network Architecture - Linear Regression example revisited - The Neuron - Neural Network Layers - The MNIST Dataset - Coding MNIST NN.	5 hours
	Deep Learning using Tensorflow Deepening the network - Images and Pixels - How humans recognise images - Convolutional Neural Networks - ConvNet Architecture - Overfitting and Regularization - Max Pooling and ReLU activations - Dropout - Strides and Zero Padding - Coding Deep ConvNets demo - Debugging Neural Networks - Visualising NN using Tensorflow - Tensorboard.	5 hours
	Transfer Learning using Keras and TFLearn Transfer Learning Introduction - Google Inception Model - Retraining Google Inception with our own	

	data demo - Predicting new images - Transfer Learning Summary - Extending Tensorflow - Keras - TFLearn - Keras vs TFLearn Comparison. **Suggest ideas for lab work** Assignment -1 Cat vs. Dog Image Classifier Assignment -2- Covid-19 Detection in Lungs Assignment -3- Digit Recognition System Assignment - 4- Facial Recognition Application Assignment -5- Face Mask Detection Assignment -6- Cyber-Attack Prediction Assignment -7- Automated Attendance System Assignment -8 Emotion Recognition Assignment -9- Object Detection System Assignment 10 - Recommender System	5 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours 3 hours
Pedagogy	Lab assignment/mini project	
References/ Readings	1. Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. An MIT Press book. 2016. 2. Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019. 3. Grokking Artificial Intelligence Algorithms by Rishal Hurbans published by Manning Publications. 4. Deep Learning From Scratch: Building with Python from First Principles by Seth Weidman published by O`Reilley. 5. Deep learning in Python/ Pytorch by Manning Publications. 6. Deep Learning with Python by francois chollet. 7. Dive into Deep Learning by Ashton Zang. 8. Introduction to Deep Learning by Sandro Skansi.	
Learning Outcomes	Solve problems in linear algebra, probability, optimization, and machine learning. - Evaluate, in the context of a case study, the advantages and	

	disadvantages of deep learning neural network architectures and other approaches. - Implement deep learning models in Python using the PyTorch library and train them with real-world datasets. - Design convolution networks for handwriting and object classification from images or video. - Design recurrent neural networks with attention mechanisms for natural language classification, generation, and translation. - Evaluate the performance of different deep learning models (e.g., with respect to the bias-variance trade-off, overfitting and underfitting, estimation of test error). - Perform regularization, training optimization, and hyperparameter selection on deep models. - Analyze a deep learning model's hardware node and GPU scalability in preparation for deployment.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-510 **Title of the Course:** Big Data Frameworks
Number of Credits: 2(2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Probability and statistics and programming background	
Objectives	1. To understand the need of Big Data, challenges and different analytical architectures 2. Installation and understanding of Hadoop Architecture and its ecosystems 3. Processing of Big Data with Advanced architectures like Spark. 4. Describe graphs and streaming data in Spark	
Content	**Introduction to big data** Data Storage and Analysis - Characteristics of Big Data – Big Data Analytics - Typical Analytical Architecture – Requirement for new analytical architecture – Challenges in Big Data Analytics – Need of big data frameworks **Hadoop framework** Hadoop – Requirement of Hadoop Framework - Design principle of Hadoop –Comparison with other system - Hadoop Components – Hadoop 1 vs Hadoop 2 – Hadoop Daemon's – HDFS Commands – Map Reduce Programming: I/O formats, Map side join, Reduce Side Join, Secondary sorting, Pipelining MapReduce jobs -	 3 hrs 6 hrs

	Hadoop Ecosystem Introduction to Hadoop ecosystem technologies: Serialization: AVRO, Co-ordination: Zookeeper, Databases: HBase, Hive, Scripting language: Pig, Streaming: Flink, Storm **Spark framework** Introduction to GPU Computing, CUDA Programming Model, CUDA API, Simple Matrix, Multiplication in CUDA, CUDA Memory Model, Shared Memory Matrix Multiplication, Additional CUDA API Features. **Data analysis with spark shell** Writing Spark Application - Spark Programming in Scala, Python, R, Java - Application Execution **Spark SQL and Graph X** SQL Context – Importing and Saving data – Data frames – using SQL – GraphX overview – Creating Graph – Graph Algorithms. **Spark streaming** Overview – Errors and Recovery – Streaming Source – Streaming live data with spark **Recent trends in big data analytics**	3 hrs 4 hrs 4 hrs 5hrs 3 hrs 2 hr
Pedagogy	Assignment / Quiz / Project / Seminar	
References/ Readings	1. Mike Frampton, "Mastering Apache Spark", Packt Publishing, 2015. 2. TomWhite,"Hadoop:TheDefinitiveGuide",O'Reilly,4thEdition,2015. 3. NickPentreath,MachineLearningwithSpark,PacktPublishing, 2015. 4. Mohammed Guller, Big Data Analytics with Spark, Apress, 2015. 5. Donald Miner, Adam Shook, "Map Reduce Design Pattern", O'Reilly, 2012.	
Learning Outcomes	On completion of this course students would have a good understanding of Big Data and understand the basics of the frameworks like hadoop and spark and have a knowledge of Spark SQL and Spark streaming.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-511 **Title of the Course:** Big Data Frameworks Lab
Number of Credits: 2(0L -0T-4P) **Contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Should have knowledge of one Programming Language (Java preferably), Practice of SQL (queries and sub queries), exposure to Linux Environment.	
Objectives	Understand the Big Data Platform and its Use cases • Provide an overview of Apache Hadoop • Provide HDFS Concepts and Interfacing with HDFS • Understand Map Reduce Jobs • Provide hands on Hodoop Eco System • Apply analytics on Structured, Unstructured Data.	
Content	**List of Experiments:** 1. Implement the following Data structures in Java Linked Lists,Stacks,Queues,Set,Map 2. Perform setting up and Installing Hadoop in its three operating modes: Standalone, Pseudo Distributed, Fully distributed. 3. Implement the following file management tasks in Hadoop: -Adding files and directories,Retrieving files (Deleting files Hint: A typical Hadoop workflow creates data files (such as log files) elsewhere and copies them into HDFS using one of the above command line utilities. 4.Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm. 5. Write a Map Reduce program that mines weather data. Weather sensors collecting data everyhour at many locations across the globe gather a large volume of log data, which is a goodcandidate for analysis with MapReduce, since it is semi structured and record-oriented. 6. Implement Matrix Multiplication with Hadoop Map Reduce 7. Install and Run Pig then write Pig Latin scripts to sort, group, join, project, and filter your data. 8. Install and Run Hive then use Hive to create, alter, and drop databases, tables, views, functions, and indexes. 9. Solve some real life big data problems. - Traffic control using big data - Medical insurance fraud detection - Recommendation system - Anomaly detection in cloud servers - Tourist behavior analysis - Web server log analysis	5 hrs 5 hrs 5 hrs 5 hrs 5 hrs 5 hrs 5 hrs 5 hrs 20 hrs
Pedagogy	Lab assignments/mini project/ seminar	
References/	Text Books	

