MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

(Autonomous)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

B. TECH DEGREE PROGRAMME

IN

COMPUTER SCIENCE AND ENGINEERING (Artificial Intelligence)

For the students admitted from 2022-23

Scheduling of Courses

i) Knowledge Segments and Credits

Every course of B. Tech Programme is placed in one of the nine categories as listed in table below. No semester shall have more than six lecture-based courses and two laboratory courses, and/ordrawing/seminar/project courses in the curriculum.

Table 1: Credit distribution and the Knowledge Domains

Sl. No.	Category	Category Code	Total credits
1	Humanities and Social Sciences including Management Courses	HSC	5
2	Basic Science Courses	BSC	26
3	Engineering Science Courses	ESC	22
4	Programme Core Courses, Comprehensive Course Work and Viva Voce	PCC	79
5	Programme Elective Courses	PEC	15
6	Open Elective Courses	OEC	03
7	Project Work and Seminar	PWS	10
8	Mandatory Non-credit Courses (P/F) with Grade	MNC	Non-Credit
9	Mandatory Student Activities (P/F)	MSA	2
Total Mandatory Credits			**162**

ii) Semester-wise Credit Distribution

Semester	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*Total*
Credits for Courses	20	18	22	22	24	22	15	17	**160**
Activity Points (Min.)	40				60				**100**
Credits for Activities	2								**2**
Total Credits									**162**

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CURRICULUM AND DETAILED SYLLABI (S5 and S6)

SEMESTER V						
Slot	**Category Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PCC	CS1U30A	Formal Languages and Automata Theory	3-1-0	4	4
B	PCC	CS1U30B	Computer Networks	3-1-0	4	4
C	PCC	CS1U30K	Operating Systems	3-1-0	4	4
D	PCC	CS2U30C	Introduction to Machine Learning	3-1-0	4	4
E	PCC	CS2U30D	Artificial Neural Network	3-1-0	4	4
F	MNC	NC0U30A	Disaster Management	2-0-0	2	---
S	PCC	CS2U38A	Operating Systems and Networking Lab	0-0-4	4	2
T	PCC	CS2U38B	Machine Learning Lab	0-0-4	4	2
R/M/H	VAC		Remedial/Minor/Honours	3-1-0	4	4
TOTAL					**30/34**	**24/28**

SEMESTER VI						
Slot	**Category Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PCC	CS2U30E	Robotics and Intelligent System	3-1-0	4	4
B	PCC	CS1U30H	Algorithm Analysis and Design	3-1-0	4	4
C	PCC	CS1U30E	Management of Software Systems	3-0-0	3	3
D	PEC	CS2UXXX	Program elective I	2-1-0	3	3
E	HSC	HS0U30A	Industrial Economics & Foreign Trade	3-0-0	3	3
F	PCC	CS2U30I	Comprehensive Course Work	1-0-0	1	1
S	PCC	CS2U38C	Robotics Lab	0-0-3	3	2
T	PWS	CS2U39A	Mini Project	0-0-3	3	2
R/M/H	VAC		Remedial/Minor/Honours	3-1-0	4	4
TOTAL					**24/28**	**22/26**

PROGRAMME ELECTIVE I

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
D	PEC	CS1U31C	Foundations of security in computing	2-1-0	3	3
		CS1U31G	Applied Data Science with Python Industry elective	2-0-2	4	3
		CS2U31A	Concepts in computer graphics and image processing	2-1-0	3	3
		CS2U31B	Object Oriented Programming using Java	2-1-0	3	3
		CS2U31C	Machine Learning models and Storage Management	2-1-0	3	3

Minors

Semester	BASKET I SOFTWARE ENGINEERING				BASKET II MACHINE LEARNING				BASKET III NETWORKING			
	Course Number	Course	L-T-P	Credit	Course Number	Course	L-T-P	Credit	Course Number	Course	L-T-P	Credit
S3	CS0M 20A	Object Oriented Programming	3-1-0	4	CS0M 20B	Python for Machine Learning	3-1-0	4	CS0M 20C	Data Communication	3-1-0	4
S4	CS0M 20D	Programming Methodologies	3-1-0	4	CS0M 20E	Mathematics for Machine Learning	3-1-0	4	CS0M 20F	Introduction to Computer Networks	3-1-0	4
S5	CS0M 30A	Concepts in Software Engineering	3-1-0	4	CS0M 30B	Concepts in Machine Learning	3-1-0	4	CS0M 30C	Client Server Systems	3-1-0	4
S6	CS0M 30D	Introduction to Software Testing	3-1-0	4	CS0M 30E	Concepts in DeepLearning	3-1-0	4	CS0M 30F	Wireless Networks and IoT Applications	3-1-0	4
S7	CS0M 49A	Mini Project	0-1-6	4	CS0M 49A	Mini Project	0-1-6	4	CS0M 49A	Mini Project	0-1-6	4
S8	CS0M 49B	Mini Project	0-1-6	4	CS0M 49B	Mini Project	0-1-6	4	CS0M 49B	Mini Project	0-1-6	4

Honours

Semester	BASKET I				BASKET II				BASKET III			
	SECURITY IN COMPUTING				COMPUTATIONAL BIOLOGY				COMPUTER VISION			
	Course Number	Course	L-T-P	Credit	Course Number	Course	L-T-P	Credit	Course Number	Course	L-T-P	Credit
S4	CS1H20A	Number Theory	3-1-0	4	CS2H20A	Computational Fundamentals for Bioinformatics	3-1-0	4	CS2H20B	Advanced Topics in Computer Graphics	3-1-0	4
S5	CS1H30A	Cryptographic Algorithms	3-1-0	4	CS2H30A	ComputationalBiology	3-1-0	4	CS2H30B	Advanced Concepts In Computer Vision	3-1-0	4
S6	CS1H30D	Network Security	3-1-0	4	CS2H30C	Machine Learning In Computational Biology	3-1-0	4	CS2H30D	Image AndVideo Processing	3-1-0	4
S7	CS1H40A	Cyber Forensics	3-1-0	4	CS2H40A	Computational Health Informatics	3-1-0	4	CS2H40B	Surveillance Video Analytics	3-1-0	4
S8	CS1H49A	Mini Project	0-1-6	4	CS2H49A	Mini Project	0-1-6	4	CS2H49A	Mini Project	0-1-6	4

SEMESTER V

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
CS1U30A	Formal Languages and Automata Theory	PCC	3	1	0	4	2022

COURSE OVERVIEW

This is a core course in theoretical computer science. It covers automata and grammar representations for languages in Chomsky Hierarchy. For regular languages, it also covers representations using regular expression and Myhill-Nerode Relation. The topics covered in this course have applications in various domains including compiler design, decidability and complexity theory, software testing, formal modelling and verification of hardware and software.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Classify a given formal language into Regular, Context-Free, Context Sensitive, Recursive or Recursively Enumerable.	**Understand**
CO 2	Explain a formal representation of a given regular language as a finite state automaton, regular grammar, regular expression and Myhill-Nerode relation.	**Understand**
CO 3	Design a Pushdown Automaton and a Context-Free Grammar for a given context-free language	**Apply**
CO 4	Design Turing machines as language acceptors or transducers	**Apply**
CO 5	Explain the notion of decidability.	**Understand**

SYLLABUS

Introduction to Automata Theory, Structure of an automaton, classification of automata, grammar and automata for generating each class of formal languages in the Chomsky Hierarchy, decidability and Halting problem.

TEXT BOOKS

1. Dexter C. Kozen, Automata and Computability, Springer (1999)

REFERENCES

1. John E Hopcroft, Rajeev Motwani and Jeffrey D Ullman, Introduction to Automata Theory, Languages and Computation, 3/e Pearson Education, 2007.

2. Michael Sipser, Introduction To Theory of Computation, Cengage Publishers, 2013.

COURSE PLAN

Module	Contents	Hours
I	Introduction to formal language theory– Alphabets, Strings, Concatenation of strings, Languages. Regular Languages - Deterministic Finite State Automata (DFA) (Proof of correctness of construction not required), Nondeterministic Finite State Automata (NFA), Equivalence of DFA and NFA, Regular Grammar (RG), Equivalence of RGs and DFA.	**13**
II	More on Regular Languages Regular Expression (RE), Equivalence of REs and DFA, Homomorphisms, Necessary conditions for regular languages, Closure Properties of Regular Languages, DFA state minimization (No proof required)	**12**
III	Myhill-Nerode Relations and Context Free Grammars Myhill-Nerode Relations (MNR)- MNR for regular languages, MyhillNerode Theorem (MNT) (No proof required), Applications of MNT.Context Free Grammar (CFG)- CFG representation of Context Free Languages (proof of correctness is required), derivation trees and ambiguity, Normal forms for CFGs	**11**
IV	More on Context-Free Languages Nondeterministic Pushdown Automata (PDA), Deterministic Pushdown Automata (DPDA), Equivalence of PDAs and CFGs (Proof not required), Pumping Lemma for Context-Free Languages (Proof not required), Closure Properties of Context Free Languages. Context Sensitive Grammar (CSG), Linear Bounded Automata. (Concept only).	**12**
V	Context Sensitive Languages, Turing Machines Context Sensitive Languages - Context Sensitive Grammar (CSG), Linear Bounded Automata.Turing Machines - Standard Turing Machine, Robustness of Turing Machine, Universal Turing Machine, Halting Problem, Recursive and Recursively Enumerable Languages. Chomsky classification of formal languages.	**12**
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
CS1U30B	Computer Networks	PCC	3	1	0	4	2022

COURSE OVERVIEW

The course provides the learners a clear understanding of how computer networks from local area networks to the massive and global Internet are built, how they allow computers to share information and communicate with one another. This course covers the physical aspects of computer networks, layers of OSI Reference model, and inter-networking. The course helps the learners to compare and analyze the existing network technologies and choose a suitable network design for a given system.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the features of computer networks, protocols, and network design models	**Understand**
CO 2	Describe the fundamental characteristics of the physical layer and identify the usage in network communication	**Apply**
CO 3	Explain the design issues of data link layer, link layer protocols, bridges and switches	**Understand**
CO 4	Illustrate wired LAN protocols (IEEE 802.3) and wireless LAN protocols (IEEE 802.11)	**Understand**
CO 5	Select appropriate routing algorithms, congestion control techniques, and Quality of Service requirements for a network	**Apply**
CO 6	Illustrate the functions and protocols of the network layer, transport layer, and application layer in inter-networking	**Understand**

SYLLABUS

TEXT BOOKS

1.Andrew S. Tanenbaum, Computer Networks, 4/e, PHI (Prentice Hall India).
2. Behrouz A Forouzan, Data Communication and Networking, 4/e, Tata McGraw Hill

REFERENCES

. 1.Larry L Peterson and Bruce S Dave, Computer Networks – A Systems Approach, 5/e,

Morgan Kaufmann.
2. Fred Halsall, Computer Networking and the Internet, 5/e.
3. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6/e.
4. Keshav, An Engineering Approach to Computer Networks, Addison Wesley, 1998.
5. W. Richard Stevens. TCP/IP Illustrated Volume 1, Addison-Wesley, 2005.
6. William Stallings, Computer Networking with Internet Protocols, Prentice-Hall, 2004.
7. Request for Comments (RFC) Pages - IETF -https://www.ietf.org/rfc.html

COURSE PLAN

Module	Contents	Hours
I	**Introduction** – Uses of computer networks, Network hardware, Network software. Reference models – The OSI reference model, The TCP/IP reference model, Comparison of OSI and TCP/IP reference models. Physical Layer – Modes of communication, Physical topologies, Signal encoding, Repeaters and hub, Transmission media overview. Performance indicators – Bandwidth, Throughput, Latency, Queuing time, Bandwidth–Delay product.	**12**
II	**Data link layer** - Data link layer design issues, Error detection and correction, Sliding window protocols, High-Level Data Link Control(HDLC)protocol. Medium Access Control (MAC) sublayer –Channel allocation problem, Multiple access protocols, Ethernet, Wireless LANs - 802.11, Bridges & switches - Bridges from 802.x to 802.y, Repeaters, Hubs, Bridges, Switches, Routers and Gateways.	**12**
III	**Network layer** : design issues. Routing algorithms - The Optimality Principle, Shortest path routing, Flooding, Distance Vector Routing, Link State Routing, Multicast routing, Routing for mobile hosts. Congestion control algorithms. Quality of Service (QoS) - requirements, Techniques for achieving good QoS.	**12**
IV	IP protocol, IP addresses, Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP), Bootstrap Protocol (BOOTP), Dynamic Host Configuration Protocol (DHCP). Open Shortest Path First(OSPF) Protocol, Border Gateway Protocol (BGP), Internet multicasting, IPv6, ICMPv6.	**12**
V	Transport service – Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP). Transmission Control Protocol (TCP) – Overview of TCP, TCP segment header, Connection establishment &release, Connection management modeling, TCP retransmission policy, TCP congestion control. Application Layer –File Transfer Protocol (FTP), Domain Name System (DNS), Electronic mail, Multipurpose Internet Mail Extension (MIME), Simple Network Management Protocol (SNMP), World Wide Web(WWW) – Architectural overview.	**12**
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
CS1U30K	**Operating Systems**	**PCC**	**3**	**1**	**0**	**4**	**2022**

PRE-REQUISITE: CS1U20A Data Structures and ES0U10G Problem Solving and Programming in C

COURSE OVERVIEW: Study of operating system is an essential to understand the overall working of computer system, tradeoffs between performance and functionality and the division of jobs between hardware and software. This course introduces the concepts of memory management, device management, process management, file management and security & protection mechanisms available in an operating system. The course helps the learner to understand the fundamentals about any operating system design so that they can extend the features of operating system to detect and solve many problems occurring in operating system and to manage the computer resources appropriately.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the relevance, structure and functions of Operating Systems in computing devices.	Understand
CO 2	Apply the concepts of process management and process scheduling mechanisms employed in Operating Systems.	Apply
CO 3	Explain process synchronization in Operating Systems and illustrate process synchronization mechanisms using Mutex Locks, Semaphores and Monitors.	Understand
CO 4	Explain different methods for detection, prevention, avoidance and recovery for managing deadlocks in Operating Systems.	Understand
CO 5	Illustrate and examine the memory management algorithms in Operating Systems.	Apply
CO 6	Explain the security aspects and algorithms for file and storage management in Operating Systems.	Understand

SYLLABUS

Introduction: Functions of an operating system-overview. Kernel Data Structures-Operating System Interfaces and implementation - User Interfaces, System Calls. Operating System implementation and Structure, System Boot process.

Process Management, Threads, Scheduling Queues- Context Switching-Process Creation and Termination-CPU Scheduling -Inter Process Communication.

Process Synchronization, Critical Section-Synchronization – Locks, Semaphores, Monitors, Classical Problems and its implementation- Deadlocks- Handling – Prevention – Avoidance-Detection Recovery.

Memory Management-Swapping - Segmentation – Paging – Page replacement algorithms. Storage Management-RAID- Disk structure, Disk scheduling and implementation

File System Interface- Protection in Operating Systems-Directory implementation – allocation methods-Protection-Access Matrix.

