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||Jai Sri Gurudev||

Sri Adichunchanagiri Shikshana Trust (R.)

SJC INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU from 2024-25

AICTE Approved, Accredited by NAAC with A+ Grade & NBA (CSE, ISE, ECE, ME & CV), NIRF(151-300) in 2023,Gold Rated by QS I-Gauge

P.B. No.20, B.B Road, Chikkaballapur - 562 101, Karnataka

Estd : 1986

VI Semester
Scheme & Syllabus of B.E. Programme
Computer Science & Engineering (AI&ML)
(2024 Scheme)

Core Values

Spiritual, Judicious, Commitment, Integrity, Trustworthy



AICTE | NATIONAL INSTITUTIONAL RANKING FRAMEWORK 151-300 | NBA | NAAC A+ | QS I-GAUGE GOLD | INSTITUTION'S INNOVATION COUNCIL (Ministry of HRD Initiative) 4-Star Rating

SJC INSTITUTE OF TECHNOLOGY, CHIKKABALLAPURA

An Autonomous institution Under VTU from 2024 – 2025

AICTE Approved, Accredited by NBA (CSE, ISE, ECE, ME, CV, AE) and NAAC with 'A+' grade, QS – I Gauge Gold Rated

SCHEME OF TEACHING AND EXAMINATION – B.E. –

Computer Science and Engineering (Artificial Intelligence and Machine Learning)

(Applicable for students admitted from the Academic Year 2024-25 and onwards)

6th Semester

Computer Science and Engineering (Artificial Intelligence and Machine Learning)												
Sl. No.	**Course Code**	**Course Title**	**Course Type**	**TD/ PSB**	**Teaching Hours / Week**			**Examination**				
					L	**T**	**P**	**SEE Duration (Hrs)**	**CIE Marks**	**SEE Marks**	**Total Marks**	**Credits**
1	BCI601	Cloud Computing Technologies	PCC	TD:CI PSD:CI	3	2	0	**3**	**50**	**50**	**100**	**4**
2	BCI602	Advanced Machine Learning	IPCC	TD:CI PSD:CI	3	0	2	**3**	**50**	**50**	**100**	**4**
3	BCI623x	Professional Elective Course-II	PEC	TD:CI PSD:CI	3	0	0	**3**	**50**	**50**	**100**	**3**
4	BCI624x	Professional Elective Course – III	PEC	TD:CI PSD:CI	3	0	0	**3**	**50**	**50**	**100**	**3**
5	BXX645x	Open Elective Course-I	OEC	TD:CI PSD:CI	3	0	0	**3**	**50**	**50**	**100**	**3**
6	BCIP636	Major Project Phase – I	PROJ	TD:CI PSD:CI	0	0	4	**3**	**100**	-	**100**	**2**
7	BCIL607	Cloud Computing Lab	PCCL	TD:CI PSD:CI	0	0	2	**3**	**50**	**50**	**100**	**1**
8	BCE608	Competency Enhancement Course-4	NCMC	CDCAC	0	2	0	-	**100**	-	**100**	**0**
9	BIK609	Indian Knowledge System	NCMC	Any Dept.	1	0	0	**1**	**100**	-	**100**	**0**
	BNS610	National Service Scheme		NSS Coordinator								

10	BPE610	Physical Education	NCMC	Physical Education Director	0	0	2	-	**100**	-	**100**	**0**
	BYO610	Yoga		Yoga Teacher								
	BMU610	Music		Music Teacher								
									700	**300**	**1000**	**20**

ASC: Applied Science Course, PCC: Professional Core Course, IPCC: Integrated Professional Core Course, PCCL: Professional Core Course laboratory, UHV: Universal Human Value Course, NCMC: Non Credit Mandatory Course, AEC: Ability Enhancement Course, SEC: Skill Enhancement Course, ESC: Engineering Science Course, ETC: Emerging Technology Course, PLC: Programming Language Course, L: Lecture, T: Tutorial, P: Practical, CIE: Continuous Internal Evaluation, SEE: Semester End Evaluation.