Readings	• Tom White " Hadoop: The Definitive Guide" Third Edit on, O'reily Media, 2012. • Seema Acharya, Subhasini Chellappan, "Big Data Analytics" Wiley 2015. References • Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2007. • Jay Liebowitz, "Big Data and Business Analytics" Auerbach Publications, CRC press (2013) • Anand Rajaraman and Jef rey David Ulman, "Mining of Massive Datasets", Cambridge University Press, 2012. • Bill Franks, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics", John Wiley & sons, 2012. • Glen J. Myat, "Making Sense of Data", John Wiley & Sons, 2007	
Learning Outcomes	The students will be able to: • Identify Big Data and its Business Implications. • List the components of Hadoop and Hadoop Eco-System • Access and Process Data on Distributed File System • Manage Job Execution in Hadoop Environment • Develop Big Data Solutions using Hadoop Eco System • Analyze Infosphere BigInsights Big Data Recommendations.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-512 **Title of the Course:** Reinforcement Learning
Number of Credits: 2(2L-0T-0P) **Contact hours:**30 hours(30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Linear algebra, multivariable calculus Basic machine learning knowledge	
Objectives	To enable the student to understand the reinforcement learning paradigm, to be able to identify when an RL formulation is appropriate, to understand the basic solution approaches in RL, to implement and evaluate various RL algorithms.	

Content	Review of ML fundamentals – Classification, Regression. Review of probability theory and optimization concepts.	2 hrs
	RL Framework; Supervised learning vs. RL; Explore-Exploit Dilemma; Examples.	2 hrs
	MAB: Definition, Uses, Algorithms, Contextual Bandits, Transition to full RL, Intro to full RL problem	2 hrs
	Intro to MDPs: Definitions , Returns, Value function, Q-function.	2 hrs
	Bellman Equation, DP, Value Iteration, Policy Iteration, Generalized Policy Iteration.	2 hrs
	Evaluation and Control: TD learning, SARSA, Q-learning, Monte Carlo, TD Lambda, Eligibility Traces.	2 hrs
	Maximization-Bias & Representations: Double Q learning, Tabular learning vs. Parameterized, Q-learning with NNs	2 hrs
	Function approximation: Semi-gradient methods, SGD, DQNs, Replay Buffer.	2 hrs
	Policy Gradients: Introduction, Motivation, REINFORCE, PG theorem, Introduction to AC methods	3 hrs
	Actor-Critic Methods, Baselines, Advantage AC, A3C Advanced Value-Based Methods: Double DQN, Prioritized Experience Replay, Dueling Architectures, Expected SARSA.	3 hrs
	Advanced PG/A-C methods: Deterministic PG and DDPG, Soft Actor-Critic (SAC) HRL: Introduction to hierarchies, types of optimality, SMDPs, Options, HRL algorithms POMDPS: Intro, Definitions, Belief states, Solution Methods; History-based methods, LSTMS, Q-MDPs, Direct Solutions, PSR.	4 hrs
	Model-Based RL: Introduction, Motivation, Connections to Planning, Types of MBRL, Benefits, RL with a Learnt Model, Dyna-style models, Latent variable models, Examples, Implicit MBRL. Case study on design of RL solution for real-world problems.	4 hrs
Pedagogy	Hands-on assignments / tutorials / peer-teaching / flip	

	classroom/ presentations.	
References/ Readings	1. Reinforcement learning -Introduction by Richard sutton and Andrew barto, 2nd edition, MIT press. 2. Algorithms for reinforcement learning by Csaba Szepesvari, Ronald Brachman, et al,2010.	
Learning Outcomes	Understanding the fundamentals of reinforcement learning and its role in building gaming applications and in turn helps to understand the challenges of real world problems , how RL will help them.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-513 **Title of the Course:** Reinforcement Learning Lab
Number of Credits: 2(2L) **Contact hours:**60 hours
Effective from AY: 2023-24

Prerequisites for the course	Linear algebra, multivariable calculus , Basic machine learning knowledge and programming background.	
Objectives	To understand the theory by carrying out the lab assignment based on the key ideas of reinforcement learning.	
Content	1. RL task formulation (action space, state space, environment definition) 2. Tabular based solutions (dynamic programming, Monte Carlo, temporal-difference) 3. Function approximation solutions (Deep Q-networks) 4. Policy gradient from basic (REINFORCE) towards advanced topics (proximal policy optimization, deep deterministic policy gradient, etc.) 5. Model-based reinforcement learning 6. Imitation learning (behavioral cloning, inverse RL, generative adversarial imitation learning) 7. Meta-learning 8. Multi-agent learning, partial observable environments	7 hours 7 hours 7 hours 7 hours 7 hours 7 hours 8 hours 10 hours
Pedagogy	Lab assignments/ mini project	
References/ Readings	1. Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", Second Edition, MIT Press, 2019. 2. Li, Yuxi. "Deep reinforcement learning." arXiv preprint arXiv:1810.06339 (2018). 3. Wiering, Marco, and Martijn Van Otterlo.	

	"Reinforcement learning." Adaptation, learning, and optimization 12 (2012): 3. 4. Russell, Stuart J., and Peter Norvig. "Artificial intelligence: a modern approach."Pearson Education Limited, 2016. 5. Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. "Deep learning." MIT press, 2016. 6. David Silver's course on Reinforcement Learning (link).	
Learning Outcomes	Understanding the fundamentals of reinforcement learning and its role in building gaming applications and in turn helps to understand the challenges of real world problems , how RL will help them.	