TEXT BOOKS

1. Abraham Silberschatz, Peter B Galvin, Greg Gagne, Operating System Concepts, 9/e, Wiley India, 2015.

REFERENCES

1. Andrew S Tanenbaum, "Modern Operating Systems", 4th Edition, Prentice Hall, 2015.
2. William Stallings, "Operating systems", 6th Edition, Pearson, Global Edition, 2015.
3. Garry Nutt, Nabendu Chaki, Sarmistha Neogy, "Operating Systems", 3rd Edition, Pearson Education,2016.
4. D.M. Dhamdhere, "Operating Systems", 2nd Edition, Tata McGraw Hill, 2011.
5. Sibsankar Haldar, Alex A Aravind, "Operating Systems", Pearson Education

COURSE PLAN

Module	Contents	No. of hours
I	Introduction: Functions of an operating system. Single processor, multiprocessor and clustered systems – overview. Kernel Data Structures Operating System Interfaces and implementation - User Interfaces, System Calls – examples. Operating System implementation - approaches. Operating System Structure – Monolithic, Layered, Micro-kernel, Modular. System Boot process.	11
II	Process Management: Process Concept – Processes-States – Process Control Block – Threads. Scheduling – Queues – Schedulers – Context Switching. Process Creation and Termination. CPU Scheduling – Scheduling Criteria – Scheduling Algorithms & implementation (P). Inter Process Communication: Shared Memory, Message Passing, Pipes	12

III	Process Synchronization: Critical Section - Peterson's solution. Synchronization – Locks, Semaphores, Monitors, Classical Problems and its implementation – Producer Consumer, Dining Philosophers and Readers-Writers Problems (P). Deadlocks – Conditions, Modeling using graphs. Handling – Prevention – Avoidance – Banker's Algorithm and its implementation (P) – Detection- Recovery.	13
IV	Memory Management: Main Memory – Swapping - fixed partitions - variable partitions - – Contiguous Memory allocation – Segmentation – Paging – Demand Paging-Page replacement algorithms. Storage Management: Overview of mass storage structure- disks and tapes. Disk structure – accessing disks. Disk scheduling and implementation (P).	12
V	File System Interface: File Concepts – Attributes – operations – types – structure – access methods. Protection. File system implementation. Directory implementation – allocation methods. Free space Management. Protection– Goals, Principles, Domain. Access Matrix.	12
	Total Hours	60

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
CS2U30C	Introduction To Machine Learning	PCC	3	1	0	4	2022

COURSE OVERVIEW

This course enables the learners to understand the advanced concepts and algorithms in machine learning. The course covers the standard and most popular supervised learning algorithms such as linear regression, logistic regression, decision trees, Bayesian learning and the Naive Bayes algorithm, basic clustering algorithms and classifier performance measures. This course helps the students to provide machine learning-based solutions to real-world problems.

Prerequisite: ES0U10H Introduction to Python

ii. COURSE OUTCOMES

Course Outcomes	Description	Level
CO1	Illustrate Machine Learning concepts and basics of supervised learning concepts.	Apply
CO2	Illustrate and evaluate supervised learning techniques	Apply
CO3	Solve real life problems using appropriate machine learning models	Apply
CO4	Illustrate basics of parameter estimation models and the working of SVM classifier	Apply
CO5	Demonstrate the use of dimensionality reduction techniques and unsupervised learning concepts	Apply

iii. SYLLABUS

iv (a) TEXT BOOKS

1. Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.
2. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.

Reference Books

1. Christopher Bishop. Neural Networks for Pattern Recognition, Oxford University Press, 1995.
2. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements Of Statistical Learning, Second edition Springer 2007.
4. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995.
5. Richert and Coelho, Building Machine Learning Systems with Python.
6. Mohammed J. Zaki and Wagner Meira, Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, First South Asia edition, 2016.
7. Jake VanderPlas, Python Data Science Handbook, O'Reilly Media, 2016

8. Davy Cielen, Arno DB Meysman and Mohamed Ali.Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools, Dreamtech Press 2016.

COURSE PLAN

Module	Contents	Hours
I	Introduction to Machine Learning, Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning. Classfication, regression and clustering , Basics of parameter estimation - Maximum Likelihood Estimation(MLE) and Maximum a Posteriori estimation(MAP). Bias-Variance decomposition Intel AI tools • Jupyter* Lab for interactive coding • NumPy, SciPy, and pandas for numerical computation • Matplotlib and seaborn for data visualization • Intel optimised library –modin Regression - Linear regression with one variable, Linear regression with multiple variables, solution using gradient descent algorithm and matrix method • Scikitlearn	**12**
II	KNN Classifier and Regressor Logistic Regression Model Evaluation-Bias-Variance-tradeoff, Overfitting and under fitting, Cost function Regularization –L1 and L2 DT in regression Bayes theorem, Naive Bayes Classifier Decision tree algorithm ID3, CART Case Study: Develop a classifier for face detection.	**12**
III	Classification Performance measures - Precision, Recall, Accuracy, F-Measure, Receiver Operating Characteristic Curve(ROC), Area Under Curve AUC. Bootstrapping, Cross Validation. Support Vector Machines - Introduction, Maximum Margin hyperplanes, Mathematics behind Maximum Margin Classification, soft margin SVM classifier, non-linear SVM, Kernels for learning non-linear functions, polynomial kernel, Radial Basis Function(RBF), Kernel Trick.	**12**
IV	Dimensionality reduction – Subset selection, Principal Component Analysis. Unsupervised Learning - Clustering Methods -Similarity measures, K-means clustering Expectation-Maximization for soft clustering, Hierarchical Clustering Methods – Agglomerative and divisive, Density based clustering. Ensemble methods, Voting, Bagging, Boosting.	**12**

V	Association Rule Mining- Apriori algorithm Perceptron, Perceptron Learning, Multilayer Feed forward Network, Activation Functions (Sigmoid, ReLU,Tanh), Back Propagation Algorithm, Illustrative Example for Back Propagation	**12**
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
CS2U30D	Artificial Neural Network	PCC	3	1	0	4	2022

COURSE OVERVIEW

This course provides a comprehensive introduction to Artificial Neural Networks, a fundamental concept in the field of machine learning and artificial intelligence. Students will gain a deep understanding of the theoretical foundations, practical applications, and design principles of neural networks.

COURSE OUTCOMES:

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the fundamentals of artificial neural networks and their applications.	Understand
CO 2	Apply supervised learning techniques, including Perceptron learning and α-Least Mean Square Learning, to solve practical problems	Apply
CO 3	Implement the Backpropagation algorithm for designing and evaluating multi-layered network architectures.	Apply
CO 4	Explain the architecture and learning techniques of various Attractor Neural Networks	Understand
CO 5	Explain the principles of self-organizing feature maps and their practical applications.	Understand

SYLLABUS

TEXTBOOKS

1. Satish Kumar, "Neural Networks: A classroom approach", Tata McGraw Hill, 2004.

REFERENCE BOOKS:

1. Simon Haykin, "Neural Networks: A comprehensive foundation", Second Edition, Pearson Education Asia.
2. Robert J. Schalkoff, "Artificial Neural Networks", McGraw-Hill International Editions, 1997
3. B. Yegnanarayana. "Artificial neural networks"., PHI Learning Pvt. Ltd.

COURSE PLAN

Module	Contents	No. of hours
I	**Introduction**: Biological Neuron-Artificial Neural Model - Types of activation functions - Architecture: Feedforward and Feedback, Convex Sets, Convex Hull and Linear Separability, Non-Linear Separable Problem. XOR Problem, Multilayer Networks.	12
II	**Supervised Learning I**: Learning Algorithms, Error correction and Gradient Descent Rules, Learning objective of TLNS, Perceptron Learning Algorithm, Perceptron Convergence Theorem. Perceptron learning and Non-Separable sets, α-Least Mean Square Learning, MSE Error surface, Steepest Descent Search, μ-LMS approximate to gradient descent, Application of LMS to Noise Cancellation.	12
III	**Supervised Learning II:** Multi-layered Network Architecture, Backpropagation Learning Algorithm, Practical consideration of BP algorithm, Applications of Feedforward Neural Networks.	12
IV	**Attractor Neural Networks**: Associative Learning Attractor Associative Memory, Linear Associative memory, Hopfield Network, application of Hopfield Network, Brain State in a Box Neural Network, Simulated Annealing, Boltzmann Machine, Bidirectional Associative Memory.	12
V	**Self-organization Feature Map**: Maximal Eigenvector Filtering, Extracting Principal Components, Generalized Learning Laws, Vector Quantization, Self- organization Feature Maps, Application of SOM, Growing Neural Gas.	12
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

NC0U30A	DISASTER MANAGEMENT	Category	L	T	P	Credit	Year of Introduction
		MNC	2	0	0	Nil	2022

COURSE OVERVIEW:

The goal of this course is to expose the students to the fundamental concepts of hazards and disaster management. The course details the various phases of disaster risk management andthe measures to reduce disaster risks.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the fundamental concepts and terminology related to disaster management cycle	Understand
CO 2	Explain hazard and vulnerability types and disaster riskassessment	Understand
CO 3	Describe the process of risk assessment and appropriatemethodologies to assess risk	Understand
CO 4	Explain the core elements and phases of disaster risk management and measures to reduce disaster risks across sectorand community	Apply
CO 5	Discuss the factors that determine the nature of disaster response and the various disaster response actions	Understand
CO 6	Explain the legislations and best practices for disaster management and risk reduction at national and international level	Understand

SYLLABUS

Introduction- Systems of Earth, Key concepts and terminology in disaster risk reduction and management Hazard types, Vulnerability types and their assessment, Disaster risk assessment Disaster risk management- Phases of disaster risk management, Measures for disaster risk reduction- prevention, mitigation, preparedness, Disaster response, Relief Participatory stakeholder engagement, Disaster communication, Capacity building Common disaster types in India, Legislations in India on Disaster Management, National Disaster Management Policy, Institutional arrangements for disaster management in India, The Sendai Framework for Disaster risk reduction.

TEXT BOOKS

1. Coppola, D.P., *Introduction to International Disaster Management*, Elsevier Science(B/H), London, 2020
2. Srivastava, H.N., Gupta, G.D., *Management of Natural Disasters in developing countries*,Daya Publishers, Delhi, 2007
3. Subramanian, R., *Disaster Management*, Vikas Publishing House, 2018
4. Sulphey, M.M., Disaster *Management*, PHI Learning, 2016

REFERENCE MATERIALS

1. NDMA, National Policy on Disaster Management, Ministry of Home Affairs,Government of India,2009.
2. National Disaster Management Division, Disaster Management in India - A Status Report, Ministry of Home Affairs, Government of India, New Delhi,2004.
3. National Disaster Management Plan, NDMA, Ministry of Home Affairs, Government ofIndia,2019.
4. Disaster Management Training Manual, UNDP, 2016
5. United Nations Office for Disaster Risk Reduction, Sendai Framework for Disaster RiskReduction 2015-2030, 2015

COURSE PLAN

Module	Contents	No. of hours
I	Introduction about various systems of earth, Lithosphere- composition, rocks, soils; Atmosphere- layers, ozone layer, greenhouse effect. Weather, cyclones, atmospheric circulations, Indian monsoon; Hydrosphere- oceans, inland water bodies; Biosphere Definition and meaning of key terms in Disaster risk reduction and Management – disaster, hazard, exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, disaster risk management, early warning systems, disaster preparedness, disaster prevention, disaster mitigation, disaster response, damage assessment, crisis counselling, needs assessment	6
II	Various hazard types, hazard mapping; Different types of vulnerability types and their assessment- Physical, social, economic and environmental vulnerability. Core elements of disaster risk assessment Components of a comprehensive disaster preparedness strategy approaches, procedures Different disaster response actions	6

III	Introduction to disaster risk management, core elements ofdisaster risk management Phases of disaster risk management, Measures for disaster riskreduction Measures for disaster prevention, mitigation, and preparedness Disaster response- objectives, requirements. Disaster responseplanning; types of responses Disaster relief, International relief organisations	7
IV	Participatory stakeholder engagement, Importance of disaster communication, Disaster communication- methods, barriers, Crisis counselling Introduction to capacity building, Concept- Structural measures, Non-structural measures Introduction to Capacity assessment, Capacity assessment-Strengthening, Capacity for reducing risk	5
V	Introduction- common disaster types in India Common disaster legislations in India on disaster management National disaster management policy, Institutional arrangements for disaster management in India. The Sendai Framework for Disaster risk reduction and targets-priorities for action, guiding principles	6
	Total hours	**30**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
CS2U38A	Operating Systems and Networking Lab	PCC	0	0	4	2	2022

PRE-REQUISITE: Nil

COURSE OVERVIEW: The course aims to offer students a hands-on experience on Operating System concepts using a constructivist approach and problem-oriented learning. Operating systems are the fundamental part of every computing device to run any type of software.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Implement Process Creation and Inter Process Communication in Operating Systems.	Apply
CO 2	Implement Process Synchronization algorithms in Operating Systems	Apply
CO 3	Implement modules for Deadlock Detection and Deadlock Avoidance in Operating Systems.	Apply
CO 4	Implement Medium Access Protocols	Apply
CO 5	Implement Transport Layer Protocols	Apply
CO 6	Implement Remote Procedure Calls	Apply

REFERENCES

1. Abraham Silberschatz, Peter B Galvin, Greg Gagne, Operating System Concepts, 9/e, Wiley India, 2015.
2. Andrew S Tanenbaum, “Modern Operating Systems”, 4th Edition, Prentice Hall, 2015.
3. William Stallings, “Operating systems”, 6th Edition, Pearson, Global Edition, 2015.

COURSE PLAN

SL No.	Topics	No. of hours
1	Implement programs for Inter Process Communication using PIPE, Message Queue and Shared Memory.	8
2	Write a program to simulate the working of the dining	8

	philosopher's problem.	
3	Implement the banker's algorithm for deadlock avoidance.	8
4	Software simulation of Medium Access Control Protocols- 1) Go Back N 2) Selective Repeat and 3) Sliding Window	9
5	Implementation of a subset of simple mail transfer protocol using UDP	9
6	Implementation of a subset of a file transfer protocol using TCP/IP	9
7	Implementation of Remote Procedure Call (RPC)	9
	Total	**60**

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 15 marks

Continuous Evaluation in Lab : 30 marks

Continuous Assessment Test : 15 marks

Viva-voce : 15 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
CS2U38B	Machine Learning Lab	PCC	0	0	4	2	2022

COURSE OVERVIEW:

This course enables the learners to get hands-on experience in most popular supervised learning algorithms (such as linear regression, logistic regression, decision trees, Bayesian learning and Naive Bayes algorithm) and unsupervised learning algorithms (such as basic clustering algorithms). This helps the learners to understand the process of knowledge inference from raw data through dataset preprocessing and analysis.

Prerequisite: Fundamentals of Programming, Python programming fundamentals, Machine learning.

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COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Implement machine learning algorithms using packages and libraries in Python for various applications	Apply
CO 2	Implement python programs for supervised learning methods through Neural network, Regression, and classification	Apply
CO 3	Implement clustering algorithms.	Apply
CO 4	Apply dimensionality reduction as a dataset preprocessing step.	Apply

TEXT BOOKS

1. Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.
2. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.

COURSE PLAN

SL No.	Topics	No. of hours
	Pandas ,Numpy and Visualization tools	20
1.	Implement K-Nearest Neighbor algorithm to classify any dataset	4
2.	Implement and demonstrate Single, Multi variable and Polynomial Regression for a given set of training data stored in a .CSV file and evaluate the accuracy.	4
3.	Implement a Python program to perform logistic regression on a dataset.	4
4.	Write a Python program to implement Naive Bayes classifier and calculate the accuracy, precision, and recall for your data set.	4
5.	Write a Python program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.	4
6.	Assuming a set of data that need to be classified, use a Support Vector Machine classifier to perform this task and evaluate the accuracy.	4
7.	Implement dimensionality reduction using PCA.	4
8.	Implement K-Means Clustering using any given dataset.	4
9.	Implement Agglomerative Hierarchical Clustering.	4
10.	Build an Artificial Neural Network using Backpropagation algorithm and test the same with appropriate dataset.	4
	Total	60

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 15 marks

Continuous Evaluation in Lab : 30 marks

Continuous Assessment Test : 15 marks

Viva-voce : 15 marks

Minor Basket 1: SOFTWARE ENGINEERING

Course Code	Course Name	Category	L	T	P		Credit		Year of Introduction
CS0M30A	**Concepts In Software Engineering**	**VAC**	**3**	**1**	**0**		**4**		**2022**

COURSE OVERVIEW

This course provides fundamental knowledge in the Software Development Process. It covers Software Development, Quality Assurance and Project Management concepts. This course enables the learners to apply state of the art industry practices in Software development.

Prerequisite: Basic understanding of Object Oriented Design and Development.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Differentiate Traditional and Agile Software Development approaches	Understand
CO 2	Prepare Software Requirement **Specification** and Software Design for a given problem.	Apply
CO 3	Justify the significance of design patterns and licensing terms in software development, prepare testing, maintenance and DevOps strategies for a project	Apply
CO 4	Make use of software project management concepts while planning, estimation, scheduling, tracking and change management of a project, with proper application of SCRUM, Kanban and Lean frameworks.	Apply
CO 5	Utilize SQA practices, Process Improvement techniques and Technology improvements namely cloud based software model and containers & microservices in a Software Development Process.	Apply

SYLLABUS

The waterfall model, Incremental development. Process activities - Software specification, Software design and implementation, Software validation, Software evolution. Coping with change - Prototyping, Incremental delivery, Boehm's Spiral Model. Agile software development - Agile methods, agile manifesto - values and principles. Agile development techniques, Agile Project Management.