Professional Elective Course – II

Course Code	Course Name	Course Code	Course Name
BCI623A	Edge Computing	BCI623C	Digital Twins and Simulation Intelligence
BCI623B	Computer Vision and Image Processing	BCI623D	Cyber Threat Intelligence

Professional Elective Course – III

Course Code	Course Name	Course Code	Course Name
BCI624A	MLops	BCI624C	Robotics and Autonomous Systems
BCI624B	Quantum Computing	BCI624D	Cloud Security and Software Defined Networking

Open Elective Course – I

Course Code	Course Name	Course Code	Course Name
BCS645A	Introduction to Data Structure	BIS645C	Mobile Application Development
BIS645B	Fundamentals of Operating System	BCI645D	Introduction to Artificial Intelligence

Professional Core Course (IPCC): Refers to Professional Core Course Theory Integrated with practical's of the same course. Credit for IPCC can be 04 and its Teaching– Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be includedin the SEE question paper. For more details, the regulation governing the Degree of Bachelor of Engineering (B.E.) 2024-25 may please be referred.

National Service Scheme /Physical Education/Yoga/Music: All students have to register for any one of the courses namely National Service Scheme, Physical Education, Yoga and Music with the concerned coordinator / teacher of the course during the first week of 3rd semester. Activities shall be carried out between 3rd semester to the 6th semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS, PE, Yoga and Music activities. These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory

for the award of degree.
Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course. The minimum number of students' strengths for offering professional electives is 10. However, this conditional shall not be applicable to cases where the admission to the program is less than 10.
Open Elective Courses: Students belonging to a particular stream of Engineering and Technology are not entitled to the open electives offered by their parent Department. However, they can opt for an elective offered by other Departments, provided they satisfy the prerequisite condition if any. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor. The minimum numbers of students' strength for offering Open Elective Course is 10. However, this condition shall not be applicable to class where the admission to the program is less than 10.
Project Phase-I: Students have to discuss with the mentor /guide and with their help he/she has to complete the literature survey and prepare the report and finally define the problem statement for the project work

Semester: VI					
Cloud Computing Technologies					
Course Code	:	BCI601	**Credits**	:	3
Hours/Week (L: T:P)	:	3:0:0	**CIE**	:	50 Marks
Total Hours	:	40 Hrs	**SEE**	:	50 Marks
Course Type	:	PEC	**SEE Duration**	:	3 Hours

Prerequisites:	
Courses	Computer Networks ,Operating Systems
Knowledge on Fundamental Concepts	Networking fundamentals: IP addressing, DNS, routing, HTTP/HTTPS Operating System concepts: Process, Memory, File system management
Knowledge on Connected Tools (If any)	Development Environments**:** OpenStack**,** AWS Cloud9, Google Cloud Shell

Course Learning Objectives: This course will enable the students to	
CLO1	Introduce the rationale behind the cloud computing revolution and the business drivers
CLO2	Understand various models, types and challenges of cloud computing
CLO3	Understand the design of cloud native applications, the necessary tools and the design tradeoffs.
CLO4	Realize the importance of Cloud Virtualization, Abstraction`s, Enabling Technologies and cloud security
CLO5	Enable students to design, deploy, and manage scalable cloud-based applications using industry-relevant platforms and tools, integrating best practices for performance, security, and cost optimization

Module – 1	**08 Hrs**
Distributed System Models and Enabling Technologies: Scalable Computing Over the Internet, Technologies for Network Based Systems, System Models for Distributed and Cloud Computing, Software Environments for Distributed Systems and Clouds, Performance, Security and Energy Efficiency. **Textbook 1**: **ch 1: 1.1 - 1.5**	
Module – 2	**08 Hrs**
Virtual Machines and Virtualization of Clusters and Data Centers: Implementation Levels of Virtualization, Virtualization Structure/Tools and Mechanisms, Virtualization of CPU/Memory and I/O devices, Virtual Clusters and Resource Management, Virtualization for Data Center Automation. **Textbook 1**: **Ch 3: 3.1 - 3.5**	
Module – 3	**08 Hrs**
Cloud Platform Architecture over Virtualized Datacenters: Cloud Computing and Service Models, Data Center Design and Interconnection Networks, Architectural Design of Compute and Storage Clouds, Public Cloud Platforms: GAE, AWS and Azure, Inter-Cloud Resource Management. **Textbook 1: Ch 4: 4.1 - 4.5**	
Module – 4	**08 Hrs**
Cloud Security: Top concern for cloud users, Risks, Privacy Impact Assessment, Cloud Data Encryption, Security of Database Services, OS security, VM Security, Security Risks Posed by Shared Images and Management OS, XOAR, A Trusted Hypervisor, Mobile Devices and Cloud Security. Cloud Security and Trust Management: Cloud Security Defense Strategies, Distributed Intrusion/Anomaly Detection, Data and Software Protection Techniques, Reputation-Guided Protection of Data Centers.	