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Programme: M.Sc. in Artificial Intelligence
Course code: CSI-514 **Title of course:** Software Engineering for AI Enabled systems
Number of credits: 2 (2L-0T-0P) **Contact hours:** 30 hours (30L-0T-0P)
Effective from AY: 2023-24

Prerequisites for the course	Programming & Data Structures, Python	
Objectives	Gain an in-depth understanding of Software Engineering including its importance. Learn Scrum, Kanban, Agile, Waterfall, Prototyping, Incremental, RAD and Spiral Software Process Models. Learn to perform systematic Software Requirement Engineering. Applying SE approach to developing AI solutions	
Content	Software Engineering: Software Processes, SDLC , agile approaches to SE	5 hours
	Requirements Engineering: elicitation techniques, specification. SCRUM and user stories.	5 hours
	Test Driven Development: Refactoring and Unit testing	5 hours
	Use of frameworks and APIS and handling of big data	5 marks
	Configuration management, continuous integration,and automated software engineering	5 hours
	Cloud based software development, DevOps	5 hours
Pedagogy	Classroom/handson instructions, assignments, miniprojects	
References/ Readings	1. Hands-On Software Engineering with Python: Move beyond basic programming and construct reliable and efficient software with complex code, Brian Allbee, Packt Publishing.	

	2. A concise Introduction to Software Engineering, Pankaj Jalote-2008n- Springer. 3. Agile Estimating and Scrum, Mike Cohn, Prentice Hall.	
Learning Outcomes	1. Application of SE principles for AI and Data Sceince projects 2. How to work in self organzing teams 3. Use of tools and techniques for automating and managing software development	

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Programme: M.Sc. in Artificial Intelligence
Course code: CSI-515 **Title of course:** Software Engineering for AI Enabled Systems Lab
Number of credits: 2 (0L-0T-4P) **Contact hours:** 60 hours (0L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Programming & Data Structures, Python	
Objectives	Applying SE approach to developing AI solutions Use of modern software engineering tools and frameworks	
Content	1)Version Control Tools- Git and Github 2)TDD –Unit testing and refactoring with Python 3)Working with Python libraries and frameworks 4)Use of testing tools- selenium, Jmeter 5) Cloud based software development & DevOps	12 hours 12 hours 12 hours 12 hours 12 hours
Pedagogy	Lab sessions and projects	
References/ Readings	1. Hands-On Software Engineering with Python: Move beyond basic programming and construct reliable and efficient software with complex code, Brian Allbee, Packt Publishing. 2. A concise Introduction to Software Engineering, Pankaj Jalote-2008n- Springer. 3. Agile Estimating and Scrum, Mike Cohn, Prentice Hall.	
Learning Outcomes	1. Application of SE principles for AI and Data Sceince projects 2. How to work in self organzing teams 3. Use of tools and techniques for automating and managing software development	

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Elective Courses

Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-521 **Title of Course:** Natural Language Processing
Number of Credits: 4 (2L-0T-2P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Fundamentals of Artificial Intelligence; Mathematical Foundations for Artificial Intelligence. Machine Learning and Programming background. Introduction to NLP (Theory), Mathematical foundations for AI.	
Objectives	This course will focus on understanding the essentials of Natural Language Processing (NLP), areas in NLP, algorithms, and NLP tasks. Students who complete this course will gain a foundational understanding in natural language processing methods and strategies. They will also learn how to evaluate the strengths and weaknesses of various NLP technologies and frameworks as they gain practical experience in the NLP toolkits available.	

Content	Part I: Foundations of Natural Language Processing
	Introduction
	● Natural Language Processing - Problems and perspectives
	● Introduction/Recall to/of probability calculus
	    ○ N-grams and Language Models
	    ○ Markov Models
	● Introduction to Machine Learning and Deep Learning
	● Recurrent Neural Network Language Models
	● The evaluation of NLP applications
	Corpora
	● Corpora and their construction: representativeness
	● Concordances, collocations and measures of words association
	● Methods for Text Retrieval
	● Regular expressions
		8 hours

	Part II: Natural Language Processing
	● Computational Phonetics and Speech Processing
	    ○ Speech samples: properties and acoustic measures
	    ○ Analysis in the frequency domain, Spectrograms
	    ○ Applications in the acoustic-phonetic field.
	    ○ Speech recognition with HMM and Deep Neural Networks
	● Tokenisation and Sentence splitting
	● Computational Morphology
	    ○ Morphological operations
	    ○ Static lexica, Two-level morphology
	● Computational Syntax
	    ○ Part-of-speech tagging
	    ○ Grammars for natural language
	    ○ Natural language Parsing
	    ○ Supplementary worksheet: formal grammars for NL
		16 hours

	■ Formal languages and Natural languages. Natural language complexity ■ Phrase structure grammars, Dependency Grammars ■ Treebanks ■ Modern formalisms for parsing natural languages ● Computational Semantics ○ Lexical semantics: WordNet and FrameNet ○ Word Sense Disambiguation ○ Distributional Semantics & Word-Space models ○ Logical approaches to sentence semantics	
	Part III: Applications and Case studies: ● Solving Downstream Tasks: Document classification, Sentiment Analysis, Named Entity Recognition, Semantic Textual Similarity ● Prompting Pre-Trained Language Models ● Network Embedding	6 hours
	Sample list of Assignments and a Mini Project using all these functionalities Assignment -1 -Import nltk and download the 'stopwords' and 'punkt' packages. Assignment-2 -Import spacy and load the language model. Assignment -3 -How to tokenize a given text? Assignment-4 -How to get the sentences of a text document ? Assignment- 5-How to tokenize a text using the `transformers` package? Assignment -6 - How to tokenize text with stopwords as delimiters? Assignment- 7- How to remove stop words in a text?	20 * 2 = 40 hours + 20 hours (Mini Project)
	Assignment -8- How to add custom stop words in spaCy? Assignment- 9 -How to remove punctuations? Assignment-10 - How to perform stemming? Assignment -11 -How to lemmatize a given text? Assignment-12 -How to extract usernames from emails? Assignment -13-How to find the most common words in the text excluding stopwords Assignment -14- How to do spell correction in a given text? Assignment -15- How to tokenize tweets? Assignment -16- How to extract all the nouns in a text? Assignment -17- How to extract all the pronouns in a text? Assignment - 18 - How to find similarity between two words? Assignment -19- How to find similarity between two documents? Assignment -20 -How to find the cosine similarity of two documents?	