Functional and non-functional requirements, Developing use cases, Software Requirements Specification Template, Personas, Scenarios, User stories, Feature identification. Design concepts Architectural Design - Software Architecture, Architectural Styles, Architectural considerations, Architectural Design Component level design Template of a Design Document as per “IEEE Std 1016-2009 IEEE Standard for Information Technology Systems Design Software Design Descriptions”.

Object-oriented design using the UML, Design patterns, Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD. DevOps automation, CI/CD/CD. Software Evolution - Evolution processes, Software maintenance.

Software Project Management - Risk management, Managing people, Teamwork. Project Planning,

Software pricing, Plan-driven development, Project scheduling, Agile planning. Estimation techniques, COCOMO cost modeling. Configuration management
Software Quality, Software Quality Dilemma, Achieving Software Quality Elements of Software Quality Assurance, SQA Tasks

TEXT BOOKS

1. Book 1 - Ian Sommerville, Software Engineering, Pearson Education, Tenth edition, 2015.
2. Book 2 - Roger S. Pressman, Software Engineering : A practitioner's approach, McGraw Hill publication, Eighth edition, 2014
3. Book 3 - Ian Sommerville, Engineering Software Products: An Introduction to Modern Software Engineering, Pearson Education, First Edition, 2020.

REFERENCES

1. Mary Poppendieck, Implementing Lean Software Development: From Concept to Cash, Addison-Wesley Signature Series, 2006
2. StarUML documentation - https://docs.staruml.io/
3. OpenProject documentation - https://docs.openproject.org/
4. BugZilla documentation - https://www.bugzilla.org/docs/
5. GitHub documentation - https://guides.github.com/
6. Jira documentation - https://www.atlassian.com/software/jira

COURSE PLAN

Module	Contents	Hours
I	**Introduction to Software Engineering:** Introduction to Software Engineering - Professional software development, Software engineering ethics. Software process models - The waterfall model, Incremental development. Process activities - Software specification, Software design and implementation, Software validation, Software evolution. Coping with change - Prototyping, Incremental delivery, Boehm's Spiral Model. Agile software development - Agile methods, agile manifesto - values and principles. Agile development techniques, Agile Project Management. Case studies: An insulin pump control system. Mentcare - a patient information system for mental health care.	**12**
II	**Requirement Analysis and Design:** Functional and non-functional requirements, Requirements engineering processes. Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix. Developing use cases, Software Requirements Specification Template, Personas, Scenarios, User stories, Feature identification. Design concepts - Design within the context of software engineering, Design Process, Design concepts, Design Model. Architectural Design - Software Architecture, Architectural Styles, Architectural considerations, Architectural Design Component level design - What is a component?, Designing Class-Based Components, Conducting Component level design, Component level design for web-apps. Template of a Design Document	**12**

	as per "IEEE Std 1016-2009 IEEE Standard for Information Technology Systems Design Software Design Descriptions". Case study: The Ariane 5 launcher failure**.**	
III	**Implementation and Testing:** Object-oriented design using the UML, Design patterns, Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD. Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. Informal Review, Formal Technical Reviews, Post-mortem evaluations. Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing, Debugging, White box testing, Path testing, Control Structure testing, Black box testing, Testing Documentation and Help facilities. Test automation, Test-driven development, Security testing. Overview of DevOps and Code Management – Code management, DevOps automation, CI/CD/CD. Software Evolution - Evolution processes, Software maintenance.	**12**
IV	**Software Project Management:** Software Project Management - Risk management, Managing people, Teamwork. Project Planning, Software pricing, Plan-driven development, Project scheduling, Agile planning. Estimation techniques, COCOMO cost modeling. Configuration management, Version management, System building, Change management, Release management, Agile software management - SCRUM framework. Kanban methodology and lean approaches.	**12**
V	**Software Quality and Process Improvement:** Software Quality, Software Quality Dilemma, Achieving Software Quality Elements of Software Quality Assurance, SQA Tasks, Software measurement and metrics. Software Process Improvement(SPI), SPI Process CMMI process improvement framework, ISO 9001:2000 for Software.	**12**
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Minor Basket 2: MACHINE LEARNING

Course Code	Course Name	Category	L	T	P		Credit		Year of Introduction
CS0M30B	**Concepts In Machine Learning**	**VAC**	**3**	**1**	**0**		**4**		**2022**

COURSE OVERVIEW

This course enables the learners to understand the fundamental concepts and algorithms in machine learning. The course covers the standard and most popular supervised learning algorithms such as linear regression, logistic regression, decision trees, Bayesian learning & the naive Bayes algorithm, support vector machines& kernels, basic clustering algorithms and dimensionality reduction methods. This course helps the students to provide machine learning based solutions to real world problems.

Prerequisite: Familiarity with basics in linear algebra, probability and Python programming.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Illustrate Machine Learning concepts and basic parameter estimation methods.	Apply
CO 2	Demonstrate supervised learning concepts (regression, linear classification).	Apply
CO 3	Illustrate the concepts of Multilayer neural network and Support Vector Machine	Apply
CO 4	Describe unsupervised learning concepts and dimensionality reduction techniques.	Apply
CO 5	Solve real life problems using appropriate machine learning models and evaluate the performance measures	Apply

SYLLABUS

Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning. - Linear regression, Linear Methods for Classification- Logistic regression, Perceptron, Naive Bayes, Decision tree algorithm ID3.NN - Multilayer feed forward network, Activation functions (Sigmoid, ReLU, Tanh), Clustering - Similarity measures, Hierarchical Agglomerative Clustering, K-means partitional clustering, Expectation maximization (EM) for soft clustering. Dimensionality reduction – Principal Component Analysis, factor Analysis, Multidimensional scaling, Linear Discriminant Analysis.
Classification Performance measures

TEXT BOOKS

1. Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.

2. Mohammed J. Zaki and Wagner Meira, Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, First South Asia edition, 2016.

3. Jake VanderPlas, Python Data Science Handbook, O'Reilly Media, 2016

4. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.

REFERENCES

1. Christopher Bishop. Neural Networks for Pattern Recognition, Oxford University Press, 1995.
2. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements Of Statistical Learning, Second edition Springer 2007.
4. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995.
5. Richert and Coelho, Building Machine Learning Systems with Python.
6. Davy Cielen, Arno DB Meysman and Mohamed Ali. Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools, Dreamtech Press 2016.

COURSE PLAN

Module	Contents	Hours
I	**Overview of machine learning:** Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning. Basics of parameter estimation - maximum likelihood estimation(MLE) and maximum a posteriori estimation(MAP). Introduction to Bayesian formulation.	12
II	**Supervised Learning** Regression - Linear regression with one variable, Linear regression with multiple variables, solution using gradient descent algorithm and matrix method, basic idea of overfitting in regression. Linear Methods for Classification- Logistic regression, Perceptron, Naive Bayes, Decision tree algorithm ID3.	12
III	**Neural Networks (NN) and Support Vector Machines (SVM)** NN - Multilayer feed forward network, Activation functions (Sigmoid, ReLU, Tanh), Backpropagation algorithm. SVM - Introduction, Maximum Margin Classification, Mathematics behind Maximum Margin Classification, Maximum Margin linear separators, soft margin SVM classifier, non-linear SVM, Kernels for learning non-linear functions, polynomial kernel, Radial Basis Function(RBF).	12
IV	**Unsupervised Learning:** Clustering - Similarity measures, Hierarchical Agglomerative Clustering, K-means partitional clustering, Expectation	12

	maximization (EM) for soft clustering. Dimensionality reduction – Principal Component Analysis, factor Analysis, Multidimensional scaling, Linear Discriminant Analysis.	
V	**Classification Assessment:** Classification Performance measures - Precision, Recall, Accuracy, F-Measure, Receiver Operating Characteristic Curve(ROC), Area Under Curve (AUC. Bootstrapping, Cross Validation, Ensemble methods, Bias-Variance decomposition. Case Study: Develop a classifier for face detection.	**12**
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Minor Basket 3: Networking

CS0M30C	CLIENT SERVER SYSTEMS	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2020

PRE-REQUISITE: Nil

COURSE OVERVIEW: The syllabus is prepared with the view of preparing the Engineering Graduates to build effective Client/Server applications. This course aims at providing a foundation in decentralized computer systems, using the client/server model. The course content is decided to cover the essential fundamentals which can be taught within the given slots in the curriculum.

COURSE OUTCOMES: After the completion of the course the student will be able to

CO 1	Identify the basics of client/server systems and the driving force behind the development of client/server systems**.**	Understand
CO 2	Outline the architecture and classifications of client/server systems.	Understand
CO 3	Summarize the client/server network services for an application.	Understand
CO 4	Identify management services and issues in network	Understand
CO 5	Outline the Client/Server technology in respect of databases and Client/Server database architecture	Understand

SYLLABUS

Introduction-Client/Server Classification-Client/Server Application Components-Client/ Server Systems Services and Support-Client/Server Technology and Databases

TEXT BOOKS

1. Patrick Smith &Steve Guengerich, Client / Server Computing, PHI
2. Subhash Chandra Yadav, Sanjay Kumar Singh, An Introduction to Client/Server Computing, New Age International Publishers.

REFERENCE

1. Jeffrey D. Schank, "N0ovell's Guide to Client-Server Application & Architecture" Novell Press
2. Robert Orfali, Dan Harkey, Jeri Edwards, Client/Server Survival Guide, Wiley-India Edition, Third Edition

3. Dawna Travis Dewire, Client Server Computing- McGraw Hill
4. W.H Inman, Developing Client Server Applications, BPB

COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Client/Server computing - Basic Client/Server Computing Model, Server for Every Client- File Server, Print Server, Application Server, Mail Server, Directory Services Server, Web Server, Database Server, Transaction Servers. Client/Server-Fat or Thin, Stateless or Stateful, Servers and Mainframes, Client/Server Functions. Driving Forces behind Client/Server Computing- Business Perspective, Technology Perspective.	**12**
II	Client/Server Types-Single Client/Single Server, Multiple Clients/Single Server, Multiple Clients/Multiple Servers, Integration With Distributed Computing, Alternatives To Client/Server Systems. Classification of Client/Server Systems- Two-Tier Computing, Middleware, Three-Tier Computing- Model View Controller (MVC), Principles behind Client/Server Systems. Client/Server Topologies. Existing Client/Server Architecture. Architecture for Business Information System.	**11**
III	Client- Services, Request for services, RPC, Windows services, Print services, Remote boot services, other remote services, Utility Services. Server- Detailed server functionality, Network operating system, Available platforms, Server operating system. Organizational Expectations, Improving performance of client/server applications, Single system image, Downsizing and Rightsizing, Advantages and disadvantages of Client/Server computing, Applications of Client/Server.	**12**
IV	Services and Support- System administration, Availability, Reliability, Scalability, Observability, Agility, Serviceability. Software Distribution, Performance, Network management. Remote Systems Management- RDP, Telnet, SSH, Security. LAN and Network Management issues.	**13**
V	Client/Server Technology and Databases **-** Storing Data, Database System Architectures. Client/Server In Respect Of Databases- Client/Server Databases, Client/Server Database Computing, Database Computing Vs. Mainframe, PC/File Server Computing. Client/Server Database Architecture - Process-Per-Client Architecture, Multi-Threaded Architecture, Hybrid Architecture. Database Middleware Component - Application Programming Interface, Database Translator, Network	**12**

	Translator.	

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks
Continuous Assessment Tests : 25 marks
Continuous Assessment Assignment : 15 marks

Honour Basket 1: Security in Computing

CS1H30A	CRYPTOGRAPHIC ALGORITHMS	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2022

PRE-REQUISITE: CS1H20A-Number Theory

COURSE OVERVIEW:

The course on Cryptographic Algorithms aims at exploring various algorithms deployed in offering confidentiality, integrity, authentication and non-repudiation services. This course covers classical encryption techniques, symmetric and public key crypto-system, key exchange and management, and authentication functions. The concepts covered in this course enable the learners in effective use of cryptographic algorithms for real life applications.

COURSE OUTCOMES: After the completion of the course the student will be able to

CO1	Identify the security services provided for different types of security attacks.	Understand
CO2	Summarize the classical encryption techniques for information hiding.	Apply
CO3	Illustrate symmetric / asymmetric key cryptographic algorithms for secure communication.	Apply
CO4	Interpret key management techniques for secure communication.	Understand
CO5	Summarize message authentication functions in a secure communication scenario.	Understand

SYLLABUS

Need for security, Principles of security, Types of attacks, OSI Security Architecture, Classical encryption techniques- Encrypting communication channels. Symmetric key cryptographic Algorithms, DES, Block cipher principles, Differential and Linear cryptanalysis, Block cipher modes of operation, IDEA, AES, Stream cipher, RC4. Principles of public key cryptosystems, RSA algorithm, ElGamal cryptographic system, Knapsack algorithm, Diffie-Hellman key exchange algorithm, Elliptical curve cryptosystems. Key Distribution-Public key infrastructure. Authentication requirements, functions, Algorithms and Services.

TEXT BOOKS

1. William Stallings, Cryptography and Network Security Principles and Practice, Pearson Edu, 6e.
2. BruiceSchneier, Applied Cryptography Protocols, Algorithms and source code in C, Wiley,2e.

REFERENCE MATERIALS

1. Behrouz A. Forouzan, Cryptography and Network Security, McGraw Hill, 2e.

2. Johannes A. Buchmann, Introduction to Cryptography, Springer, 2e.
3. DouglasR. Stinson, Cryptography Theory and Practice, 3e, Chapman& Hall/CRC, 2006.
4. Bernard Menezes, Network Security and Cryptography, Cengage Learning, 2011.

COURSE PLAN

Module	Contents	No. of hours
I	Need for security, Security approaches, Principles of security, Types of attacks, OSI Security Architecture, Classical encryption techniques - Substitution techniques, Transposition techniques. Stream cipher, Block cipher, Public key cryptosystems vs. Symmetric key cryptosystems, Encrypting communication channels.	**12**
II	Overview of symmetric key cryptography, Block cipher principles, Data Encryption Standard (DES), Differential and Linear cryptanalysis, Double DES, Triple DES, International Data Encryption Algorithm (IDEA), Advanced Encryption Algorithm (AES),Block cipher modes of operation, Stream cipher, RC4.	**13**
III	Principles of public key cryptosystems, RSA algorithm, RSA illustration, Attacks, ElGamal cryptographic system, Knapsack algorithm, Diffie-Hellman key exchange algorithm, Elliptical curve cryptosystems.	**12**
IV	Symmetric key distribution using symmetric encryption, Symmetric key distribution using asymmetric encryption, Distribution of public keys, Generating keys, transferring keys, Verifying keys, Updating keys, Storing keys, Backup keys, Compromised keys, Public key infrastructure.	**12**
V	Authentication requirements, Authentication functions, Message authentication codes (MAC), Hash functions, Security of Hash functions and MAC, Message Digest 5 (MD5), Secure Hash Algorithm (SHA)-512, Hash-based Message Authentication Code (HMAC), Cipher-based Message Authentication Code (CMAC), X.509 Authentication services.	**11**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Honour Basket 2: COMPUTATIONAL BIOLOGY

CS2H30A	Computational Biology	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2022

COURSE OVERVIEW:

This course helps the learners to understand concepts in Genomics, Proteomics Computational Biology, Next Generation Sequencing, NGS Data Analysis and Systems biology. It enables the learners to understand various Next Generation Sequencing Techniques, analysis and interpretation of the NGS Data. Also, course introduces computational and mathematical analysis and modeling of complex biological systems and Systems Biology.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the basic concepts of genomics, microarray, protein structure determination and prediction	**Understand**
CO 2	Explain the fundamental aspects drug discovery and molecular modelling	**Apply**
CO 3	Demonstrate Networks in Biology, types of networks and its representation	**Apply**
CO 4	Explain Next Generation sequencing Technologies and DNA Protein interaction analysis	**Understand**
CO 5	Illustrate Next Generation sequence analysis, Mapping approaches and algorithms	**Understand**

SYLLABUS

Genomics and Proteomics, Microarray, Analysis of microarray data, Proteins and peptides, Experimental Protein structure, Computer Aided Drug Discovery, Molecular modelling, Computer Aided Drug Discovery, Network Biology, (Next Generation Sequencing and analysis, NGS Data Analysis

TEXT BOOKS

1. Goodfellow, I., Bengio, Y., and Courville, A., Deep Learning, MIT Press, 2016.
2. Neural Networks and Deep Learning, Aggarwal, Charu C., c Springer International Publishing AG, part of Springer Nature 2018
3. Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms (1st. ed.). Nikhil Buduma and Nicholas Locascio. 2017. O'Reilly Media, Inc.