Textbook 1: **Ch 4: 4.6** **Textbook 2**: **Ch 11: 11.1 -11.3, 11.5 - 11.8, 11.10 - 11.14**	
Module – 5	**08 Hrs**
Cloud Programming and Software Environments: Features of Cloud and Grid Platforms, Parallel and Distributed Computing Paradigms, Programming Support for Google App Engine, Programming on Amazon AWS and Microsoft, Emerging Cloud Software Environments. **Textbook 1**: **Ch6: 6.1 - 6.5**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Evaluate various cloud computing platforms and service providers with respect to their architecture, features, and service models.
CO2	Illustrate the significance of various types of virtualization.
CO3	Apply cloud computing architectures, service delivery models, and industrial platforms to design and implement cloud-based applications.
CO4	Analyze the role of Security aspects of cloud computing.
CO5	Develop cloud based applications using suitable platforms and tools.

Text Book	
1	Distributed and Cloud Computing Kai Hwang, Geoffrey C Fox, and Jack J Dongarra, Morgan Kaufmann, 2012 Elsevier, ISBN: 978-0-12-385880-1
2	Cloud Computing Theory and Practice ,Dan C. Marinescu, , Morgan Kaufmann, 2nd Edition, 2018 Elsevier, ISBN: 978-0-12404-627-6

Reference Books	
1	Mastering Cloud Computing, Rajkumar Buyya, Christian Vecchiola, and Thamrai Selvi, 1st Edition, 2017, McGrawHill Education, ISBN: 978-0-12-411454-8.
2	Cloud Computing: A Practical Approach To, Velte, Anthony Velte, 2017, McGraw-Hill Education, ISBN-13. 978-0070683518.
3	Cloud Application Architectures: Building Applications and Infrastructure in the Cloud George Reese, 1st Edition, 2009, O'Reilly Publication ISBN: 978-0-596-1536-7.
4	Cloud Computing Explained: Implementation Handbook for Enterprises, John Rhoton, , 2nd Edition, 2009,Recursive Press ISBN:0956355609.

CO – PO MAPPING

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	2	2		2				
CO2	3		3	2	2		-				
CO3	3		3	2	3		2				
CO4	3	2	3	2	2	2	2				2
CO5	3		3	3	3	2	2	2	2	2	2

Semester: VI					
Advanced Machine Learning					
Course Code	:	BCI602	**Credits**	:	04
Hours/Week(L:T:P)	:	3:0:2	**CIE**	:	50 Marks
Total Hours	:	40L+14P	**SEE**	:	50 Marks
Course Type	:	IPCC	**SEE Duration**	:	03 Hours

Prerequisites:	
Courses	Data Structures, Mathematics foundation and Artificial Intelligence
Knowledge on Fundamental Concepts	Statistics, Data Analysis, Data Visualization
Knowledge on Connected Tools (If any)	Jupyter Notebook

Course Learning Objectives: This course will enable the students to	
CLO1	Infer the underlying mechanisms of genetic algorithms and well posed learning.
CLO2	Outline the basic sequential covering algorithm, including a learn-one-rule subroutine, evaluation threshold and rule removal mechanism on a dataset.
CLO3	Demonstrate the standard k-means algorithm, normalization and competitive neural models.
CLO4	Explore the concepts of vector quantization with centroid-based density modeling.
CLO5	Evaluate and compare tracking methods, by applying the kalman and particle filters to real-world datasets.

Module – 1	**08 Hrs**
Introduction: Well-Posed Learning Problems, Designing a Learning System, Perspectives and Issues in Machine Learning. **Genetic Algorithms:** Motivation, Genetic Algorithm, Extensions, Hypothesis Space Search, Genetic Programming, Models of Evolution and Learning, Parallelizing Genetic Algorithms. **Text Book 1: Ch 1: 1.1 to 1.5 & Ch 9: 9.1 to 9.7**	
Module – 2	**08 Hrs**
Learning Sets of Rules: Sequential Covering Algorithms, Learning Rule Sets: Example-Based Methods, Learning First-Order Rules, FOIL: A First-Order Inductive Learner. **Analytical Learning:** Perfect Domain Theories: Explanation-Based Learning, Explanation-Based Learning of Search Control Knowledge, Inductive-Analytical Approaches to Learning. **Text Book 1: Ch 10: 10.1 to 10.7 & Ch 11: 11.1 to 11.4**	
Module – 3	**08 Hrs**
Decision By Committee Ensemble Learning: Boosting: Adaboost, Stumping, Bagging: Subagging, Random Forests, Comparison With Boosting, Different Ways to Combine Classifiers. **Unsupervised Learning: The K-Means Algorithm:** Dealing With Noise, The K-Means Neural Network, Normalization, A Better Weight Update Rule, Using Competitive Learning for Clustering. **Text Book 2: Ch 13: 13.1 to 13.4 & Ch 14: 14.1**	
Module – 4	**08 Hrs**
Unsupervised Learning: Vector Quantization, The Self-Organizing Feature Map, The SOM Algorithm, Neighborhood Connections, Self-Organization, Network Dimensionality and Boundary Conditions, Examples of Using the SOM. **Markov Chain Monte Carlo (MCMC) Methods:** Sampling: Random Numbers, Gaussian Random Numbers, Monte Carlo or Bust, The Proposal Distribution, Markov Chain Monte Carlo.	