Pedagogy	Hands-on assignments/tutorials / peer-teaching / pair programming/presentations / mini-project. Lectures / Practical / tutorials / assignments / self-study / mini-project	
References/ Readings	1. Allen, James, Natural Language Understanding, Second Edition, Benjamin/Cumming, 1995. 2. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993. 3. Jurafsky, Dan and Martin, James, Speech and Language Processing, Second Edition, Prentice Hall, 2008. 4. Manning, Christopher and Heinrich, Schutze, Foundations of Statistical 5. Natural Language Processing, MIT Press, 1999. 6. Tamburini, F.. Neural Models for the Automatic Processing of Italian, Bologna: Pàtron. 2022 7. T. McEnery and A. Wilson. Corpus Linguistics, EUP. 2001 **8.** https://corpora.ficlit.unibo.it/NLP/ 9. https://www.machinelearningplus.com/nlp/nlp-exercises/ 10. Deep Learning by Goodfellow, Bengio, and Courville free online 11. Machine Learning — A Probabilistic Perspective by Kevin Murphy online 12. Natural Language Processing by Jacob Eisenstein free online Speech and Language Processing by Dan Jurafsky and James H. Martin (3rd ed. draft)	
Learning Outcomes	1. Learners will learn about the concepts in natural language processing. 2. Learners will have a fair idea of different areas in NLP 3. Learners will appreciate the complexities involved in natural language processing. 4. Through lectures and practical assignments, students will learn the necessary tricks for making their models work on practical problems. 5. They will learn how to contribute towards the development of NLP Resources and Tools.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-522 **Title of Course:** Computer Vision
Number of Credits: 4 (2L-0T-4P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Python programming, linear algebra and calculus , array manipulation	
Objectives	The aim of the course is to introduce the fundamental concept of computer vision and to emphasize the importance of computer vision in developing and implementing different	

	projects	
Theory:	Image Formation - Geometric Camera Models - Light and Shading - Color - Early Vision: Just One Image Linear Filters - Local Image Features - Texture - Early Vision: Multiple Images - Stereopsis - Structure from Motion - Mid-Level Vision Segmentation by Clustering - Grouping and Model Fitting- Tracking - High-Level Vision- Registration- Smooth Surfaces and Their Outlines - Range Data - Learning to Classify - Classifying Images Detecting Objects in Images- Topics in Object Recognition Applications Image-Based Modeling and Rendering - Looking at People- Image Search and Retrieval - Optimization Techniques	6 hours 6 hours 6 hours 6 hours 6 hours
Practical:	1. Open CV setup and demo on getting started up. 2. Image representation and image manipulation using open CV 3. Image storage and manipulation. 4. Photographs and perspective projections 5. Gaussian smoothings 6. Canny edge detection 7. Corner detection 8. Gabor filters 9. Hough transformation for lines 10. Hough transformation for circles	6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours 6 hours
Pedagogy:	lectures/Practical/ tutorials/assignments/self-study	
References/Readings:	1. Computer Vision: Algorithms And Applications by Richard Szeliski https://www5.cs.fau.de/lectures/ss-14/computer-vision-cv/mputer-vision-exercises/index.html Read more at: https://viso.ai/computer-vision/computer-vision-books/ 2. Computer Vision: Models, Learning, and Inference	

	Read more at: https://viso.ai/computer-vision/computer-vision-books/ 3. Modern Computer Vision with PyTorch by Yeshwanth Reddy and V Kishore Ayyadevara Read more at: https://viso.ai/computer-vision/computer-vision-books/ 4. Learning OpenCV 4 Computer Vision with Python 3 Read more at: https://viso.ai/computer-vision/computer-vision-books/	
Learning Outcomes:	Student will be able to 1. Acquire and process raw image data . 2. Relate image data to 3D scene structures . 3. Know the concepts behind and how to use several model-based object representations, and to critically compare them. 4. Know many of the most popularly used current computer vision techniques by carrying out suitable lab experiments listed above 6. Undertake computer vision work in MATLAB or python OpenCV	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-523 **Title of Course:** Robotics
Number of Credits: 4 (2L-0T-4P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Linear Algebra, Set Theory, Complex Analysis, Matrices	
Objectives	1. To summarize and analyze the fundamentals of robotics. 2. To introduce students the kinematics and dynamics of robots. 3. To elucidate students the types of motion control. 4. To familiarize students with the basic techniques of designing the robots.	
Theory:	**Module:1 Fundamentals** Introduction – Components, Degrees of Freedom, Joints, Coordinates, Mechanisms, Controller. **Module:2 Kinematics** Position and Orientation of Objects, Coordinate Transformation, Joint Variables and Position of End Effector, Inverse Kinematics Problem, Jacobian Matrix, Statics and Jacobian Matrices. **Module:3 Dynamics** Lagrangian and Newton-Euler Formulations, Derivation of Dynamics Equations Based on Lagrangian	5 hours 5 hours 5 hours

	Formulation, Derivation of Dynamic Equations Based on Newton-Euler, Formulation, Use of Dynamics Equations and Computational Load, Identification of Manipulator Dynamics. **Module:4 Manipulability** Manipulability Ellipsoid and Manipulability Measure, Best Configurations of Robotic Mechanisms from Manipulability Viewpoint, Various Indices of Manipulability, Dynamic Manipulability. **Module:5 Position Control** Generating a Desired Trajectory, Linear Feedback Control, Two-Stage Control by Linearization and Servo Compensation, Design and Evaluation of Servo Compensation, Decoupling Control, Adaptive Control. **Module:6 Force Control** Impedance Control - Passive-Impedance Method, Active-Impedance Method-One- Degree-of- Freedom Case, Active-Impedance Method-General Case. **Module:7 Hybrid Control** Hybrid Control - Hybrid Control via Feedback Compensation, Dynamic Hybrid Control.	5 hours 5 hours 3 hours 2 hours
Practical:	1. Assignment on introduction to Robot Configuration. 2. Demonstration of Robot with 2 dof, 3 dof, 4 dof etc. 3. Two assignments on programming the Robot for some simple real life applications. 4. Two assignments on programming the Robot for applications in Val II. 5. Two programming exercises for robots. 6. Two case studies of applications in industry. 7. Exercise on robotic simulation software. Note: Above practicals suggested considering availability of infrastructure and possible collaboration with other Engineering disciplines of Goa University)	5 hours 5 hours 10 hours 10 hours 10 hours 10 hours 10 hours
Pedagogy	Lectures/Practical/ Tutorials/Assignments	
References/ Readings	**Text Book(s)** 1. Tsuneo Yoshikawa, "Foundations of Robotics Analysis and Control", The MIT Press Cambridge, 1990. 2. Saeed B Niku, "Introduction to Robotics Analysis, Control, Applications", 3rd Edition, Wiley, 2020. **Reference Books** 1. Robert J. Schilling, "Fundamentals of Robotics, Analysis and Control", Prentice Hall India, 2003.	