REFERENCE MATERIALS

1. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.
2. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.

3. Michael Nielsen, Neural Networks and Deep Learning, 2018

COURSE PLAN

Module	Contents	No. of hours
I	Genes, Genes in genomes, Genomes of prokaryotes and Eukaryotes, Protein-coding genes, RNA, Single-nucleotide polymorphisms, Microarray, Analysis of microarray data, Proteins and peptides, Experimental Protein structure identification, computational methods for protein structure prediction, Homology modelling, Protein folding and fold recognition	**10**
II	Drug discovery pipeline, Drug target identification & validation, Active site identification, pharmacophore, Lead/Ligand identification, lead compound optimization, Binding energy calculation, Energy Minimization. Molecular modelling in drug discovery, concept of Molecular Dynamics, concept of Absorption, Distribution, Metabolism and Excretion (ADME), Quantitative Structure-Activity Relationships	**10**
III	Transcriptional Regulatory Networks, Genes and DNA Regulatory Regions, Genetic Interaction Map, Protein Interaction Networks, Experimental methodologies to obtain Protein Interaction Data, Computational methods to Predict Protein-Protein Interactions, Visualization of Protein Interaction Networks, Metabolic Networks, Interacting Partners, Mathematical Representation	**14**
IV	A Typical NGS Experimental Workflow, Next-Generation Sequencing (NGS) Technologies, Illumina Reversible Dye-Terminator Sequencing, Ion Torrent Semiconductor Sequencing, Pacific Biosciences Single Molecule Real-Time (SMRT) Sequencing, RNA-sequencing (RNA Seq), Protein-DNA Interaction Analysis (ChIP-Seq)	**13**
V	Base Calling, FASTQ File Format, and Base Quality Score, NGS Data Quality Control and Preprocessing, Reads Mapping, Mapping Approaches and Algorithms, Selection of Mapping Algorithms and Reference Genome Sequences, SAM/BAM as the Standard Mapping File Format, Mapping File Examination and Operation, Tertiary Analysis	**13**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks

Honour Basket 3: COMPTER VISION

CS2H30B	Advanced Concepts in Computer Vision	Category	L	T	P	Credit	Year of Introduction
		VAC	3	1	0	4	2022

COURSE OVERVIEW:

This course enables the learners to understand the advanced concepts in computer vision. The course covers the basics of image processing, imaging geometry, image segmentation, feature extraction, object recognition and classification and common applications of computer vision. This course helps the students to design solutions for complex real-life problems.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Illustrate the concepts of image formation and image model.	**Understand**
CO 2	Demonstrate various feature extraction and edge detection techniques.	**Apply**
CO 3	Apply edge-based and region-based image segmentation techniques.	**Apply**
CO 4	Understand and implement image recognition and classification methods.	**Apply**
CO 5	Explain the various applications of computer vision	**Understand**

SYLLABUS

Image Formation and Processing, Fundamentals of Image processing, Feature Extraction, Edges Image Segmentation, Image processing using OpenCV - blending, smoothing, and reshaping. Image Recognition and Classification, Object classification using CNNs, Applications,

TEXT BOOKS

1. David A. Forsyth & Jean Ponce, Computer vision – A Modern Approach, Prentice Hall, 2002.
2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer.
3. Francesco Camastra, Alessandro Vinciarelli, “Machine Learning for Audio, Image and Video Analysis: Theory and Applications”, Springer 2015.

REFERENCES

1. Reinhard Klette, “Concise Computer Vision: An Introduction into Theory and Algorithms”, Springer London, 2014.
2. Olivier Faugeras, “Three-Dimensional Computer Vision”, The MIT Press, 1993.

COURSE PLAN

Module	Contents	No. of hours
I	Image formation and Image model- Components of a vision system- Cameras- camera model and camera calibration-Radiometry- Light in space- Light in surface - Sources, shadows and shading. Fundamentals of Image processing: Basic steps of Image processing system sampling and quantization of an Image – Basic relationship between pixels	10
II	Points and Patches – Feature detectors, feature descriptors, feature matching, feature tracking. Edges – edge detection, edge linking. Lines - Successive approximation, Hough transforms, Vanishing points.	10
III	Classification of segmentation techniques, Edge detection, Edge linking, Thresholding, Region growing, Region splitting and merging, Watershed based segmentation. Shadow detection and removal. Image processing using OpenCV - blending, smoothing, and reshaping.	14
IV	Shape based object classification, Motion based object classification, Viola Jones Object Detection Framework, Object classification using CNNs, use of RCNN for object classification	13
V	Speech and Handwriting Recognition, Automatic Face Recognition, Video Segmentation and Keyframe Extraction, Real-Time Hand Pose Recognition.	13

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

SEMESTER VI

Course Code	Course Name	Category	L	T	P		Credit	Year of Introduction
CS2U30E	ROBOTICS AND INTELLIGENT SYSTEM	**PCC**	**3**	**1**	**0**		**4**	**2022**

COURSE OVERVIEW

This course enables the learners to understand the fundamental concepts and algorithms in Robotics and Intelligent systems. The course covers the standard hardware and kinematic concepts for robot design. Standard algorithms for localization, mapping, path planning, navigation and obstacle avoidance, to incorporate intelligence in robots are included in the course. This course helps the students to design robots with intelligence in a real world environment.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the concepts of manipulator and mobile robotics.	**Understand**
CO 2	Choose the suitable sensors, actuators and control for robot design.	**Apply**
CO 3	Developing kinematic model of mobile robot and understand robotic vision intelligence.	**Apply**
CO 4	Make use of the localization and mapping methods in robotics	**Apply**
CO 5	Plan the path and navigation of robot by applying artificial intelligence algorithm	**Apply**

SYLLABUS

Introduction to robotics - Anatomy of a robotic manipulator-links, joints, actuators, sensors, controllers. Robot configurations-PPP, RPP, RRP, RRR. Mobile robots. Dynamic characteristics. Introduction to End effectors , Ethics in robotics - 3 laws - applications of robots. Sensor classification, Internal sensors-External sensors, Digital, Sensor characteristics. Actuators. Control - On-Off Control - PID Control - Velocity Control and Position Control. Robotic Vision: Camera sensor hardware interfacing. Representation of Transformations, Pure Rotation about an Axis - Combined Drive Wheeled Mobile Robot, Car-Like Wheeled Mobile Robot. Kinematic model of a differential drive and a steered mobile robot. Position and Orientation - Representing robot position. Basics of reactive navigation; Robot Localization, Challenges in localization Current challenges in map representation. Probabilistic map-based localization, Path Planning and Navigation

TEXT BOOKS

1. R Siegwart, IR Nourbakhsh, D Scaramuzza, Introduction to Autonomous Mobile

Robots ,, MIT Press, USA, 2011
2. Thomas Bräunl - Embedded Robotics,Mobile Robot Design and Applications with Embedded Systems-Springer (2006)
3. S.G. Tzafestas - Introduction to Mobile Robot Control-Elsevier (2014)
4. Francis X. Govers - Artificial Intelligence for Robotics-Packt Publishing (2018)
5. Saeed B. Niku - Introduction to Robotics_ Analysis, Control, Applications

REFERENCES

1. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005
2. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
3. Peter Corke - Robotics, Vision and Control_ Fundamental Algorithms in MATLAB® - Springer-Verlag Berlin Heidelberg (2021)

COURSE PLAN

Module	Contents	Hours
I	Introduction to robotics – Degrees of freedom, Robot types- Manipulators- Anatomy of a robotic manipulator-links, joints, actuators, sensors, controllers. Robot configurations-PPP, RPP, RRP, RRR. Mobile robots- wheeled, legged, aerial robots, underwater robots, surface water robots . Dynamic characteristics- speed of motion, load carrying capacity & speed of response. Introduction to End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and Passive grippers. Ethics in robotics - 3 laws - applications of robots.	**12**
II	Sensor classification- touch, force, proximity, vision sensors. Internal sensors- Position sensors, velocity sensors, acceleration sensors, Force sensors; External sensors-contact type, non contact type; Digital Camera - CCD camera - CMOS camera - Omnidirectional cameras Sensor characteristics. Actuators - DC Motors - H-Bridge - Pulse Width Modulation - Stepper Motors – Servos, Hydraulic & pneumatic actuators. Control - On-Off Control - PID Control - Velocity Control and Position Control	**12**
III	Robotic Vision: Sensing, Pre-processing, Segmentation, Description, Recognition, Interpretation, Feature extraction -Camera sensor hardware interfacing. Representation of Transformations - Representation of a Pure Translation - - Pure Rotation about an Axis - Combined Transformations - Transformations Relative to the Rotating Frame. Basic understanding of Differential-Drive Wheeled Mobile Robot, Car-Like Wheeled Mobile Robot. Kinematic model of a differential drive and a steered mobile robot, Degree of freedom and manoeuvrability, Degree of steerability, Degree of mobility - different wheel configurations, holonomic and nonholonomic robots. Omnidirectional Wheeled Mobile Robots	**12**
IV	Position and Orientation - Representing robot position. Basics of reactive navigation; Robot Localization, Challenges in localization - An error model for odometric position estimation Map Representation - Continuous representations - Decomposition strategies - Current challenges in map representation. Probabilistic map-based localization (only Kalman method), Autonomous map building, Simultaneous localization and mapping (SLAM) - Mathematical definition of SLAM - Visual SLAM with a single camera - Graph-based SLAM - Particle filter SLAM - Open challenges in SLAM	**12**
V	Path Planning- Graph search, deterministic graph search - , breadth first search - depth first search- Dijkstra' s algorithm, A*, D* algorithms, Potential field based	**12**

	path planning. Obstacle avoidance - Bug algorithm - Vector Field Histogram - Dynamic window approaches. Navigation Architectures - Modularity for code reuse and sharing - Control localization - Techniques for decomposition. Alternatives for navigation - Neural networks - Processing the image - Training the neural network for navigation - Convolutional neural network robot control implementation	
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	**CIE**	**ESE**	**ESE Duration**
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

CS1U30H	ALGORITHM ANALYSIS AND DESIGN	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0	4	2022

PRE-REQUISITE: ES0U10E Programming in C, CS1U20A Data Structures , MA0U20E Graph Theory.

COURSE OVERVIEW: The course introduces students to the design of computer algorithms, as well as analysis of algorithms. Algorithm design and analysis provide the theoretical backbone of computer science and are a must in the daily work of the successful programmer. The goal of this course is to provide a solid background in the design and analysis of the major classes of algorithms. At the end of the course students will be able to develop their own versions for a given computational task and to compare and contrast their performance.

COURSE OUTCOMES: After the completion of the course the student will be able to

Course Outcomes	Description	Level
CO1	Analyze any given algorithm and express its time and space complexities in asymptotic notations	**Apply**
CO2	Derive recurrence equations and solve it using Iteration, Recurrence Tree, Substitution and Master's Method to compute time complexity of algorithms.	**Apply**
CO3	Illustrate Graph traversal algorithms & applications and Advanced Data structures like AVL trees and Disjoint set operations.	**Apply**
CO4	Demonstrate Divide-and-conquer, Greedy Strategy, Dynamic programming, Branch-and Bound and Backtracking algorithm design techniques	**Apply**
CO5	Classify a problem as computationally tractable or intractable, and discuss strategies to address intractability	**Understand**
CO6	Identify the suitable design strategy to solve a given problem	**Apply**

SYLLABUS

Introduction to algorithm analysis, Advanced data structures and graph algorithms, Various algorithm design techniques, Introduction to Complexity Theory and Approximation Algorithms.

TEXT BOOKS

1. T.H.Cormen, C.E.Leiserson, R.L.Rivest, C. Stein, Introduction to Algorithms, 2nd Edition, Prentice-Hall India (2001)
2. Ellis Horowitz, SartajSahni, Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", 2nd Edition, Orient Longman Universities Press (2008)
3. Sara Baase and Allen Van Gelder —Computer Algorithms, Introduction to Design and
4. Analysis, 3rd Edition, Pearson Education (2009)

REFERENCE MATERIALS

1. Jon Kleinberg, Eva Tardos, " Algorithm Design", First Edition, Pearson(2005)
2. Robert Sedgewick, Kevin Wayne, "Algorithms", 4th Edition Pearson(2011)
3. Gilles Brassard, Paul Brately, " Fundamentals of Algorithmics", Pearson(1996)
4. Steven S Sjiena, " The Algorithm Design Manual", 2nd Edition, Springer(2008)

COURSE PLAN

Module	Contents	No. of hours
I	Characteristics of Algorithms, Criteria for Analysing Algorithms, Time and Space Complexity - Best, Worst and Average Case Complexities, Asymptotic Notations - Big-Oh (O), Big- Omega (Ω), Big-Theta (Θ), Little-oh (o) and Little- Omega (ω) and their properties. Classifying functions by their asymptotic growth rate, Time and Space Complexity Calculation of simple algorithms. Analysis of Recursive Algorithms: Recurrence Equations, Solving Recurrence Equations – Iteration Method, Recursion Tree Method, Substitution method and Master's Theorem (Proof not required).	13
II	Self Balancing Tree - AVL Trees (Insertion and deletion operations with all rotations in detail, algorithms not expected); Disjoint Sets- Disjoint set operations, Union and find algorithms. DFS and BFS traversals - Analysis, Strongly Connected Components of a Directed graph, Topological Sorting.	12
III	The Control Abstraction of Divide and Conquer- 2-way Merge sort, Strassen's Algorithm for Matrix Multiplication-Analysis. The Control Abstraction of Greedy Strategy- Fractional Knapsack Problem, Minimum Cost Spanning Tree Computation- Kruskal's Algorithms - Analysis, Single Source Shortest Path Algorithm - Dijkstra's Algorithm-Analysis.	12
IV	The Control Abstraction- The Optimality Principle- Matrix Chain Multiplication-Analysis, All Pairs Shortest Path Algorithm - Floyd-Warshall Algorithm-Analysis. The Control Abstraction of Back Tracking – The N Queen's Problem. Branch and Bound Algorithm for Travelling Salesman Problem.	11
V	Tractable and Intractable Problems, Complexity Classes – P, NP, NP- Hard and NP-Complete Classes- NP Completeness proof of Clique Problem and Vertex Cover Problem- Approximation algorithms- Bin Packing, Graph Coloring. Randomized Algorithms (Definitions of Monte Carlo and Las Vegas algorithms), Randomized version of Quick Sort algorithm with analysis.	12
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks

CS1U30E	MANAGEMENT OF SOFTWARE SYSTEMS	Category	L	T	P	Credit	Year of Introduction
		PCC	3	0	0	3	2022

PRE-REQUISITE: CS2U20A Object Oriented Programming using Python.

COURSE OVERVIEW: This course provides fundamental knowledge in the Software Development Process. It covers Software Development, Quality Assurance, Project Management concepts and technology trends. This course enables the learners to apply state of the art industry practices in Software development.

COURSE OUTCOMES: After the completion of the course the student will be able to

Course Outcomes	Description	Level
CO1	Demonstrate Traditional and Agile Software Development approaches	**Apply**
CO2	Prepare Software Requirement Specification and Software Design for a given problem.	**Apply**
CO3	Justify the significance of design patterns and licensing terms in software development, prepare testing, maintenance and DevOps strategies for a project.	**Apply**
CO4	Make use of software project management concepts while planning, estimation, scheduling, tracking and change management of a project, with a traditional/agile framework**.**	**Apply**
CO5	Utilize SQA practices, Process Improvement techniques and Technology advancements in cloud based software models and containers & microservices.	**Apply**

SYLLABUS

Introduction to Software Engineering-Software process models- Process activities - Agile software development-case studies: An insulin pump control system. Mentcare - a patient information system for mental health care. Functional and non-functional requirements-Requirements engineering processes. Software Requirements Specification- Template - Design Concepts-Architectural Design - What is a component? - Designing Class-Based Components, Conducting Component level design, Component level design for web-apps-Object-oriented design using the UML-Review Techniques -Software testing strategies-Test automation-Overview of DevOps and Code Management-Software Evolution - Evolution processes, Software maintenance. Software Project Management - Risk management-Project Planning - Project scheduling - Configuration management - Software Quality- Software Process Improvement(SPI) - Cloud-based Software - Software as service.