Text Book 2: Ch 14: 14.2 to 14.3 & Ch 15: 15.1 to 15.4	
Module – 5	**08 Hrs**
Graphical Models: Bayesian Networks: Approximate Inference, Making Bayesian Networks, Markov Random Fields, Hidden Markov Models (HMMS), The Forward Algorithm, The Viterbi Algorithm, The Baum–Welch Or Forward–Backward Algorithm, Tracking Methods, The Kalman Filter, The Particle Filter. **Text Book 2: Ch 16: 16.1 to 16.4**	

PRACTICAL COMPONENT OF IPCC

SL.NO	Experiments
1	Develop a program to implement the Random Forest algorithm for classification using the Breast Cancer dataset. Compare its accuracy with a Decision Tree classifier.
2	Implement Support Vector Machine (SVM) with Linear and Polynomial kernels for classification using the Iris dataset. Compare the performance of different kernels.
3	Develop a program to implement the AdaBoost algorithm using weak learners (Decision Stumps) and evaluate its classification accuracy on the Heart Disease dataset.
4	Implement Gradient Boosting for regression classification using the Wine Quality dataset and compare the results with Random Forest.
5	Develop a program to implement DBSCAN using the Mall Customers dataset to perform customer segmentation and compare the results with K-Means.
6	Build a program to implement Spectral Clustering on a non-linearly separable dataset such as Two Moons and visualize the resulting clusters.
7	Implement Linear Discriminant Analysis (LDA) to reduce the dimensionality of the Wine dataset and compare its performance with PCA.
8	Develop a program to detect anomalies using the Local Outlier Factor (LOF) algorithm on the Credit Card Fraud Detection dataset.
9	Develop a program to implement Grid Search with Cross Validation for hyperparameter tuning of a Random Forest classifier using the Adult Income dataset and compare the performance before and after optimization.
10	Develop a program to perform Agglomerative Hierarchical Clustering using the Wholesale Customers dataset. Visualize the dendrogram and analyze the clusters formed using different linkage methods.

Course Outcomes: After completing the course, the students will be able to	
CO1	Interpret the strengths and limitations of Genetic Extension Systems.
CO2	Inspect and prune a learned set of rules using the Sequential Covering approach.
CO3	Design ensemble classifiers using decision-by-committee techniques.
CO4	Distinguish the Key SOM Mechanisms, Network Grid Formation, Best Matching Unit (BMU) Identification.
CO5	Evaluate between exact and approximate inference methods in probabilistic graphical models.

Text Books	
1	Machine Learning, T. M. Mitchell, 1st Edition, 1997, Mcgraw Hill, ISBN-10 :1-25-909695-5

2	Machine Learning-An Algorithmic Perspective, Stephen Marsland, 2nd Edition, 2015, CRC Press - Taylor and Francis Group, ISBN-10: 1466583282

Reference Books	
1	Introduction to Machine Learning, Ethem Alpaydin, 4thEdition, 2020, MIT Press, ISBN-13**:** 978-0262043793
2	Pattern Recognition & Machine Learning, Christopher M. Bishop,1st Edition, 2006, Springer, ISBN-10: 0387310738

Web links and Video Lectures (e – Resources)	
1	Machine Learning – Introduction to everyone https://www.coursera.org/learn/ma chine-learning-introduction-for everyone
2	Machine Learning Tutorials https://www.tutorialspoint.com/machine_learning/index.htm
3	Introduction to Machine Learning https://archive.nptel.ac.in/courses/1 06/106/106106139/

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	3	3	1	2							1
CO2	3	3	2	2	2				1	1	1
CO3	3	2	2	2	2				1	1	1
CO4	3	3	2	3	2				1	1	1
CO5	3	3	2	3	3				2	2	2