	2. John J. Craig, “Introduction to Robotics, Mechanics and Control”, 3rd Edition, Pearson Prentice Hall, 2005.	
Learning Outcomes	After the completion of the course, student will be able to: 1. Comprehend, classify and analyze the fundamentals of robotics. 2. Analyze the kinematics in robots. 3. Gain knowledge about the dynamics of robots. 4. Elucidate the motion control in robotics.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-524 **Title of Course:** IoT Architecture and Protocols
Number of Credits: 4 (2L-0T-4P) **Contact Hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Internet Technologies, Computer Organization and architecture, Operating Systems.	
Objectives	To understand the fundamentals of Internet of Things and the protocols and standards designed for IoT	
Theory	Introduction to IoT: Introduction, IoT ecosystem, Applications, Challenges. Fundamentals: IoT Devices - Sensors, Actuators, and gateways, Basics of the wireless sensor network. IoT Architecture & Design: oneM2M, IoTWF, Additional Reference Models, Core functional stack, Data Management and compute stack. Communicating smart objects: Communication criteria, communication models, IoT access technologies – 3GPP MTC, IEEE 802.11, IEEE 802.15, WirelessHART, ZWave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 IoT Network Layer: IP as IoT network layer, IPv6, 6LoWPAN, 6TiSCH, RPL, CORPL, CARP IoT Transport and Application protocols: Transport Layer: TCP, UDP, DCCP, SCTP, TLS, DTLS IoT application transport methods, HTTP, CoAP, XMPP, MQTT, AMQP, DDS Security in IoT: MAC802.15.4, 6LoWPAN, RPL, Application Layer security. IoT Application case study: Discuss any 3 applications of IoT	2 hours 4 hours 4 hours 8 hours 3 hours 3 hours 3 hours 3 hours
Practical:	1. Smart Agriculture System 2. Weather Reporting System	20 * 3 = 60 hours

	3. Home Automation System 4. Face Recognition Bot 5. Smart Garage Door 6. Smart Alarm Clock 7. Air Pollution Monitoring System 8. Smart Parking System 9. Smart Traffic Management System 10. Smart Cradle System 11. Smart Gas Leakage Detector Bot 12. Streetlight Monitoring System 13. Smart Anti-Theft System 14. Liquid Level Monitoring System 15. Night Patrol Robot 16. Health Monitoring System 17. Smart Irrigation System 18. Flood Detection System 19. Mining Worker Safety Helmet 20. Smart Energy Grid	
Pedagogy	lectures/ tutorials/Hands-on assignments/self-study	
References/ Readings	1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, CISCO Press, 2017 2. Hersent, Olivier, David Boswarthick, and Omar Elloumi, The internet of things: Key applications and protocols. John Wiley & Sons, 2011. 3. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and Paradigms. Elsevier, 2016.	
Learning Outcomes	After completing the course, students will be able to: 1. Understand the concepts of the IoT Architecture Reference model 2. Identify the IoT networking components and protocols.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-525 **Title of Course:** Machine Translation
Number of Credits: 4 (2L-0T-2P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Knowledge of Mathematics for Computer Science and Machine Learning will prove beneficial, A previous course on Artificial Intelligence and Natural Language Processing will help; Exposure to Linguistics is useful, though not mandatory	

Objectives:	The objective of the course is to understand and get an insight into the different approaches used for Machine Translation (MT).	
Content:	Introduction: Data-driven MT, MT Approaches, Language divergence, three major paradigms of MT, MT Evaluation,	8 hours
	Bilingual Word Mappings: Combinatorial Argument, One-to-One Alignment, Heuristic and Iterative bases computation, Mathematics of Alignment, Expectation Maximization, IBM models of Alignment	4 hours
	Phrase-Based Machine Translation (PBMT): Need, Examples, Phrase Table, Mathematics of Phrase-Based SMT, Decoding.	10 hours
	Rule-Based Machine Translation (RBMT): Kinds, UNL, Interlingua and Word Knowledge, UNL conversion, Transfer-based MT.	5 hours
	Example-Based Machine Translation (EBMT): Essential steps of EBMT, Text similarity computation, Translation memory, Statistical Machine Translation	3 hours
	Practical	
	Assignment 1: Data-driven MT, MT Approaches, Language divergence, three major paradigms of MT, MT Evaluation,	16 hours
	Assignment 2: Bilingual Word Mappings: Combinatorial Argument, One-to-One Alignment, Heuristic and Iterative bases computation, Mathematics of Alignment, Expectation Maximization, IBM models of Alignment	8 hours
	Assignment 3: Phrase-Based Machine Translation (PBMT): Need, Examples, Phrase Table, Mathematics of Phrase-Based SMT, Decoding.	20 hours
	Assignment 4: Rule-Based Machine Translation (RBMT): Kinds, UNL, Interlingua and Word Knowledge, UNL conversion, Transfer-based MT.	10 hours
	Assignment 5: Example-Based Machine Translation (EBMT): Essential steps of EBMT, Text similarity computation, Translation memory, Statistical Machine Translation	6 hours
Pedagogy:	lectures/ tutorials/assignments/self-learning/ flipped classroom	
References/ Readings	1. Machine Translation by Pushpak Bhattacharyya, Chapman and Hall/CRC, February 2015 2. Machine Translation on Coursera by Prof. Alexander Waibel and Jan Niehues https://www.coursera.org/learn/machinetranslation 3. An Open Source Neural Machine Translation System https://opennmt.net/ 4. Bhashini Project – https://bhashini.gov.in/bhashadaan/en/likho-india	
Learning Outcomes	After completion of this course, students will - • Understand the Machine Translation Approaches	