TEXT BOOKS

1. Book 1 - Ian Sommerville, Software Engineering, Pearson Education, Tenth edition, 2015.

2. Book 2 - Roger S. Pressman, Software Engineering : A practitioner's approach, McGraw Hill publication, Eighth edition, 2014
3. Book 3 - Ian Sommerville, Engineering Software Products: An Introduction to Modern Software Engineering, Pearson Education, First Edition, 2020.

REFERENCE MATERIALS

1. IEEE Std 830-1998 - IEEE Recommended Practice for Software Requirements Specifications
2. IEEE Std 1016-2009 IEEE Standard for Information Technology—Systems Design— Software Design Descriptions
3. David J. Anderson, Kanban, Blue Hole Press 2010
4. David J. Anderson, Agile Management for Software Engineering, Pearson, 2003
5. Walker Royce, Software Project Management : A unified framework, Pearson Education, 1998
6. Steve. Denning, The age of agile, how smart companies are transforming the way work gets done. New York, Amacom, 2018.

COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Software Engineering - Professional software development, Software engineering ethics. Software process models - The waterfall model, Incremental development. Process activities - Software specification, Software design and implementation, Software validation, Software evolution. Coping with change - Prototyping, Incremental delivery, Boehm's Spiral Model. Agile software development - Agile methods, agile manifesto - values and principles. Agile development techniques, Agile Project Management. Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care.	**9**
II	Functional and non-functional requirements, Requirements engineering processes. Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix. Developing use cases, Software Requirements Specification Template, Personas, Scenarios, User stories, Feature identification. Design concepts - Design within the context of software engineering, Design Process, Design concepts, Design Model. Architectural Design - Software Architecture, Architectural Styles, Architectural considerations, Architectural Design Component level design - What is a component?, Designing Class-Based Components, Conducting Component level design, Component level design for web-apps. Template of a Design Document as per "IEEE Std 1016-2009 IEEE Standard for Information Technology Systems Design Software Design Descriptions". Case study: The Ariane 5 launcher failure.	**10**
III	Object-oriented design using the UML, Design patterns, Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD. Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. Informal	**11**

	Review, Formal Technical Reviews, Post-mortem evaluations. Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing, Debugging, White box testing, Path testing, Control Structure testing, Black box testing, Testing Documentation and Help facilities. Test automation, Test-driven development, Security testing. Overview of DevOps and Code Management - Code management, DevOps automation, Continuous Integration, Delivery, and Deployment (CI/CD/CD). Software Evolution - Evolution processes, Software maintenance.	
IV	Software Project Management - Risk management, Managing people, Teamwork. Project Planning, Software pricing, Plan-driven development, Project scheduling, Agile planning. Estimation techniques, COCOMO cost modeling. Configuration management, Version management, System building, Change management, Release management, Agile software management - SCRUM framework. Kanban methodology and lean approaches.	**8**
V	Software Quality, Software Quality Dilemma, Achieving Software Quality Elements of Software Quality Assurance, SQA Tasks , Software measurement and metrics. Software Process Improvement(SPI), SPI Process CMMI process improvement framework, ISO 9001:2000 for Software. Cloud-based Software - Virtualisation and containers, Everything as a service (IaaS, PaaS), Software as a service. Microservices Architecture -Microservices, Microservices architecture, Microservice deployment.	**7**
	Total Hours	**45**

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

(Each student shall identify a software development problem and prepare Requirements Specification, Design Document, Project Plan and Test case documents for the identified problem as the assignment.)

HS0U30A	INDUSTRIAL ECONOMICS & FOREIGN TRADE	Category	L	T	P	Credit	Year of Introduction
		HSC	3	0	0	3	2020

PRE REQUISITE : NIL

COURSE OVERVIEW:

The course enables students to make better economic decisions in wage employment and entrepreneurship using economic alternatives and investment alternatives.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the problem of scarcity of resources, consumer behaviour and the equilibrium condition of demand and supply.	Understand
CO 2	Demonstrate the production function and equilibrium condition of a producer	Understand
CO 3	Survey the functional requirement of a firm under various competitive conditions.	Analyse
CO 4	Infer the overall performance of the economy, the regulation of economic fluctuations and its impact on various sections in the society.	Analyse
CO 5	Compare the profitability of projects and businesses with the help of capital budgeting methods	Evaluate
CO 6	Determine the current impact of global economic policies on the business opportunities of a firm	Analyse

SYLLABUS

Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.

Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.
Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing –

Penetration pricing – Predatory pricing – Going rate pricing – Price skimming. Principles of taxation - Direct Tax – Indirect Tax – GST. Concepts of demonetization. Cryptocurrency

Circular flow of economic activities – Stock and flow Gross. National Income – Concepts - Methods of measuring national income – Inflation- causes and effects – Measures to control inflation. Monetary and fiscal policies – Business financing- Bonds and shares -Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY. Capital Budgeting - Methods of Investment analysis - Pay back, ARR, NPV, IRR and B/C ratio

Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers

REFERENCE MATERIALS

1. Gregory N Mankiw, 'Principles of Micro Economics', Cengage Publications 2015
2. Gregory N Mankiw, 'Principles of Macro Economics', Cengage Publications 2012
3. Dwivedi D.N., 'Macro Economics', Tata McGraw Hill, New Delhi
4. Mithani D M, 'Managerial Economics', Himalaya Publishing House, Mumbai
5. Tulsian, 'Financial Management' S Chand & Company 2017
6. Francis Cherunilam, 'International Economics', McGraw Hill, New Delhi

COURSE PLAN

Module	Contents	No. of hours
I	Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.	**8**
II	Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.	**8**
III	Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory pricing – Going rate pricing – Price skimming. Principles of taxation - Direct Tax – Indirect Tax – GST. Concepts of demonetization. Cryptocurrency	**9**
IV	Circular flow of economic activities – Stock and flow Gross. National Income – Concepts - Methods of measuring national income – Inflation- causes and effects – Measures to control inflation. Monetary and fiscal policies – Business financing- Bonds and shares -Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY. Capital Budgeting - Methods of Investment analysis	**11**

	- Pay back, ARR, NPV, IRR and B/C ratio	
V	Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers	**9**
	Total hours	**45**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks

CS2U30I	COMPREHENSIVE COURSE WORK	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	1	0	0	1	2022

Preamble: The objective of this Course work is to ensure the comprehensive knowledge of each student in the most fundamental core courses in the curriculum. Five core courses credited from semesters 3, 4 and 5 are chosen for the detailed study in this course work. This course helps the learner to become competent in cracking GATE, placement tests and other competitive examinations

Prerequisite:

1. **Data Structures**
2. **Operating Systems**
3. **Computer Organization And Architecture**
4. **Database Management Systems**
5. **Introduction to Machine Learning**

Course Outcomes: After the completion of the course the student will be able to

Course Outcomes	Description	Level
CO1	Comprehend the concepts and applications of data structures	**Understand**
CO2	Comprehend the concepts, functions and algorithms in Operating System	**Understand**
CO3	Comprehend the organization and architecture of computer systems	**Understand**
CO4	Comprehend the fundamental principles of database design and manipulation	**Understand**
CO5	Comprehend the concepts in Machine Learning	**Understand**

Mark distribution

Total Marks	CIE	ESE	ESE Duration
50	**0**	**50**	**1 hour**

End Semester Examination Pattern: Objective Questions with multiple choice, a maximum of four options. Question paper includes fifty questions of one mark each, distributed equally from all the five identified courses.

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS2U38C	Robotics lab	PCC	0	0	3		2	2022

COURSE OVERVIEW

Robotics lab provides students with exposure to the common sensor and actuator interfacing, setting up mobile robots and familiarizing intelligent systems.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Interface different peripherals to arduino board	**Apply**
CO 2	Assemble a mobile robot with different sensors and actuators	**Apply**
CO 3	Familiarise about localisation of mobile robots	**Apply**
CO 4	Impart intelligence to robot using standard algorithms	**Apply**
CO 5	Familiarise the robot navigation	**Apply**

SYLLABUS

ROS Essentials

• Installing and Configuring Your ROS Environment—ROS Kinetic/Melodic/Compatible versions

• Familiarisation with ROS (Master, nodes, topics, messages, services, parameters and actions)

• Familiarisation with ROS Tools – Gazebo , Moveit , Rviz

• Creating Workspace and Package in ROS

LIST OF EXPERIMENTS

Any 4 experiments from each group are mandatory

Part A:

Interfacing sensors and actuators

1.Familiarisation of Arduino IDE, Arduino microcontroller I/O interfacing(LED, LCD, Serial Monitor)

2. Interfacing IR and Ultrasonic sensor with Arduino

3. Interfacing DC motors with arduino - speed and direction control

4. Interfacing Servo Motors with Arduino - angle of rotation

5. Calibration of sensors-sonar, IR sensors and obtain the calibration curve

6. Mobile Robot assembly

7. Networking with Arduino: GSM and Bluetooth

Part B:

Intelligent systems

8. Writing a Simple Publisher and Subscriber, Simple Service and Client, Recording and playing back data, Reading messages from a bag file(Python/C++)

9. Localization of a mobile robot using LIDAR (ROS)

10. Touch Sensors interfacing and feedback system

11. Line following Robot using IR sensor

12. Obstacle avoidance of a mobile robot while moving to a point.

13. Object detection using any one standard algorithm

14. Navigation simulation using turtlebot using ROS

REFERENCES

1. Siegwart, Roland, Introduction to Autonomous Mobile Robots, Cambridge, Mass. : MIT Press, 2nd ed.
2. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer 2021
3. John. J. Craig, Introduction to Robotics (Mechanics and control), Pearson Education Asia 2002.
4. S K Saha, Introduction to Robotics by Mc Graw Hill Education, 2014.
5. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
6. Dahiya, Ravinder S., Valle, Maurizio, Robotic Tactile Sensing, Springer, 2013. https://emanual.robotis.com/docs/en/platform/turtlebot3/simulation

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 15 marks
Continuous Evaluation in Lab	: 30 marks
Continuous Assessment Test	: 15 marks
Viva-voce	: 15 marks

CS2U39A	MINI PROJECT	Category	L	T	P	Credit	Year of Introduction
		PCC	0	0	3	2	2022

PRE-REQUISITE: A sound knowledge in any programming language and fundamental concepts of Software Engineering.

COURSE OVERVIEW:

The objective of this course is to apply the fundamental concepts of Software Engineering principles for the effective development of an application/research project. This course helps the learners to practice the different steps to be followed in the software development process such as literature review and problem identification, preparation of Software Requirement Specification &Software Design Document (SDD), testing, development and deployment. Mini project enables the students to boost their skills, widen the horizon of thinking and their ability to resolve real life problems.

COURSE OUTCOMES: After the completion of the course the student will be able to

Course Outcomes	Description	Level
CO1	Identify technically and economically feasible problems	**Apply**
CO2	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes	**Apply**
CO3	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques	**Apply**
CO4	Prepare technical report and deliver presentation	**Apply**
CO5	Apply engineering and management principles to achieve the goal of the project	**Apply**

Guidelines

Student Groups with 3 or 4 members should identify a topic of interest in consultation with a Faculty/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives by strictly following steps specified in the teaching plan. Innovative design concepts, performance, scalability, reliability considerations, aesthetics/ergonomic, user experience and security aspects taken care of in the project shall be given due weight. The progress of the mini project is evaluated

based on a minimum of two reviews. The review committee may be constituted by the Head of the Department comprising HoD or a senior faculty member, Mini Project coordinator and project guide. The internal evaluation shall be made based on the progress/outcome of the project, reports and a viva-voce examination, conducted internally by a 3-member committee. A project report is required at the end of the semester. The project has to be demonstrated for its full design specifications.

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks
150	75	75

CONTINOUS ASSESSMENT EVALUATION PATTERN

Attendance	10 marks
Project Guide	15 marks
Project Report	10 marks

Minors

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction	
CS0M30D	INTRODUCTION TO SOFTWARE TESTING	**VAC**	**3**	**1**	**0**		**4**	**2022**	

COURSE OVERVIEW

This is a course in theoretical computer science that includes test cases for white-box, black- box, and grey-box approaches. This course describes the various techniques for test case design used to test software artifacts, including requirements, design, and code. The course includes different techniques for test case design based on graphs, programming language syntaxes and inputs. The course also covers symbolic execution using PEX tool.

Prerequisite: NIL

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	
CO 1	List a range of different software testing techniques and be able to apply specific unit testing method to the projects using Junit.	Understand
CO 2	Explain mutation testing method for a given piece of code to identify hidden defects that can't be detected using other testing methods.	Understand
CO 3	Explain graph coverage criteria in terms of control flow graph and data flow graph for a given program	Understand
CO 4	Demonstrate the importance of black-box approaches in terms of domain and functional testing.	Understand
CO 5	Illustrate the use of PEX tool with symbolic execution.	Understand

SYLLABUS

Software testing, Types of Testing- Unit testing, integration testing, System testing, Acceptance testing, Beta testing, Concept of Unit testing. Static Unit testing. Dynamic Unit testing - Control Flow testing, Data Flow testing, Domain testing, Overview of Graph Coverage Criteria. Structural Graph Coverage Criteria - Node/vertex coverage, Edge coverage, Edge pair coverage, Path coverage, Complete path coverage, Prime path coverage, Complete round trip coverage, Simple round trip coverage. Data Flow Criteria - du paths, du pairs., Coverage criteria on inheritance graph, Data flow at the design level, Inter-procedural DU pairs, Coupling du-pairs example. Example - Quadratic Root. Case Study - Graph Based testing using JUnit Framework. Domain Testing / Input Space Partitioning - Partitions of a set. Input domain modelling - Interface-based approach, Introduction to Grey Box testing

TEXT BOOKS

1. Paul Ammann and JeffOffutt ,Introduction to Software Testing.
2. KshirasagarNaik and PriyadarshiTripathy, Software Testing And Quality Assurance: Theory And Practice.

REFERENCES

1. https://www.csc.ncsu.edu/academics/undergrad/honors/thesis/muclipsebinder.pdf - Muclipse tutorial.
2. King, James C, "Symbolic Execution and Program Testing", Association for Computing Machinery, July 1976.

COURSE PLAN

Module	Contents	
I	**Introduction to Software Testing :** Some Popular Errors – Ariane 5, Therac 25, Intel Pentium Bug. What is Software testing? Why should it be tested? Software Quality, Role of Testing. Testing Process - Level 0 thinking, Level 1 thinking, Level 2 thinking, Level 3 thinking, Level 4 thinking. Software Testing Terminologies - Verification, Validation and Testing, Faults, Error and Bug, Test cases, Coverage Criteria. Types of Testing- Unit testing, integration testing, System testing, Acceptance testing, Beta testing, Functional testing, Stress testing, Performance testing, Usability testing and Regression testing. Testing Methods - Black Box testing, White Box testing, Grey Box testing.	**12**
II	**Unit Testing :** Concept of Unit testing. Static Unit testing. Dynamic Unit testing - Control Flow testing, Data Flow testing, Domain testing, Functional Program testing. Mutation testing - Mutation and Mutants, Mutation operators, Mutation score. Junit - Framework for Unit testing. Case Study - Mutation testing using Junit and Muclipse.	**12**
III	**Unit Testing - White Box Approaches :** Overview of Graph Coverage Criteria. Structural Graph Coverage Criteria - Node/vertex coverage, Edge coverage, Edge pair coverage, Path coverage, Complete path coverage, Prime path coverage, Complete round trip coverage, Simple round trip coverage. Data Flow Criteria - du paths, du pairs. Subsumption Relationships among Graph Coverage Criteria. Graph Coverage for Source Code - Control flow graphs for code, CFG: If statement, CFG: If statement with return, CFG: Switch-case, CFG: Loops, CFG: Exceptions (try-catch). Example program – Statistics. Graph Coverage for Design Elements - Call graphs and classes, Class inheritance testing: Coverage criteria, Coverage criteria on inheritance graph, Data flow at the design level, Inter-procedural DU pairs, Coupling du-pairs example. Example - Quadratic Root. Case Study - Graph Based testing using JUnit Framework	**12**
IV	**Unit Testing - Black Box Approaches :** Domain Testing / Input Space Partitioning - Partitions of a set. Input domain modelling - Interface-based approach, Functionality-based approach. Identifying values. Multiple partitions of the inputdomain - All Combinations Coverage (ACoC), Each Choice Coverage (ECC), Pair-wise Coverage, T-wise Coverage, Base Choice Coverage, Multiple Base Choices Coverage. TriTyp example. Functional Testing - Functional Testing Concepts of Howden. Functional	**12**

	testing - Important Steps. Types of Functional testing - Equivalence Class Partitioning, Boundary Value Analysis, Decision Tables, Random Testing. Case Study - Black Box testing approaches using Junit.	
V	**Grey Box Testing Approaches :** Introduction to Grey Box testing - Why Grey Box testing, Gray Box Methodology, Advantages and Disadvantages. Techniques of Grey Box Testing - Matrix Testing, Regression Testing, Orthogonal Array Testing or OAT, Pattern Testing. An Introduction to PEX - Parameterized Unit Testing, The Testing Problem. Symbolic Execution – Example, Symbolic execution tree. PEX application Case Study – PEX.	**12**
	Total Hours	

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction	
CS0M30E	CONCEPTS IN DEEP LEARNING	VAC	3	1	0		4	2022	

COURSE OVERVIEW

This course aims to introduce the learner to an overview of the concepts and algorithms involved in deep learning. Deep learning is a subfield of machine learning, a subfield of artificial intelligence. Basic concepts and application areas of machine learning, deep networks, convolutional neural network and recurrent neural network are covered here. This is a foundational program that will help students understand the capabilities, challenges, and consequences of deep learning and prepare them to participate in the development of leading-edge AI technology. They will be able to gain the knowledge needed to take a definitive step in the world of AI.