2024 Scheme

Semester: VI					
Computer Vision and Image Processing					
Course Code	**:**	BCS623B	**Credits**	**:**	3
Hours/Week (L: T:P)	**:**	3:0:0	**CIE**	**:**	50 Marks
Total Hours	**:**	40 Hrs	**SEE**	**:**	50 Marks
Course Type	**:**	PEC	**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Introduction to Digital Image Processing, CV
Knowledge on Fundamental Concepts	Image Formation, Preprocessing, Feature Extraction & Segmentation,
Knowledge on Connected Tools (If any)	

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the fundamentals of digital image processing and analysis, including image formation, representation, sensing, and an overview of computer vision systems.
CLO2	Design and implement computer vision solutions using CVIP GUI, CVIP Lab (C/C++), and MATLAB CVIP Toolbox.
CLO3	Explore image analysis and computer vision techniques, including preprocessing, binary image analysis, thresholding, labeling, and feature extraction.
CLO4	Describe the edge, line, corner, and shape detection techniques in images.
CLO5	Apply various image segmentation techniques, including region growing/shrinking, clustering, boundary detection, deep learning methods, and morphological filtering.

Module – 1	**08 Hrs**
Digital Image Processing and Analysis: Introduction, Image Analysis and Computer Vision Overview, Digital Imaging Systems, Image Formation and Sensing, Image Representation. **Text Book: Ch 1: 1.1-1.5**	
Module – 2	**08 Hrs**
Computer Vision Development Tools: Introduction and Overview, CVIP tools Windows GUI, CVIP lab for C/C++ Programming, The Mat lab CVIP Toolbox. **Text Book: Ch 2: 2.1-2.4**	
Module – 3	**08 Hrs**
Image Analysis and Computer Vision: Introduction, Preprocessing, Binary Image Analysis: Thresholding Bimodal, Histograms, connectivity and Labeling, Basic Binary Object Features, Computer Vision. **Text Book: Ch 3: 3.1-3.3**	
Module – 4	**08 Hrs**
Edge, Line and Shape Detection: Introduction and Overview, Edge Detection, Line Detection, Corner and Shape Detection. **Text Book: Ch 4: 4.1-4.4**	
Module – 5	**08 Hrs**
Segmentation: Introduction and Overview, Region Growing and Shrinking, Clustering Techniques, Boundary Detection, Deep Learning Segmentation Methods, Morphological Filtering **Text Book: Ch 5: 5.1-5.7**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the fundamental concepts of digital image processing and analysis, including computer vision systems.
CO2	Develop and implement computer vision applications using CVIP Windows GUI, CVIP Lab (C/C++), and MATLAB CVIP Toolbox
CO3	Analyze images using preprocessing, binary image analysis, thresholding, labeling, and feature extraction techniques in computer vision applications.
CO4	Identify the edge, line, corner, and shape detection techniques to analyze and interpret images.
CO5	Analyze image segmentation techniques, including region-based methods, clustering, boundary detection, deep learning, and morphological filtering, for extracting meaningful information from images.

Text Book	
1	Digital Image Processing and Analysis: Computer Vision and Image Analysis, Scott E Umbaugh, 4th Edition, 2024, Pearson, ISBN 9781032117089

Reference Books	
1	Computer Vision A Modern Approach. 2ndEdition, 2024, Pearson, ISBN 978-93-325-5011-7
2	Digital Image Processing, Rafael C G, Woods R E. and Eddins S L, 4th Edition, 2019, Pearson, ISBN-13: 978-9353062989

2024 Scheme

Semester: VI					
EDGE COMPUTING					
Course Code	**:**	BCI623A	**Credits**	**:**	03
Hours/Week (L:T:P)	**:**	3:0:0	**CIE**	**:**	50 Marks
Total Hours	**:**	40 Hrs	**SEE**	**:**	50 Marks
Course Type	**:**	PEC	**SEE Duration**	**:**	03 Hours

Prerequisites:	
Courses	Computer Networks, Computer Networks, Internet of Things Fundamentals
Knowledge on Fundamental Concepts	Basic understanding of software defined networking, IoT fundamentals, and edge computing concepts.
Knowledge on Connected Tools (If any)	Basic familiarity with IoT devices, Raspberry Pi, sensors, and simple networking tools.