	• Understand the differences between Phrase-Based, Rule-Based, and Example-Based Machine Translation • explain, apply, and assess evaluation methods for machine translation; • describe and critically discuss the architecture of machine translation systems; • build their own translation model using existing tools for machine translation and evaluate and analyse the translation results; • compare different types of machine translation strategies, such as rule-based, statistical, and neural machine translation; • implement components of machine translation systems or components used in evaluation or pre-processing

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-526 **Title of the Course:** Mathematics for Computer Vision and Robotics
Number of Credits: 4(2L+0T+4P) **Contact hours:** 90 hours(30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Linear Algebra, Probability and Statistics, Signal Processing	
Objectives	To understand basic concepts of linear algebra and to illustrate its power and utility through applications to computer vision. To apply the concepts of vector spaces, linear transformations, matrices and inner product spaces in engineering. To understand the concepts of curves and surfaces and solving linear programming problems that arise in engineering.	
Theory:	Vectors and Matrices Points, vectors, vector spaces(Rn only), lines and planes as subspaces -Matrices and four fundamental spaces-Gaussian elimination. Factorization of Matrices LU factorizations-Cholesky decomposition –eigenvalues and eigenvectors-–SVD - Applications of the SVD .-Solving Linear Systems and the Pseudoinverse -Principal Components Analysis (PCA) Linear transformations Linear transformations(R^n only) – Basic properties-invertible linear transformation - matrices of linear transformations. Geometry in Linear Transformation Projections, Rotations and reflection and applications Orthogonality Dot products and inner products(R^n only) – lengths and angles of vectors –orthogonal matrices- Gram Schmidt orthogonalizations - QR factorization- orthogonal projections–Least Square solutions Differential geometry Introduction to differential geometry - curves-curvature-torsion-osculating plane –surfaces Linear programming Linear programming – Formulation of LPP-Graphical method - Simplex method	3 hours 6 hours 6 hours 6 hours 3 hours 3 hours 3 hours

Practical:	Assignment 1- Getting to Know the Python math Module, Constants of the math Module:Pi, Tau, Euler's Number, Infinity, Not a Number (NaN) and Arithmetic Functions,Find Factorials With Python factorial(), Find the Ceiling Value With ceil(), Find the Floor Value With floor(), Truncate Numbers With trunc(), Find the Closeness of Numbers With Python isclose() Assignment-2 - Power Functions, Calculate the Power of a Number With pow(),Find the Natural Exponent With exp(),Practical Example With exp(),Logarithmic Functions, Python Natural Log With log(),Understand log2() and log10(), Practical Example With Natural Log Assignment-3 -Other Important math Module Functions, Calculate the Greatest Common Divisor, Calculate the Sum of Iterables, Calculate the Square Root, Convert Angle Values, Calculate Trigonometric Values Assignment -4 -New Additions to the math Module in Python 3.8.cmath vs math, NumPy vs math, Assignment -5 -Calculating combinations and permutations using factorials,Calculating the height of a pole using trigonometric functions, Calculating radioactive decay using the exponential function, Calculating the curve of a suspension bridge using hyperbolic functions, Solving quadratic equations Assignment - 6 -Simulating periodic functions, such as sound and light waves, using trigonometric functions, Assignment -7 -Vector algebra in python, Physical Quantities, Vector and Scalars, Representation of vectors, Types of Vectors, Operations on Vectors, Section Formula, Concept of Euclidean Distance between two vectors,	10 hours 10 hours 10 hours 5 hours 10 hours 5 hours 10 hours
Pedagogy	Lectures/ Lab Assignments/ Seminar Presentations /Project Work	
References/ Readings	1. Linear Algebra, Jin Ho Kwak and Sungpyo Hong, Second edition Springer, 2004. 2. Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong,Cambridge University Press, 2020. 3. Operations Research principles and applications, G.Srinivasan, 3rd edition, PHI learning, 2017, 4. Differential Geometry of Curves and Surfaces: Revised and	

	Updated Second Edition, Manfredo P. do Carmo, Dover publications 2016. 5. Linear Algebra and Optimization with Applications to Machine Learning - Volume I. 6. Linear Algebra for Computer Vision, Robotics, and Machine Learning, Jean H. Gallier, Jocelyn Quaintance, World Scientific Publishing Company, 2020. 7. Basics of Matrix Algebra for Statistics with R, Nick Fieller, CRC press, 2016. 8. Introduction to Linear Algebra, Gilbert Strang, 5th Edition, Cengage Learning (2015). 9. Modern Mathematics And Applications In Computer Graphics And Vision, Hongyu Guo, World scientific publishing company,2014. 10. Computer Vision: A Modern Approach, Forsyth and Ponce, 2nd Edition Pearson 2012.	
Learning Outcomes	At the end of this course the students are expected to learn 1. The abstract concepts of matrices and system of linear equations using decomposition methods and applications in engineering 2. Understand the geometry behind linear transforms which is used in computer graphics 3. Understand the concepts of orthogonality through linear algebra 4. Understating properties curves and surfaces 5. Solving linear programming problems arise in engineering 6. Solving problems in Linear algebra, linear programming and differential geometry using matplotlib or Python.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-527 **Title of the Course:** Soft Computing
Number of Credits: 4 (2L+0T+4P) **Contact hours:** 90 hours (30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Machine Learning, Statistics	
Objectives	The objective of this course is to introduce methods for handling imprecise and uncertain data using Rough sets, Neuro Fuzzy Systems and foster their abilities in designing and implementing optimal solutions for real-world and engineering problems using derivative free optimization techniques.	
Content	**Introduction to Soft Computing** Soft Computing Overview – Uncertainty in data, Hard vs Soft Computing **Neural Networks**	3 hours 2 hours