Prerequisite: Sound knowledge in Basics of linear algebra and probability theory.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Demonstrate basic concepts in machine learning.	Understand
CO 2	Illustrate the validation process of machine learning models using hyper-parameters and validation sets.	Understand
CO 3	Demonstrate the concept of the feed forward neural network and its training process.	Apply
CO 4	Build CNN and Recurrent Neural Network (RNN) models for different use cases.	Apply
CO 5	Use different neural network/deep learning models for practical applications.	Apply

SYLLABUS

Neural Networks. Introduction to optimization– Convolutional Neural Networks Practical challenges of common deep learning architectures- early stopping, parameter sharing, dropout. Case study: AlexNet, VGG, ResNet. Recurrent neural networks Applications – computer vision, speech recognition, natural language processing, common word embedding: continuous Bag-of-Words, Word2Vec, global vectors for word representation (GloVe). Research Areas – autoencoders, representation learning, boltzmann machines, deep belief networks.

TEXT BOOKS

1. Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, MIT Press 2015 ed.
2. Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola, Dive into Deep Learning, August 2019.
3. Neural Networks and Deep Learning, Aggarwal, Charu C., c Springer International Publishing AG, part of Springer Nature 2018

REFERENCES

1. Neural Smithing: Supervised Learning in Feedforward Artificial Neural Networks by Russell Reed, Robert J MarksII, A Bradford Book,2014
2. Practical Convolutional Neural Networks by MohitSewak, Md. Rezaul Karim, PradeepPujari,Packt Publishing 2018
3. Hands-On Deep Learning Algorithms with Python by SudharsanRavichandran,Packt Publishing 2019
4. Deep Learning with Python by Francois Chollet,Manning Publications Co.,2018

COURSE PLAN

Module	Contents	Hours
I	**Introduction:** Key components - Data, models, objective functions, optimization algorithms, Learning algorithm. Supervised learning- regression, classification, tagging, web search, page ranking, recommender systems, sequence learning, Unsupervised learning, Reinforcement learning, Historical Trends in Deep Learning. Other Concepts - overfitting, underfitting, hyperparameters and validation sets, estimators, bias and variance.	**12**
II	**Optimization and Neural Networks :** Neural Networks –Perceptron, Gradient Descent solution for Perceptron, Multilayer perceptron, activation functions, architecture design, chain rule, back propagation, gradient based learning. Introduction to optimization– Gradient based optimization, linear least squares. Stochastic gradient descent, Building ML algorithms and challenges.	**12**
III	**Convolutional Neural Network :** Convolutional Neural Networks – convolution operation, motivation, pooling, Structure of CNN, Convolution and Pooling as an infinitely strong prior, variants of convolution functions, structured outputs, data types, efficient convolution algorithms. Practical challenges of common deep learning architectures- early stopping, parameter sharing, dropout. Case study: AlexNet, VGG, ResNet.	**12**
IV	**Recurrent Neural Network :** Recurrent neural networks – Computational graphs, RNN design, encoder – decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, modern RNNs LSTM and GRU, Practical use cases for RNNs.	**12**
V	**Application Areas :** Applications – computer vision, speech recognition, natural language processing, common word embedding: continuous Bag-of-Words, Word2Vec, global vectors for word representation (GloVe). Research Areas – autoencoders, representation learning, boltzmann machines, deep belief networks.	**12**
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS0M30F	**WIRELESS NETWORKS AND IoT APPLICATIONS**	**VAC**	**3**	**1**	**0**		**4**	**2022**

COURSE OVERVIEW

This course equips the learners with fundamental wireless technologies for the Internet of Things(IoT) and the IoT ecosystem. It covers the underlying concepts in wireless networks, communication mechanisms, protocols, hardware, software, and the cloud platforms for IoT. The students will be able to design smart IoT applications for real world problems.

Prerequisite: Sound knowledge in Data Communication, Computer Networks and Programming in C.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description
CO 1	Recognize wireless technologies required for IoT ecosystem **(Cognitive Knowledge Level : Understand)**
CO 2	Perceive the concept of IoT and M2M architecture, IoT examples, and Data Management in IoT **(Cognitive Knowledge Level :Apply)**
CO 3	Outline the hardware components used in IoT including Sensors, Actuators and development boards **(Cognitive Knowledge Level : understand)**
CO 4	Explain the software components of IoT **(Cognitive Knowledge Level :Understand)**
CO 5	Demonstrate the protocols used in IoT and build IoT Programs **(Cognitive Knowledge Level : Apply)**
CO 6	Demonstrate the protocols used in IoT and build IoT Programs **(Cognitive Knowledge Level : Apply)**

SYLLABUS

Module- 1 (Introduction to IoT and wireless technologies required for IoT)

Internet of Things, Role of Things and the Internet, Wireless IoT. Wireless Networks - Network Topologies, Types of Networks. Role of Wireless Standards in IoT. Protocol Stack - OSI Model, TCP/IP Model, IEEE 802 Reference Model, Protocols for Wireless IoT. Bluetooth - Transceiver, Frequency Channels, Typical Range, Access and Spread Spectrum, Modulation and Data Rate, Error Correction and Detection, Network Topology. ITU G.9959, Zwave, IEEE 802.15.4, Zigbee Specification, Thread, WiFi, 6LowPAN, IPv6, LoRaWAN.

Module- 2 (IoT architecture, Data and Device management)

Internet of Things - IoT Architectural View, Technology Behind IoT - Server End Technology, Sources of Internet of Things, M2M Communication. IoT Application Areas. IoT Examples. IoT Data Management - Device Management Gateways. Design Principles for Web Connectivity - Web Communication Protocols for Connected Devices, Web Connectivity for Connected Devices using

Gateways. Internet Connectivity Principles – Internet Connectivity, Internet based communication, IP addressing in the IoT.

Module- 3 (Data Acquiring and Enabling Technologies)

Data Acquiring and Storage for IoT Sevices- Organization of Data, Big data, Acquiring Methods, Management Techniques, Analytics, Storage Technologies. Cloud Computing for Data storage - IoT Cloud based Services using Xively, Nimbits, and Other Platforms. Sensor Technologies for IoT Devices - Sensor Technology, Participatory Sensing, Industrial IoT and Automotive IoT, Actuators for Various Devices, Sensor Data Communication Protocols, Wireless Sensor network Technology

Module-4 (Prototyping the Embedded Devices for IoT)

Embedded Computing Basics, Embedded Hardware Unit. Embedded Platforms for Prototyping - Arduino, Intel Galileo, Intel Edison, Raspberry Pi, BeagleBone, mBed. Prototyping and Designing the Software for IoT Applications- Introduction, Prototyping Embedded DeviceSoftware- Programming using Arduino, Programming for an Arduino Controlled Traffic Control Lights at a Road Junction, Basic Arduino Programs to Blink LED, Find the Distance using Ultrasonic Sensor, Estimate Room Temperature, Measuring Soil Moisture Level

Module 5 (Business Models and Case Studies)

Business Models and Processes using IoT. Value Creation in the Internet of Things. Cloud PaaS- Xively, Nimbits, IBM Bluemix, CISCO IoT, AWS IoT, TCS Connected AWS Platform, Case studies- Smart Home, Smart Environment, Smart healthcare, Smart agriculture

TEXT BOOKS

1. Daniel Chew, “Wireless Internet of Things -A Guide to the lower layers”, IEEE Standards and Association, IEEE Press, Wiley
2. Rajkamal, “Internet of Things : Architecture and Design Principles”, McGraw Hill (India) Private Limited.

REFERENCES

1. ArshadeepBahga, Vijay Madisetti, “Internet of Things: A hands-on approach”, University Press, 2015 (First edition)
2. Dieter Uckelmann, Mark Harrison, Michahelles Florian (Ed.), Architecting the internet of things, Springer, 2011
3. Dr. Ovidiu Vermesan, Dr. Peter Friess, Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, River Publishers, 2013
4. Simon Monk, “Programming Arduino: Getting Started with Sketches”, McGraw Hill Publications

COURSE PLAN

Module	Contents	Hours
I	**Introduction to IoT and wireless technologies required for IoT :** Internet of Things, Role of Things and the Internet, Wireless IoT. Wireless Networks - Network Topologies, Types of Networks. Role of Wireless Standards in IoT. Protocol Stack - OSI Model, TCP/IP Model, IEEE 802 Reference Model, Protocols for Wireless IoT. Bluetooth - Transceiver, Frequency Channels, Typical Range, Access and Spread Spectrum, Modulation and Data Rate, Error Correction and Detection, Network Topology. ITU G.9959, Zwave, IEEE	**12**

	802.15.4, Zigbee Specification, Thread, WiFi, 6LowPAN, IPv6, LoRaWAN.	
II	**IoT architecture, Data and Device management :** Internet of Things - IoT Architectural View, Technology Behind IoT - Server End Technology, Sources of Internet of Things, M2M Communication. IoT Application Areas. IoT Examples. IoT Data Management - Device Management Gateways. Design Principles for Web Connectivity - Web Communication Protocols for Connected Devices, Web Connectivity for Connected Devices using Gateways. Internet Connectivity Principles – Internet Connectivity, Internet based communication, IP addressing in the IoT.	**12**
III	**Data Acquiring and Enabling Technologies :** Data Acquiring and Storage for IoT Sevices- Organization of Data, Big data, Acquiring Methods, Management Techniques, Analytics, Storage Technologies. Cloud Computing for Data storage - IoT Cloud based Services using Xively, Nimbits, and Other Platforms. Sensor Technologies for IoT Devices - Sensor Technology, Participatory Sensing, Industrial IoT and Automotive IoT, Actuators for Various Devices, Sensor Data Communication Protocols, Wireless Sensor network Technology	**12**
IV	**Prototyping the Embedded Devices for IoT :** Embedded Computing Basics, Embedded Hardware Unit. Embedded Platforms for Prototyping - Arduino, Intel Galileo, Intel Edison, Raspberry Pi, BeagleBone, mBed. Prototyping and Designing the Software for IoT Applications- Introduction, Prototyping Embedded DeviceSoftware- Programming using Arduino, Programming for an Arduino Controlled Traffic Control Lights at a Road Junction, Basic Arduino Programs to Blink LED, Find the Distance using Ultrasonic Sensor, Estimate Room Temperature, Measuring Soil Moisture Level	**12**
V	**Business Models and Case Studies :** Business Models and Processes using IoT. Value Creation in the Internet of Things. Cloud PaaS- Xively, Nimbits, IBM Bluemix, CISCO IoT, AWS IoT, TCS Connected AWS Platform, Case studies- Smart Home, Smart Environment, Smart healthcare, Smart agriculture	**12**
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Honour Basket 1: SECURITY IN COMPUTING

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS1H30D	NETWORK SECURITY	**VAC**	**3**	**1**	**0**		**4**	**2022**

COURSE OVERVIEW

The purpose of this course is to create a better understanding of the network security concepts. This course covers network security standards, email security services, web security mechanisms, firewalls and wireless security mechanisms. This course helps the learner to gain insight into the key aspects of secure network communication and enables to apply in real-life scenarios.

Prerequisite: A sound background in Number Theory and Cryptographic Algorithms

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description
CO 1	Identify the key aspects of security, intrusion detection systems and digital signature schemes (Cognitive Knowledge Level: Apply)
CO 2	Explain the security standards used in network communication (Cognitive Knowledge Level:Understand)
CO 3	Identify the mechanisms in email security services (Cognitive Knowledge Level: Apply)
CO 4	Summarize the protocols used to provide web security (Cognitive Knowledge Level: Understand)
CO 5	Explain the fundamental concepts of wireless network security and firewalls (Cognitive Knowledge Level: Understand)

SYLLABUS

Module – 1 (Network Security Basics) Introduction to network security - Security requirements, Challenges of security, Network security model. Malicious programs – Worms, Viruses, Trojans, Spyware, Adware. Intrusion Detection Systems (IDS) - Uses, Techniques. Digital signatures - ElGamal, Schnorr, Digital Signature Standard (DSS).

Module – 2 (Network Security Standards) Kerberos v4 – Configuration, Authentication, Encryption, Message formats. Kerberos v5 – Cryptographic algorithms, Message formats. Public Key Infrastructure (PKI) – Trust models, Revocation. Real-time communication security – Perfect Forward Secrecy (PFS), Denial-ofService protection, Endpoint identifier hiding, Live partner reassurance. Internet Protocol Security (IPSec) - Authentication Header (AH), Encapsulating Security Payload (ESP), Internet Key Exchange (IKE) phases.

Module – 3 (Email Security) Introduction to email security - Security services for email, Establishing keys, Privacy, Authentication, Message integrity, Non-repudiation. Privacy Enhanced Mail (PEM) – Encryption, Source authentication and integrity protection, Message formats. Secure/Multipurpose Internet Mail Extensions (S/MIME) – Messages, Differences from PEM. Pretty Good Privacy (PGP) - Encoding, Certificate and key revocation, Anomalies, Object formats.

Module – 4 (Web Security) Introduction to web security - Web security considerations, Threats. Secure

Sockets Layer (SSL) – Architecture, Protocols, Transport Layer Security (TLS) – Differences from SSL. Hypertext Transfer Protocol Secure (HTTPS) – Connection initiation, Closure. Secure Shell (SSH) – Transport layer protocol, User authentication protocol, Connection protocol.

Module – 5 (Wireless Network Security and Firewalls) IEEE 802.11 Wireless LAN - Network components, Architectural model, Services. IEEE 802.11i wireless LAN security - Services, Phases of operation. Wired Equivalent Privacy (WEP), Wi-Fi Protected Access (WPA), WPA2, Wireless Application Protocol (WAP) – Services, Protocol architecture. Firewalls – Need for firewalls, Packet filters, Circuit-level firewalls, Application layer firewalls.

TEXT BOOKS

1. C. Kaufman, R. Perlman and M. Speciner, "Network Security: Private Communication in a Public World", 2/e, PHI.
2. William Stallings, "Cryptography and Network Security Principles and Practice", 5/e, Pearson

REFERENCES

1. Behrouz A. Forouzan, Debdeep Mukhopadhyay, "Cryptography and Network Security", 3/e, Tata McGraw Hill.
2. Tyler Wrightson, "Wireless Network Security A Beginner's Guide", 2012, Tata McGraw Hill. 3. William Stallings, "Network Security Essentials: Applications and Standards", 4/e, Prentice Hall.
3. Schiller J., Mobile Communications, 2/e, Pearson Education.
4. Roberta Bragg et. al., "Network Security: The Complete Reference", Tata McGraw Hill.