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the fundamental concepts, architecture, characteristics, and applications of Edge Computing.
CLO2	Analyze IoT architecture, core IoT modules, and the integration of Edge Computing in IoT ecosystems.
CLO3	Implement Raspberry Pi hardware, operating system configuration, and peripheral interfacing for Edge Computing applications.
CLO4	Develop Edge-to-Cloud communication using MQTT protocols and Raspberry Pi-based IoT systems.
CLO5	Evaluate Edge Computing solutions for industrial and commercial IoT applications based on performance and deployment requirements.

Module – 1	**08 Hrs.**
IoT AND EDGE COMPUTING DEFINITION AND USE CASES Introduction to Edge Computing Scenario's and Use cases- Edge computing purpose and definition, Edge computing use cases, Edge computing hardware architectures, Edge platforms, Edge *vs* Fog Computing, Communication Modles-Edge, Fog and M2M. **Textbook 1: Ch.1,Ch.8**	
Module – 2	**08 Hrs.**
IoT ARCHITECTURE AND CORE IoT MODULES A Connected ecosystem, IoT versus machine-to-machine versus, SCADA, The value of Network and Metcalfe's and Beckstroms's laws, IoT and Edge Architecture, Role of an architect, Understanding Implementations with examples-Example use case and deployment, Case study-Telemedicine palliative care, Requirements, Implementation, Use case retrospective. **Textbook 1: Ch.2**	
Module – 3	**08 Hrs.**
RASBERRYPi RasberryPi: Introduction to RasberryPi, About RasberryPi Board, Hardware Layout and Pin outs, Operating systems on RasberryPi, Configuring RasberryPi, Programming RasberryPi, Connecting RasberryPi via SSH, Remote access tools, Interfacing DHT Sensor with Pi, Pi as Webserver, Pi Camera, Image & Video Processing using Pi. **Textbook 2: Ch.1,Ch.4,Ch.7,Ch.8,Ch.12**	

Module – 4	08 Hrs.
INTERFACING RASBERRYPi & MQTT Implementation of Microcomputer RasberryPi and device Interfacing, Edge to Cloud Protocols-Protocols, MQTT, MQTT publish-subscribe, MQTT Architecture details, MQTT state transitions, MQTT packet structure, MQTT data types, MQTT communication formats, MQTT 3.1.1 working example. **Textbook 1: Ch.10 Textbook 2: Ch.16,Ch.7**	
Module – 5	**08 Hrs.**
EDGE COMPUTING WITH RASBERRYPi Edge Computing with RasberryPi, Industrial and Commercial IoT and Edge, Edge Computing and solutions. **Textbook 1: Ch.8,Ch.11,Ch.12 Textbook 2: Ch.16,Ch.18**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Illustrate Edge Computing concepts, architecture, hardware platforms, and use cases for IoT applications.
CO2	Analyze IoT architecture and implement suitable Edge Computing solutions for real-world applications.
CO3	Apply Raspberry Pi hardware, operating system configuration, and sensor interfacing techniques for Edge Computing applications.
CO4	Develop Edge-to-Cloud communication using MQTT protocols and Raspberry Pi-based IoT systems.
CO5	Evaluate industrial and commercial IoT applications using Edge Computing technologies and recommend appropriate deployment solutions.

Text Book	
1	Perry Lea**,** *IoT Edge Computing for Architects*, 2nd Edition, Packt Publishing, 2020. ISBN: 978-1839214806.
2	Simon Monk, *Raspberry Pi Cookbook*, 3rd Edition, O'Reilly Media, Inc., 2019. ISBN: 978-1492043227.

Reference Books	
1	Fog and Edge Computing: Principles and Paradigms by Rajkumar Buyya, Satish Narayana Srirama, Wiley Publication, 2019, ISBN: 9781119524984.
2	David Jensen, "Beginning Azure IoT Edge Computing: Extending the Cloud to the Intelligent. Edge, Microsoft Azure

Web links and Video Lectures (e – Resources)	
1	Edge Computing: https://www.ibm.com/topics/edge-computing
2	IoT: https://aws.amazon.com/iot/what-is-the-internet-of-things/
3	RaspberryPi: https://www.raspberrypi.com/documentation/
4	MQTT: https://learn.microsoft.com/en-us/azure/iot-edge/about-iot-edge

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	3	2			1					1	
CO2	3	3	2	2	2					1	
CO3	3	2	3	2	3				1	1	
CO4	3	3	3	2	3				2	2	
CO5	3	3	2	3	2	2	2		1	1	2

Semester: VI					
Digital Twins and Simulation Intelligence					
Course Code	:	BCI623C	**Credits**	:	03
Hours/Week (L:T:P)	:	3:0:0	**CIE**	:	50 Marks
Total Hours	:	40 Hrs	**SEE**	:	50 Marks
Course Type	:	PEC	**SEE Duration**	:	03 Hours