	Introduction, RBF Networks, Self-Organizing Map, Boltzmann Machines, Convolutional Neural Networks. **Fuzzy Systems** Fuzzy Sets, Fuzzy Relations, and Membership functions, Properties of Membership functions, Fuzzification and Defuzzification. **Fuzzy logic** Fuzzy Rule based systems, Fuzzy Decision making, Fuzzy Classification, Fuzzy CMeans Clustering. **Rough Sets** Rough Sets – Definition, Upper and Lower Approximations, Boundary Region, Decision Tables and Decision Algorithms. Properties of Rough Sets. Rough K-means clustering, Rough **Optimization Techniques** Introduction, Genetic Algorithm, Memetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization, Frog-Leaping. **Hybrid Systems** GA Based Back Propagation Networks, Fuzzy Back Propagation Networks, Evolutionary Ensembles	5 hours 5 hours 5 hours 5 hours 5 hours
Practical:	**List of Experiments:** 1. To demonstrate the working of Hebbian learning rule 2. To demonstrate the working of perceptron learning rule 3. To demonstrate the working of Delta learning rule 4. To demonstrate the working of Widrow-Hoff learning rule 5. To demonstrate the working of Radial basis function network 6. To demonstrate the working of Learning vector quantization 7. To demonstrate the working of Self-Organizing maps 8. To demonstrate the working of Recurrent neural networks 9. To demonstrate the working of Fuzzy inference system 10. To demonstrate the working of Genetic algorithm 11. To demonstrate the working of Particle Swarm Optimization 12. To demonstrate the working of Ant Colony Optimizations and TSP	12 * 5 = 60 hours
Pedagogy	Lectures / Assignments / Quiz / Mini Project / Seminar Presentations	

References/ Readings	**Main Readings** 1. S.N. Sivanandham and S.N.Deepa, "Principles of Soft Computing", 2nd Edition, Wiley Publications. 2. Andries P. Engelbrecht, "Computational Intelligence: An Introduction", John Wiley & Sons, 2007. 3. Laurene V. Fausett "Fundamentals of Neural Networks: Architectures, Algorithms And Applications", Pearson, 1993. 4. Simon Haykin "Neural Networks and Learning Machines" Prentice Hall, 2008. Timothy Ross, "Fuzzy Logic with Engineering Applications", Third Edition,Wiley.	
Learning Outcomes	After successfully completing the course the student should be able to: 1. Have a general understanding of soft computing methodologies, to deal with imprecise and uncertain data 2. Develop computational neural network models for some simple biological systems; 3. Develop fuzzy models for engineering systems, particularly for control systems; 4. Apply derivative free optimization methods to solve real world problems 5. Demonstrate some applications of computational intelligence.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-528 **Title of the Course:** Regression Analytics and Predictive Models
Number of Credits: 4 (2L+0T+4P) **Total Contact Hours:** 90 hours(30L+0T+60P)
Effective from AY: 2023-24

Prerequisites for the course	Probability Theory and Distributions	
Objectives	• Develop an understanding of regression analysis and model building. • Provide the ability to develop relationship between variables • Investigate possible diagnostics in regression techniques • Formulate feasible solutions using a regression model for real-life problems.	
Theory:	**Simple Regression Analysis** Introduction to a linear and nonlinear model. Ordinary Least Square methods. Simple linear regression model, using simple regression to describe a linear relationship. Fitting a linear trend to time series data, Validating simple regression model using t, F and p test. Developing confidence interval. Precautions in interpreting regression results. **Multiple Regression Analysis** Concept of Multiple regression model to describe a linear	4 hours 4hours

	relationship, Assessing the fit of the regression line, inferences from multiple regression analysis, problem of overfitting of a model, comparing two regression model, prediction with multiple regression equation.	4 hours
	Fitting Curves and Model Adequacy Checking Introduction, fitting curvilinear relationship, residual analysis, PRESS statistics, detection and treatment of outliers, lack of fit of the regression model, test of lack of fit, Problem of autocorrelation and heteroscedasticity. Estimation of pure errors from near neighbors.	4 hours
	Transformation techniques Introduction, variance stabilizing transformations, transformations to linearize the model, Box Cox methods, transformations on the repressors variables, Generalized and weighted least squares, Some practical applications.	4 hours
	Multicollinearity Introduction, sources of multicollinearity, effects of multicollinearity. Multicollinearity diagnostics: examination of correlation matrix, variance Inflation factors (VIF), Eigen system analysis of X1X. Methods of dealing with Multicollinearity: collecting additional data, model re-specification, and ridge regression.	4 hours
	Generalized Linear Models Generalized linear model: link functions and linear predictors, parameter estimation and inference in the GLM, prediction and estimation with the GLM, Residual Analysis, and concept of over dispersion.	6 hours
	Model building and Nonlinear Regression Variable selection, model building, model misspecification. Model validation techniques: Analysis of model coefficients, and predicted values, data splitting method. Nonlinear regression model, nonlinear least squares, transformation to linear model, parameter estimation in nonlinear system, statistical inference in nonlinear regression.	

Practical:	1. Linear Regression 2. Minimum Least Square Method 3. Calculating coefficients values 4. Ascombe's Quartet 5. Regression Equations- x on y & y on x 6. Predicting mom's height based on daughter's height 7. Regression-Solved problem-2 8. Probable Error- Calculating correlation coefficient of POPULATION 9. Predictive modelling project for credit card fraud detection 10. Predictive modelling project for customer value prediction 11. Predictive modelling project for stock market forecasting 12. Predictive modelling project for corporate bankruptcy prediction	12 * 5 = 60 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining, Introduction to Linear Regression Analysis, Third Ed., Wiley India Pvt. Ltd., 2016. Norman R. 2. Draper, Harry Smith; Applied Regression Analysis, WILEY India Pvt. Ltd. New Delhi; Third Edition, 2015. 3. Johnson, R A., Wichern, D. W., Applied Multivariate Statistical Analysis, Sixth Ed., PHI learning Pvt., Ltd., 2013. 4. Iain Pardoe, Applied Regression Modeling, John Wiley and Sons, Inc, 2012.	
Learning Outcomes	At the end of the course students will be able to: ● Develop in-depth understanding of the linear and nonlinear regression model. ● Demonstrate the knowledge of regression modeling and model selection techniques. ● Examine the relationships between dependent and independent variables. ● Estimate the parameters and fit a model. ● Investigate possible diagnostics in regression modeling and analysis. ● Validate the model using hypothesis testing and confidence interval approach. ● Understand the generalizations of the linear model to binary and count data.	