COURSE PLAN

Module	Contents	Hours
I	Introduction to network security - Security requirements, Challenges of security, Network security model. Malicious programs – Worms, Viruses, Trojans, Spyware, Adware. Intrusion Detection Systems (IDS) - Uses, Techniques. Digital signatures - ElGamal, Schnorr, Digital Signature Standard (DSS).	**12**
II	Module – 2 (Network Security Standards) Kerberos v4 – Configuration, Authentication, Encryption, Message formats. Kerberos v5 – Cryptographic algorithms, Message formats. Public Key Infrastructure (PKI) – Trust models, Revocation. Real-time communication security – Perfect Forward Secrecy (PFS), Denial-ofService protection, Endpoint identifier hiding, Live partner reassurance. Internet Protocol Security (IPSec) - Authentication Header (AH), Encapsulating Security Payload (ESP), Internet Key Exchange (IKE) phases.	**12**
III	Module – 3 (Email Security) Introduction to email security - Security services for email, Establishing keys, Privacy, Authentication, Message integrity, Non-repudiation. Privacy Enhanced Mail (PEM) – Encryption, Source authentication and integrity protection, Message formats. Secure/Multipurpose Internet Mail Extensions (S/MIME) – Messages, Differences from PEM. Pretty Good Privacy (PGP) - Encoding, Certificate and key revocation, Anomalies, Object formats.	**12**
IV	Module – 4 (Web Security) Introduction to web security - Web security considerations, Threats. Secure Sockets Layer (SSL) – Architecture, Protocols,	**12**

	Transport Layer Security (TLS) – Differences from SSL. Hypertext Transfer Protocol Secure (HTTPS) – Connection initiation, Closure. Secure Shell (SSH) – Transport layer protocol, User authentication protocol, Connection protocol.	
V	Module – 5 (Wireless Network Security and Firewalls) IEEE 802.11 Wireless LAN - Network components, Architectural model, Services. IEEE 802.11i wireless LAN security - Services, Phases of operation. Wired Equivalent Privacy (WEP), Wi-Fi Protected Access (WPA), WPA2, Wireless Application Protocol (WAP) – Services, Protocol architecture. Firewalls – Need for firewalls, Packet filters, Circuit-level firewalls, Application layer firewalls.	**12**
	Total Hours	**60**

Honour Basket 2: COMPUTATIONAL BIOLOGY

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS2H30C	MACHINE LEARNING IN COMPUTATIONAL BIOLOGY	**VAC**	**3**	**1**	**0**		**4**	**2022**

COURSE OVERVIEW

This course is intended to provide the learners a outlook towards application of Machine learning algorithms in the field of computational biology. This course helps the learners to apply the Machine learning methods - clustering algorithms, dimensionality reduction, decision drees, Artificial Neural Network, Support Vector Machine to the computational biology problems. Also the course discuss Challenges of Machine Learning in Computational Biology and Future directions of Machine Learning in Computational Biology

Prerequisite: Basic background in Bioinformatics and Machine Leaning

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the basic concepts of Machine Leaning, Classification, regression and clustering problems, parameters and measures	Under stand
CO 2	Demonstrate the clustering algorithm on computational biology problems	Apply
CO 3	Explain Dimensionality reduction techniques and Decision Trees in computational biology	Apply
CO 4	Illustrate Feature Extraction and Pattern recognition and Classification in the domain of Computational Biology analysis	Apply
CO 5	Explain the role and challenges of Machine Learning in Computational	Under stand

SYLLABUS

TEXT BOOKS

1. Statistical Modelling and Machine Learning Principles for Bioinformatics Techniques, Tools, and Applications. Germany, Springer Singapore, 2020.
2. Yang, ZhengRong. Machine Learning Approaches to Bioinformatics. Singapore, World Scientific Publishing Company, 2010.

REFERENCES

1. Izadkhah, Habib. Deep Learning in Bioinformatics: Techniques and Applications in Practice. Netherlands, Elsevier Science, 2022.

2. Agapito, Giuseppe, et al. Artificial Intelligence in Bioinformatics: From Omics Analysis to Deep Learning and Network Mining. Netherlands, Elsevier Science, 2022.
3. Data Analytics in Bioinformatics: A Machine Learning Perspective. United States, Wiley, 2021.
4. Michailidis, George, et al. Introduction to Machine Learning and Bioinformatics. United Kingdom, CRC Press, 2008.
5. Zhang, Yanqing, and Rajapakse, Jagath C, Machine Learning in Bioinformatics, Germany, Wiley, 2009.
6. Baldi, Professor Pierre, et al. Bioinformatics, Second Edition: The Machine Learning Approach. India, Bradford, 2001.

COURSE PLAN

Module	Contents	Hours
I	Overview of Machine Learning- Overview of Machine Learning, fitting predictive models to data, Supervised and unsupervised learning, Classification, regression and clustering problems, Loss or cost functions. Parameters and hyperparameters, Training. validation and testing, Inductive bias and the bias variance trade-off, Use of clustering models.	**12**
II	Clustering problems Computational Biology Hierarchical Clustering, Partition Clustering, Overview Model-Based Clustering, k-Means clustering, k-Means clustering algorithm, Advantages, Disadvantages, illustrative example of kMeans clustering, Clustering for creating phylogenetic trees, Using Clustering Approach to Identify Patients' Subtypes, Application of clustering algorithms on gene expression data.	**12**
III	Supervised techniques for Computational Biology- Proteomics Dataset, Data Pre-processing Algorithms, Dimension and Feature Subset Selection, Dimensionality reduction - Principal Component Analysis (PCA), Partial Least Square (PLS), Linear Discriminant Analysis (LDA), Protein Classification, Decision Trees in Bioinformatics, Proteomic Mass Spectra Classification Using Decision Tree Technique.	**12**
IV	Machine-Learning Algorithms for Computational Biology- Machine-Learning Algorithms for Feature Selection from Gene Expression Data, Feature Extraction and Pattern recognition from sequence data, measures of a Feature. Artificial Neural Network (ANN) in Bioinformatics, Genetic Algorithms (GA) in Bioinformatics, Designing ANN for Bioinformatics, ANN in Protein Bioinformatics, Support Vector Machine with Feature Elimination.	**12**
V	Scope of Machine Learning in Computational Biology-Role of Machine Learning in Computational Biology, Creation and analysis of sequence data, Challenges of Machine Learning in Computational Biology, Data Errors, Mean Square Error Generative versus Discriminative, Approximation Versus Explanation, Single Versus Multiple Methods, Future directions of Machine Learning in Computational Biology.	**12**
	Total Hours	**60**

Honour Basket 3: COMPUTER VISION

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS2H30D	IMAGE AND VIDEO PROCESSING	VAC	3	1	0		4	2022

COURSE OVERVIEW

This course enables the learners to understand how digital images are stored and processed. The learners are exposed to different spatial and frequency domain methods for image enhancement, image restoration techniques, morphological operations that could be performed on digital images and also various image and video compression techniques. The course also gives an introduction to the basics of video processing and video segmentation.

Prerequisite: Advanced Computer Graphics, Advanced Concepts in Computer Vision

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Summarize the steps of digital image processing and pixel relationships.	Understand
CO 2	Apply spatial and frequency domain methods for image enhancement.	Apply
CO 3	Apply restoration techniques and morphological operations on digital images.	Apply
CO 4	Compare different methods for digital image and video compression.	Apply
CO 5	Understand the basics of video and video segmentation	Understand

SYLLABUS pocessing

Image Enhancement: Spatial Domain methods - Gray level transformations, Histogram Processing, Fundamentals of Spatial Filtering,), Discrete Wavelet transforms. Frequency Domain methods: Basics of filtering in frequency domain, image smoothing, image sharpening, homomorphic filtering, , Periodic Noise reduction by frequency domain filtering. Morphological Operations: Erosion, Dilation, Video processing

TEXT BOOKS

1. Gonzalez and Woods , “Digital Image Processing”, 3rd edition , Pearson, 2009.
2. Li, Ze-Nian, Mark S. Drew, and Jiangchuan Liu. “Fundamentals of multimedia”, Pearson Prentice Hall, 2004.
3. Bovik, Alan C. “Handbook of image and video processing”, Academic press, 2010.

REFERENCES

1. David A. Forsyth & Jean Ponce, Computer vision – A Modern Approach, Prentice Hall, 2002.
2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer.
3. Maheshkumar H Kolekar, “Intelligent Video Surveillance Systems: An Algorithmic

Approach", CRC Press.
4. Francesco Camastra, Alessandro Vinciarelli, "Machine Learning for Audio, Image and Video Analysis: Theory and Applications", Springer 2015.
5. M. Tekalp ,"Digital video Processing", Prentice Hall International
6. Relf, Christopher G.,"Image acquisition and processing with LabVIEW", CRC press Chris Solomon, Toby Breckon ,"Fundamentals of Digital Image Processing A Practical Approach with Examples in Matlab", John Wiley & Sons,
7. Yao wang, Joem Ostarmann and Ya – quin Zhang, "Video processing and communication ",1st edition , PHI

COURSE PLAN

Module	Contents	Hours
I	Module – 1 Fundamentals of Image processing: Basic steps of Image processing system, sampling and quantization of an Image, basic relationship between pixels and connectivity. Image Enhancement: Spatial Domain methods - Gray level transformations, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing Spatial filters, Sharpening Spatial filters.	**12**
II	Module -2 Image Transforms: Unitary transforms, 2D Discrete Fourier Transform, Discrete Cosine Transform (DCT), Discrete Wavelet transforms. Frequency Domain methods: Basics of filtering in frequency domain, image smoothing, image sharpening, homomorphic filtering	**12**
III	Module - 3 Image Restoration: Image degradation/Restoration model, Noise models, Restoration in presence of noise only - spatial filtering, Periodic Noise reduction by frequency domain filtering. Morphological Operations: Erosion, Dilation, Opening, Closing, Hit-or-miss transformation, Boundary extraction.	**2**
IV	Module - 4 Image compression fundamentals – Coding Redundancy, spatial and temporal redundancy. Compression models : Lossy and Lossless, Huffman coding, Arithmetic coding, LZW coding, run length coding, Bit Plane coding, JPEG standards.	**12**
V	Module - 5 Video processing: Basics of Video Processing: Analog video, Digital Video. Video segmentation: Introduction to video segmentation, Change detection. COMPUTER SCIENCE AND ENGINEERING(ARTIFICIAL INTELLIGENCE) Video Compression: Introduction to video compression, video compression based on motion compensation, Search for motion vectors, H.261 standard, Transform coding, predictive codingMPEG.	**12**
	Total Hours	**60**

PROGRAM ELECTIVE I

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS1U31C	FOUNDATIONS OF SECURITY IN COMPUTING	PEC	2	1	0		3	2022

PRE-REQUISITE:MA0U20B- Discrete Mathematical Structures, CS1U20F-Operating Systems and CS1U20E-Database Systems.

COURSE OVERVIEW: The purpose of this course is to create awareness among learners about the fundamentals of security and number theory. This course covers Integer & Modular Arithmetic, Primes & Congruences, Discrete Logarithms & Elliptic Curve Arithmetic and an overview of computer security. The concepts covered in this course enable the learners in effective use of cryptographic algorithms and to identify the security threats in computing.

COURSE OUTCOMES: After the completion of the course, the student will be able to

CO1	Illustrate the operations and properties of algebraic structures, integer arithmetic and modular arithmetic.	**Understand**
CO2	Use the concepts of prime numbers and factorization for ensuring security in computing	**Apply**
CO3	Illustrate the concepts of Linear Congruence, Primitive Roots, Discrete Logarithms and Elliptic Curve Arithmetic	**Apply**
CO4	Summarize the threats and attacks related to computer and program security	**Understand**
CO5	Outline the key aspects of operating system and database security	**Understand**

SYLLABUS

Integer arithmetic-Modular arithmetic-Algebraic structures-Prime numbers-Fermat's theorem-Primality testing-Euler's theorem- Factorization-Linear congruence-Simultaneous linear congruence-Solving congruence modulo prime powers-Primitive roots-Elliptic curve arithmetic-Prime curves, Binary curves-Introduction to computer security-Browser attack types-Web attacks -Email attack types-Introduction to program security-Operating system security -Database security.

TEXT BOOKS

1. Behrouz A Forouzan, Cryptography and Network Security, 3/e, Tata McGraw-Hill.
2. Charles P Pfleeger, Shari Lawrence Pfleeger, Jonathan Margulies, Security in Computing, 5/e, Prentice Hall.
3. G.A. Jones & J.M. Jones, Elementary Number Theory, Springer UTM, 2007

REFERENCE MATERIALS

1. William Stallings, Cryptography and Network Security Principles and Practices, 4/e,

Pearson Ed.

COURSE PLAN

Module	Contents	No. of hours
I	Integer arithmetic - Integer division, Divisibility, Greatest Common Divisor (GCD), Euclid's algorithm for GCD, Extended Euclid's algorithm, Linear Diophantine Equations. Modular arithmetic - Operations, Properties. Algebraic structures - Groups, Rings, Fields, Finite fields, GF(p), GF (2^n).	**8**
II	Prime numbers - Prime numbers and prime-power factorization, Fermat and Mersenne primes, Fermat's theorem, Applications, Euler's theorem, Euler's totient function, Applications. Primality testing – Deterministic algorithms and Probabilistic algorithms. Factorization - Fermat's factorization, Pollard p-1 method.	**10**
III	Linear congruence - Simultaneous linear congruence, Chinese Remainder Theorem (CRT). Congruence with a prime - Power modulus, Arithmetic modulo p, Pseudoprimes and Carmichael numbers, Solving congruence modulo prime powers. Primitive roots - Existence of primitive roots for primes, Discrete logarithms. Elliptic curve arithmetic – Prime curves, Binary curves, Addition of two points, Multiplication of a point by a constant.	**10**
IV	Introduction to computer security – Threats, Vulnerabilities, Controls. Browser attack types, Web attacks targeting users, Email attack types. Introduction to program security - Non-malicious programming oversights, Malware.	**9**
V	Operating system security – Security in operating system, Security in design of operating system. Database security – Security requirements of databases, Reliability and integrity, Database disclosure.	**8**
	Total Hours	**45**

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS1U31G	Applied Data Science with Python Industry elective	**PEC**	**2**	**0**	**2**		**3**	**2022**

PRE-REQUISITES

Python Basics: Basic Python syntax, Control structures (loops, conditionals), Functions and lambda functions, Basic data structures (lists, dictionaries, tuples, sets Mathematics: Linear Algebra, Calculus, Probability and Statistics, General Computing Knowledge: Familiarity with the command line or terminal, Basic understanding of how databases work, including SQL, Experience with a code editor or an Integrated Development Environment(IDE) like PyCharm or Visual Studio Code.

COURSE OVERVIEW

Applied Data Science with Python course, a comprehensive journey designed to equip you with th knowledge, skills, and tools necessary to thrive in today's data-driven world. This course serves as bridge between theoretical foundations and real-world applications, offering you the hands-c experience required to tackle actual data challenges.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Make use of Pandas library to effectively process complex datasets.	**Apply**
CO 2	Create effective data visualization using Python libraries	**Apply**
CO 3	Build machine learning and deep learning models using Python libraries	**Apply**
CO 4	Apply Natural Language Processing techniques in data analysis.	**Apply**
CO 5	Develop models using Time series data to solve real world problems	**Apply**

SYLLABUS

Introduction to Data Science and Python ,Data Manipulation with Pandas, Advanced Pandas-Merging, Joining and Concatenating, Pivot Tables, Time Series Analysis in Pandas, Data Visualization with Matplotlib and Seaborn, Seaborn for Statistical Visualization, Advanced Visualization Techniques, Exploratory Data Analysis (EDA),Visual EDA , Introduction to Machine Learning with Scikit-learn, Regression Techniques ,Classification Techniques, Model Evaluation ,Advanced Machine Learning Techniques, Ensemble Methods ,Unsupervised Learning ,Hyperparameter Tuning, Introduction to Deep Learning with TensorFlow/Keras. Understanding Neural Networks, Implementing Neural Networks, Introduction to Convolutional Neural Networks, Natural Language Processing with NLTK and SpaCy, Text Classification and Sentiment Analysis, Named Entity Recognition, Time Series Forecasting with Python, Forecasting Models, Data Science Project.

TEXT BOOKS

1. McKinney, W., 2022. Python for data analysis. " O'Reilly Media, Inc.".
2. Goodfellow, I., Bengio, Y. and Courville, A., 2016. Deep learning. MIT press.
3. Géron, A., 2022. Hands-on machine learning with Scikit-Learn, Keras and TensorFlow. " O'Reilly Media, Inc.".
4. Hapke, H., Howard, C. and Lane, H., 2019. Natural Language Processing in Action: Understanding, analyzing, and generating text with Python. Simon and Schuster.