Prerequisites:	
Courses	Probability & Statistics, Basic Calculus
Knowledge on Fundamental Concepts	Python Programming, Data Structures & Algorithms
Knowledge on Connected Tools (If any)	Jupyter Notebook, Google Colab and Anaconda

Course Learning Objectives: This course will enable the students to	
CLO1	Understand Digital Twin concepts and system architecture
CLO2	Develop simulation and system models
CLO3	Integrate real-time data with computational systems
CLO4	Apply data analytics and machine learning techniques
CLO5	Build simulation-based solutions for real-world applications

Module – 1	**08 Hrs**
Introduction to Digital Twins and Complex Systems: Digital Twin concept and evolution, importance and applications, architecture and components of Digital Twins, types of digital twins and lifecycle, introduction to complex systems and system thinking, modeling interactions in complex systems, basics of Cyber-Physical Systems (CPS). **Text Book 1: Ch1: 1.1-1.6, Ch 2:2.1-2.8 & Ch 3:3.1-3.8**	
Module – 2	**08 Hrs**
System Modeling and Simulation: Modeling of physical systems, abstraction and system representation, mathematical and computational models, introduction to simulation and types, discrete and continuous systems, agent-based modeling concepts, system dynamics and feedback mechanisms. **Text Book 1: Ch 4: 4.1-4.6,& Ch 5: 5.1-5.6 Ch6: 6.1-6.8**	
Module – 3	**08 Hrs**
Data Handling and Integration: Introduction to data in Digital Twin systems, data collection and preprocessing, structured and unstructured data, NumPy arrays and operations, indexing, slicing, and broadcasting, data visualization basics, real-time data handling and integration concepts. **Text Book 2: Ch1: 1.1-1.9, & Ch 2: 2.1-2.14**	
Module – 4	**08 Hrs**
Predictive Analytics and Machine Learning: Introduction to machine learning concepts, supervised and unsupervised learning, data analysis and feature extraction, predictive modeling techniques, anomaly detection methods, model evaluation techniques, applications in predictive maintenance.	

Text Book 2: Ch3: 3.1-3.9, & Ch 4: 4.1-4.12	
Module – 5	**08 Hrs**
Simulation Tools and Applications of Digital Twins: Python-based simulation concepts , integrating simulation with real-time data, visualization techniques for monitoring systems , applications in Industry 4.0 and smart manufacturing , applications in healthcare and smart cities , challenges including security and scalability, future trends and research directions. **Text Book 2: Ch7: 7.1-7.9, & Ch 8: 8.1-8.10**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Interpret Digital Twin architecture and system concepts.
CO2	Develop simulation models for real-world systems
CO3	Process and analyze data using Python tools
CO4	Apply ML techniques for prediction and anomaly detection
CO5	Implement basic Digital Twin applications using appropriate tools and technologies.

Text Books	
1	Think Complexity: Complexity Science and Computational Modeling, Allen B. Downey, O'Reilly Media, 2nd Edition 2018, ISBN-10: 1492040207
2	Python Data Science Handbook, Jake VanderPlas,1st Edition, 2020, O'Reilly Media, ISBN: 9781491912053

Reference Books	
1	Digital Twins: Concepts and Technologies, Yogini Borole, Pradnya Borkar, Roshani Raut, Vijaya Parag Balpande, and Prasenjit Chatterjee, De Gruyter, O'Reilly Media 1st Edition, 2023, ISBN: 9783110778960.
2	Artificial Intelligence-Enabled Digital Twin for Smart Manufacturing, Amit Kumar Tyagi, Shrikant Tiwari, Senthil Kumar Arumugam, and Avinash Kumar Sharma, Wiley-Scrivener, O'Reilly Media ,1st Edition, 2025, ISBN: 9781394303571
3	Digital Twin Technology for the Energy Sector: Fundamentals, Advances, Mohammadreza Aghaei, Amin Moazami, Gabriele Lobaccaro, Umit Cali, Elsevier, 1st Edition, 2024,ISBN: 9780443140709

Web links and Video Lectures (e – Resources)	
1	https://drive.google.com/file/d/1xtXj95tJeBGxD4quXCDYoKqyQTg-BoUf/view
2	https://piazza.com/class_profile/get_resource/jjyt9xcoem64k5/jmicotl4p4l5xy
3	https://cmu-multicomp-lab.github.io/mmml-tutorial/schedule/
4	https://piazza.com/cmu/fall2018/11777/resources