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Programme: M.Sc. in Artificial Intelligence
Course Code: CSI-529 **Title of the Course:** Essentials of Data Analytics
Number of Credits: 4(2L+0T+4P) **Contact hours:** 90 hours(30L-0T-60P)
Effective from AY: 2023-24

Prerequisites for the course	Probability and Statistics	
Objectives	1. To understand the concepts of analytics using various machine learning models. 2. To appreciate supervised and unsupervised learning for predictive analysis. 3. To understand data analytics as the next wave for businesses looking for competitive advantage. 4. Carry out rule-based analysis of the data in line with the analysis plan. 5. Validate the results of their analysis according to statistical guidelines. 6. Validate and review data accurately and identify anomalies. 7. To learn aspects of computational learning theory. 8. Apply statistical models to perform Regression Analysis, Clustering and Classification.	

Theory:	**Module:1** Regression Analysis Linear regression: simple linear regression - Regression Modelling - Correlation, ANOVA, Forecasting, Autocorrelation **Module:2** Classification Logistic Regression, Decision Trees, Naïve Bayes-conditional probability - Random Forest - SVM Classifier **Module:3** Clustering K-means, K-medoids, Hierarchical clustering **Module:4** Optimization Gradient descent - Variants of gradient descent - Momentum - Adagrad - RMSprop - Adam - AMSGrad **Module:5** case study -Managing Health and Safety Comply with organization's current health, safety and security policies and procedures - Report any identified breaches in health, safety, and security policies and procedures to the designated person - Identify and correct any hazards that they can deal with safely, competently and within the limits of their authority - Report any hazards that they are not competent to deal with to the relevant person in line with organizational procedures and warn other people who may be affected. **Module:6- requirement analysis -** Data and Information Management Establish and agree with appropriate people the data/information they need to provide, the formats in which they need to provide it, and when they need to provide it - Obtain the data/information from reliable sources - Check that the data/information is accurate, complete and up-to-date **Module:7** Learning and Self Development Obtain advice and guidance from appropriate people to develop their knowledge, skills and competence - Identify accurately the knowledge and skills they need for their job role - Identify accurately their current level of knowledge, skills and competence and any learning and development needs - Agree with appropriate people a plan of learning and development activities to address their learning needs	5 hours 5 hours 5 hours 5 hours 5 hours 3 hours 2 hours
Practical:	1. Web Scraping:- a. While you'll find no shortage of excellent (and free) public data sets on the internet, you might want to show prospective employers that you're able to find and scrape your own data as well. Plus, knowing how to scrape web data means you can find and use data sets that match your interests, regardless of whether or not they've already been compiled. b. If you know some Python, you can use tools like Beautiful Soup or Scrapy to crawl the web for interesting data. If you don't know how to code, don't worry. You'll also find several tools that automate the process (many offer a free trial), like Octoparse or ParseHub.	5 * 12 = 60 hours

	c. If you're unsure where to start, here are some websites with interesting data options to inspire your project: d. Reddit, Wikipedia, Job portals 2. Data Cleaning a. A significant part of your role as a data analyst is cleaning data to make it ready to analyze. Data cleaning (also called data scrubbing) is the process of removing incorrect and duplicate data, managing any holes in the data, and making sure the formatting of data is consistent. b. As you look for a data set to practice cleaning, look for one that includes multiple files gathered from multiple sources without much curation. Some sites where you can find "dirty" data sets to work with include: c. CDC Wonder, Data.gov, World Bank, Data.world/r/datasets 3. Exploratory data analysis (EDA) a. Data analysis is all about answering questions with data. Exploratory data analysis, or EDA for short, helps you explore what questions to ask. This could be done separate from or in conjunction with data cleaning. Either way, you'll want to accomplish the following during these early investigations. b. Ask lots of questions about the data. c. Discover the underlying structure of the data. d. Look for trends, patterns, and anomalies in the data. e. Test hypotheses and validate assumptions about the data. f. Think about what problems you could potentially solve with the data. 4. Sentiment analysis a. Sentiment analysis, typically performed on textual data, is a technique in natural language processing (NLP) for determining whether data is neutral, positive, or negative. It may also be used to detect a particular emotion based on a list of words and their corresponding emotions (known as a lexicon). b. This type of analysis works well with public review sites and social media platforms, where people are likely to offer public opinions on various subjects.	

	c. To get started exploring what people feel about a certain topic, you can start with sites like: Amazon (product reviews), Rotten Tomato (movie reviews), Facebook witter, News sites 5. Data visualization a. Humans are visual creatures. This makes data visualization a powerful tool for transforming data into a compelling story to encourage action. Great visualizations are not only fun to create, they also have the power to make your portfolio look beautiful.	
Pedagogy	Lectures/Assignments/Seminar Presentations/Mini-Project	
References/ Readings	1.Cathy O'Neil and Rachel Schutt. "Doing Data Science, Straight talk from the Frontline",O'Reilly. 2014. 2.Dan Toomey, "R for Data Science", Packt Publishing, 2014. 3.Trevor Hastie, Robert Tibshirani and Jerome Friedman. "Elements of Statistical Learning",Springer , Second Edition. 2009. 4.Kevin P. Murphy. "Machine Learning: A Probabilistic Perspective", MIT Press; 1st Edition, 2012. **Reference Books** Glenn J. Myatt, "Making Sense of Data: A Practical Guide to Exploratory Data Analysis and Data Mining", John Wiley & Sons, Second Edition, 2014. G. K. Gupta, —Introduction to Data Mining with Case Studies", Easter Economy Edition, Prentice Hall of India, 2006. Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2007. Colleen Mccue, "Data Mining and Predictive Analysis: Intelligence Gathering and Crime Analysis", Elsevier, 2007. R N Prasad, Seema Acharya, "Fundamentals of Business Analytics", Wiley; Second edition, 2016. https://www.sscnasscom.com/qualification-pack/SSC/Q2101/ Mode of Evaluation: ISA/Assignment / Quiz / Project / Seminar	
Learning Outcomes	1. Identify and apply the appropriate supervised learning techniques to solve real world problems with labeled data. 2. Choose and implement typical unsupervised algorithms for different types of applications with unlabelled data. 3. Implement statistical analysis techniques for solving practical problems. 4. Understand different techniques to optimize the learning algorithms.	

	5. Aware of health and safety policies followed in organization, data and information management and knowledge & skill development.	

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