REFERENCES

1. VanderPla, 2016. Jake. Python Data Science Handbook.
2. Andrew Park, 2021, Data Science for Beginners
3. Müller, A.C. and Guido, S., 2016. Introduction to machine learning with Python: a guide for data scientists. " O'Reilly Media, Inc.".
4. Muller, A.C. and Guido, S., 2017. Introduction to machine learning with Python. O'Reilly.

COURSE PLAN

Module	Contents	Hours
I	Introduction to Data Science and Python, What is Data Science, Introduction to Python, Why Python for Data Science?, Data Manipulation with Pandas, Introduction to Pandas ,Data Frames and Series, Basic Operations, Advanced Pandas	8
II	Data Visualization with Matplotlib and Seaborn, Matplotlib Basics ,Seaborn for Statistical Visualization ,Advanced Visualization Techniques Exploratory Data Analysis (EDA) Understanding EDA , Visual EDA -Univariate, Bivariate, and Multivariate Analysis- Correlation and Heatmaps	8
III	Introduction to Machine Learning with Scikit-learn , Understanding Machine Learning Regression Techniques, Classification Techniques Logistic Regression Model Evaluation, Advanced Machine Learning Techniques, Ensemble Methods Unsupervised Learning, Hyperparameter Tuning	10
IV	Introduction to Deep Learning with TensorFlow/Keras, Understanding Neural Networks, Implementing Neural Networks ,Introduction to Convolutional Neural Networks Natural Language Processing with NLTK and SpaCy, Basics of NLP, Text Classification and Sentiment Analysis, Named Entity Recognition	11
V	Time Series Forecasting with Python, Basics of Time Series Analysis Forecasting Models - ARIMA, Exponential Smoothing Practical Data Science Project-Complete End-to-End Project Walkthrough	8
	Total Hours	**45**

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS2U31A	CONCEPTS IN COMPUTER GRAPHICS AND IMAGE PROCESSING	PEC	3	1	0		4	2022

PRE-REQUISITE: Nil

COURSE OVERVIEW: The purpose of this course is to make awareness about strong theoretical relationships between computer graphics and image processing. This course helps the learner to understand three- dimensional environment representation in a computer, transformation of 2D/3D objects, basic mathematical techniques and algorithms used to build useful applications, imaging, and image processing techniques. The study of computer graphics and image processing develops the ability to create image processing frameworks for different domains and develops algorithms for emerging display technologies.

COURSE OUTCOMES: After the completion of the course the student will be able to

Course Outcomes	Description	Level
CO1	Describe the working principles of graphics devices	**Understand**
CO2	Illustrate line drawing, circle drawing and polygon filling algorithms	**Apply**
CO3	Demonstrate geometric representations, transformations on 2D & 3D objects, clipping algorithms and projection algorithms	**Apply**
CO4	Summarize visible surface detection methods	**Understand**
CO5	Summarize the concepts of digital image representation, processing and demonstrate pixel relationships	**Apply**
CO6	Solve image enhancement and segmentation problems using spatial domain techniques	**Apply**

SYLLABUS

Basics of Computer Graphics and its applications. Video Display devices. Line drawing algorithms. Circle drawing algorithms. Filled Area Primitives. Two dimensional transformations, Matrix representations and homogeneous coordinates. Basic 3D transformations. Window to viewport transformation. Cohen Sutherland Line clipping algorithm. Sutherland Hodgeman Polygon clipping algorithm. Three dimensional viewing pipeline. Projections- Parallel and Perspective projections. Visible surface detection algorithms- Depth buffer algorithm, Scan line algorithm. Introduction to Image processing and applications. Fundamental steps in image processing. Components of image processing system. Coordinate conventions. Sampling and quantization. Spatial and Gray Level Resolution. Basic relationship between pixels– neighbourhood, adjacency, connectivity. Fundamentals of spatial domain-convolution operation. Basic gray level transformation functions. Histogram equalization. Basics of spatial filtering - Sharpening spatial filters. Fundamentals of Image Segmentation. Thresholding. Region based Approach - Region Growing, Region Splitting and Merging. Edge Detection - Edge Operators- Sobel and Prewitt.

TEXT BOOKS

1. Donald Hearn and M. Pauline Baker, Computer Graphics, PHI, 2e, 1996
2. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing. Pearson, 4e, 2017

REFERENCE MATERIALS

1. William M. Newman and Robert F. Sproull, Principles of Interactive Computer Graphics. McGraw Hill, 2001.
2. Zhigang Xiang and Roy Plastock, Computer Graphics (Schaum's outline Series), McGraw Hill 2019.
3. David F. Rogers , Procedural Elements for Computer Graphics, Tata McGraw Hill,2001.
4. M. Sonka, V. Hlavac, and R. Boyle, Image Processing, Analysis, and Machine Vision, Thomson India Edition, 4e, 2017.

COURSE PLAN

Module	Contents	No. of hours
I	Basics of Computer Graphics and its applications. Video Display devices- Refresh Cathode Ray Tubes, Random Scan Displays and systems, Raster scan displays and systems. Line drawing algorithms- DDA, Bresenham's algorithm. Circle drawing algorithms- Midpoint Circle generation algorithm, Bresenham's algorithm.	**10**
II	Filled Area Primitives- Scan line polygon filling, Boundary filling and flood filling. Two dimensional transformations-Translation, Rotation, Scaling, Reflection and Shearing, Composite transformations, Matrix representations and homogeneous coordinates. Basic 3D transformations.	**10**
III	Window to viewport transformation. Cohen Sutherland Line clipping algorithm. Sutherland Hodgeman Polygon clipping algorithm. Three dimensional viewing pipeline. Projections- Parallel and Perspective projections. Visible surface detection algorithms- Depth buffer algorithm, Scan line algorithm.	**13**
IV	Introduction to Image processing and applications. Image as 2D data. Image representation in Gray scale, Binary and Colour images. Fundamental steps in image processing. Components of image processing system. Coordinate conventions. Sampling and quantization. Spatial and Gray Level Resolution. Basic relationship between pixels– neighbourhood, adjacency, connectivity. Fundamentals of spatial domain-convolution operation.	**13**
V	Basic gray level transformation functions - Log transformations, Power-Law transformations, Contrast stretching. Histogram	**14**

	equalization. Basics of spatial filtering - Smoothing spatial filter-Linear and nonlinear filters, and Sharpening spatial filters-Gradient and Laplacian. Fundamentals of Image Segmentation. Thresholding - Basics of Intensity thresholding and Global Thresholding. Region based Approach - Region Growing, Region Splitting and Merging. Edge Detection - Edge Operators- Sobel and Prewitt.	
	Total Hours	**60**

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS2U31B	**Object Oriented Programming using Java**	**PEC**	**2**	**1**	**0**	**0**	**3**	**2022**

PRE-REQUISITE: Nil

COURSE OVERVIEW

Aim of the course is to introduce Object oriented concepts in programming. The course introduces Object Oriented Principles, Object Oriented Programming in Java, Exception handling, Event handling, multithreaded programming and graphical user interface programming. The course will enable learners to solve problems by breaking it down to object level while designing software and implementing it using Java.

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Summarize the Basic features and architecture of Java	Understand
CO 2	Construct Object Oriented Design using Unified Modelling Language (UML)	Apply
CO 3	Apply the object-oriented concepts - classes, objects, constructors, data hiding, inheritance, and polymorphism to write Java programs.	Apply
CO 4	Utilize packages & interfaces, input/output streams, files and string-handling mechanisms to develop programs	Apply
CO 5	Utilize exception handling, multithreading and database connectivity to develop java applications.	Apply
CO 6	Apply event handling features and swing to develop Graphical User Interface based Java application programs	Apply

SYLLABUS

Approaches to Software Design - Functional Oriented Design, Object Oriented Design, Object Modeling Using Unified Modeling Language (UML) – Use case model, Class diagram, Interaction diagram, Activity diagram, State chart diagram. Introduction to Java - Java programming Environment and Runtime Environment, Java Virtual Machine (JVM), Java compiler, Bytecode.

Core Java Fundamentals: Data types, Operators, Control Statements, Object Oriented Programming in Java - Class Fundamentals, Constructors, Method Overloading, Access Control, Command Line Arguments, Inheritance - Method Overriding, Abstract Classes and Methods.

Packages and Interfaces, Interfaces, String Handling, Comparison of String Buffer and String, Input/ Output - Reading Console Input, Writing Console Output, Object Streams and Serialization, Working with Files.

Exception Handling, Collections framework, Collections Class, Event handling - Delegation Event Model, Multithreaded Programming.

Swings fundamentals - Model View Controller (MVC), Event Handling in Swings, Exploring Swings, Java Database Connectivity (JDBC).

TEXTBOOKS

1. Herbert Schildt, Java: The Complete Reference, 8/e, Tata McGraw Hill, 2011.
2. Bahrami A., Object Oriented Systems Development using the Unified Modeling Language, McGraw Hill, 1999.
3. Paul Deitel, Harvey Deitel, Java How to Program, Early Objects 11th Edition, Pearson, 2018.

REFERENCES

1. Y. Daniel Liang, Introduction to Java Programming, 7/e, Pearson, 2013.
2. Nageswararao R., Core Java: An Integrated Approach, Dreamtech Press, 2008
3. Balaguruswamy E., Programming JAVA a Primer, 5/e, McGraw Hill, 2014.

COURSE PLAN

Module	Contents	Hours
I	Approaches to Software Design - Functional Oriented Design, Object Oriented Design, Object Modeling Using Unified Modeling Language (UML) – Basic Object Oriented concepts, UML diagrams, Use case model, Class diagram, Interaction diagram, Activity diagram, State chart diagram. Introduction to Java - Java programming Environment and Runtime Environment, Development Platforms -Standard, Enterprise. Java Virtual Machine (JVM), Java compiler, Bytecode, Java Buzzwords, Java program structure, Comments, Garbage Collection.	**8**
II	Primitive Data types - Integers, Floating Point Types, Characters, Boolean. Literals, Type Conversion and Casting, Variables, Arrays, Strings, Vector class. Object Oriented Programming in Java - Class Fundamentals, Declaring Objects, Object Reference, Introduction to Methods, Constructors, this Keyword, Method Overloading, Using Objects as Parameters, Returning Objects, Recursion, Access Control, Static Members, Final Variables, Inner Classes, Command Line Arguments, Inheritance - Super Class, Sub Class, The Keyword super, protected Members, Calling Order of Constructors, Method Overriding, the Object class, Abstract Classes and Methods, using final with Inheritance.	**12**
III	Java Library - String Handling – String Constructors, String Length, Special String Operations - Character Extraction, String Comparison, Searching Strings, Modifying Strings, using value Of(), Comparison of String Buffer and String. Packages and Interfaces - Defining Package, CLASSPATH, Access Protection, Importing Packages, Interfaces. Input/ Output - I/O Basics, Reading Console Input, Writing Console Output, PrintWriter Class, Object Streams and Serialization, Working with Files.	**8**
IV	Exception Handling - Checked Exceptions, Unchecked Exceptions, try Block and catch Clause, Multiple catch Clauses, Nested try Statements, throw, throws and finally. Collections framework - Collections overview, Collections Interfaces-	**9**

	Collection Interface, List Interface. Collections Class – Array List class. Accessing a Collection via an Iterator. Event handling - Event Handling Mechanisms, Delegation Event Model, Event Classes, Sources of Events, and Event Listener Interfaces, Using the Delegation Model. Multithreaded Programming - The Java Thread Model, The Main Thread, Creating Thread, Creating Multiple Threads, Synchronization, Suspending, Resuming and Stopping Threads.	
V	Graphical User Interface and Database support of Java: Swings fundamentals - Swing Key Features, Model View Controller (MVC), Swing Controls, Components and Containers, Swing Packages, Event Handling in Swings, Swing Layout Managers, Exploring Swings –JFrame, JLabel, The Swing Buttons, JTextField. Java Database Connectivity (JDBC) - JDBC overview, Creating and Executing Queries – create table, delete, insert, select.	**8**
	Total Hours	**45**

M**ARK DISTRIBUTION**

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks

Course Code	Course Name	Category	L	T	P	J	Credit	Year of Introduction
CS2U31C	Machine Learning Models and Storage Management	PEC	2	1	0	0	3	2022

COURSE OVERVIEW

This course enables the learners to understand the advanced concepts and algorithms in machine learning. The course covers the standard and most popular supervised learning algorithms. This course aims to provide the basics for developing deployable machine learning systems. The course helps the students to provide machine learning based solutions to real world problems.

Prerequisite : Nil

COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the basic concepts and techniques of Machine Learning.	**Understand**
CO 2	Demonstrate supervised learning techniques of classification and regression	**Apply**
CO 3	Illustrate the concepts of kernel functions, support vector machines and Markov model.	**Apply**
CO 4	Apply the techniques of clustering and multilayer neural networks.	**Apply**
CO 5	Summarize the process of development of a machine learning model in real-world applications.	**Understand**

SYLLABUS

Examples of Machine Learning applications - Learning associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning. Supervised learning- Input representation, Cross validation and re-sampling methods- K- fold cross validation, Boot strapping, Measuring classifier performance. Support Vector Machine, Hidden Markov models, Evaluation problem, finding state sequence, Learning model parameters. Clustering Methods Requirements for ML Systems - Iterative process for developing ML systems in production – Data Systems Fundamentals: data sources, data formats , data models, data storage engines and processing – Training data: Sampling techniques, Labelling, Handling class imbalance - Model Development and Training: Evaluating ML Models, Ensembles - Model Offline Evaluation: Baselines, Evaluation Methods – Model Deployment: Batch Prediction vs. Online Prediction, Model Compression, Model Optimization

TEXT BOOKS

1. Ethem Alpaydın, Introduction to Machine Learning (Adaptive Computation and Machine Learning), MIT Press, 2004.
2. Huyen, Chip. Designing machine learning systems. " O'Reilly Media, Inc.", 2022.

REFERENCES

1. Christopher Bishop. Neural Networks for Pattern Recognition, Oxford University Press, 1995.
2. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements Of Statistical Learning, Second edition Springer 2007.
4. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995.

COURSE PLAN

Module	Contents	Hours
I	**Introduction to Machine Learning:** Examples of Machine Learning applications - Learning associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning. Supervised learning- Input representation, Hypothesis class, Version space, Vapnik-Chervonenkis (VC) Dimension. Probably Approximately Learning (PAC), Noise, Learning Multiple classes, Model Selection and Generalization, Dimensionality reduction- Subset selection, Principal Component Analysis.	**9**
II	**Classification:** Cross validation and re-sampling methods- K- fold cross validation, Boot strapping, Measuring classifier performance- Precision, recall, ROC curves. Bayes Theorem, Bayesian classifier, Maximum Likelihood estimation, Density functions, Regression. Decision Trees- Entropy, Information Gain, Tree construction, ID3, Issues in Decision Tree learning- Avoiding Over-fitting, Reduced Error Pruning, The problem of Missing Attributes, Gain Ratio, Classification by Regression (CART).	**9**
III	**Kernel Machines:** Support Vector Machine- Optimal Separating hyper plane, Soft-margin hyperplane, Kernel trick, Kernel functions. Discrete Markov Processes, Hidden Markov models, Three basic problems of HMMs- Evaluation problem, finding state sequence, Learning model parameters. Combining multiple learners, Ways to achieve diversity, Model combination schemes, Voting, Bagging, Booting.	**6**
IV	**Unsupervised Learning:** Clustering Methods - K-means, Expectation-Maximization Algorithm, Hierarchical Clustering Methods, Density based clustering. Neural Networks- The Perceptron, Activation Functions, Training Feed Forward Network by Back Propagation- Multi-Layer Perceptron in Practice – Examples of using the MLP- Radial Basis Functions and Splines – Concepts – RBF Network – Curse of Dimensionality – Interpolations and Basis Functions.	**6**
V	**Designing ML Systems in Production:** Requirements for ML Systems - Iterative process for developing ML systems in production – Data Systems Fundamentals: data sources, data formats , data models, data storage engines and processing – Training data: Sampling techniques, Labelling, Handling class imbalance - Model Development and Training: Evaluating ML Models, Ensembles - Model Offline Evaluation: Baselines, Evaluation Methods – Model Deployment: Batch Prediction vs. Online Prediction, Model Compression, Model Optimization.	**15**
	Total Hours	**45**

MARK DISTRIBUTION

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 hours

CONTINOUS INTERNAL EVALUATION PATTERN

Attendance	: 10 marks
Continuous Assessment Tests	: 25 marks
Continuous Assessment Assignment	: 15 marks