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	3	2									1
CO2	3	3	2		2				1		1

2024 Scheme

CO3	2	2	2	2	2				1		1
CO4	3	3	2	3	2				1	1	1
CO5	3	3	2	2	3				1	2	2

Semester: VI					
Cyber Threat Intelligence					
Course Code	**:**	BCI623D	**Credits**	**:**	03
Hours/Week (L:T:P)	**:**	3:0:0	**CIE**	**:**	50 Marks
Total Hours	**:**	40 Hrs	**SEE**	**:**	50 Marks
Course Type	**:**	PEC	**SEE Duration**	**:**	03 Hours

Prerequisites:	
Courses	Computer networks, Operating systems
Knowledge on Fundamental Concepts	Cybersecurity Basics
Knowledge on Connected Tools (If any)	VirusTotal, Cisco Talos Intelligence, OpenCTI

Course Learning Objectives: This course will enable the students to	
CLO1	Describe key terminologies such as intelligence, cyber threat, and cyber threat intelligence.
CLO2	Trace the historical development of threat intelligence across different ages and technological eras.
CLO3	Analyze different types of threat actors, vulnerabilities, attack vectors, and their motivations.
CLO4	Evaluate cyber threat intelligence to support effective cybersecurity decision-making.
CLO5	Use the intelligence cycle and situational awareness models to support threat modeling, incident readiness, and response planning.

Module – 1	**08 Hrs**
Introduction: Definitions, Intelligence, Cyber Threat, Cyber Threat Intelligence. **History of Threat Intelligence**, Antiquity, Ancient Rome, Medieval and Renaissance Age, Industrial Age, World War I, World War II, Post War Intelligence, Cyber Threat Intelligence, Emergence of Private Sector Intelligence Sharing, **Utility of Threat Intelligence**, Developing Cyber Threat Intelligence. **Text Book 1: Ch 1: 1.1 to 1.3**	
Module – 2	**08 Hrs**
Threat Environment: Threat, Threat Classification, Risk and Vulnerability. Human Vulnerabilities, Configuration Vulnerabilities, Software Vulnerabilities. Threat Actors, TTPs – Tactics, Techniques, and Procedures, Victimology, Threat Landscape, Attack Vectors, Vulnerabilities, and Exploits, The Kill Chain, Untargeted versus Targeted Attacks, Persistence, Thinking Like a Threat Actor. **Text Book 1: Ch 2: 2.1 to 2.11**	
Module – 3	**08 Hrs**
Applying Intelligence: Planning Intelligence Gathering, The Intelligence Cycle, Situational Awareness, Goal Oriented Security and Threat Modelling, Strategic, Operational, and Tactical Intelligence, Incident Preparedness and Response, **Text Book 1: Ch 3: 3.1 to 3.6**	
Module – 4	**08 Hrs**

Collecting Intelligence: Hierarchy of Evidence, Understanding Intelligence, Third Party Intelligence Reports, Internal Incident Reports, Root Cause Analysis, Active Intelligence Gathering, **Text Book 1: Ch 4: 4.1 to 4.6**	
Module – 5	**08 Hrs**
Generating Intelligence: The Intelligence Cycle in Practice, Sources of Data, Searching Data, Threat Hunting, Transforming Data into Intelligence, Sharing Intelligence, Measuring the Effectiveness of Generated Intelligence. **Text Book 1: Ch 5: 5.1 to 5.7**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the fundamental concepts of intelligence and the historical evolution of cyber threat intelligence.
CO2	Analyze various cyber threats, threat actors, vulnerabilities, and attack vectors in the modern threat environment.
CO3	Utilize intelligence frameworks, models, and methodologies to plan, gather, and assess cyber threat data.
CO4	Evaluate internal and external intelligence sources to support incident response and security decision-making.
CO5	Develop actionable cyber threat intelligence and evaluate its effectiveness in defending systems and organizations.

Text Book	
1	Cyber Threat Intelligence, Martin Lee, 1st edition, John Wiley & Sons, Inc, 2023, ISBN:9781119861744.

Reference Books	
1	Practical Cyber Intelligence: How action-based intelligence can be an effective response to incidents, Wilson Bautista, 1st edition, Packt Publishing, April 24, 2018, ISBN: 9781788835244.
2	Mitre ATT&CK For Dummies, AttackIQ Special Edition, The Experts at For Dummies, 1st Edition, For Dummies, 2020, ISBN 978-1119748090.

Web links and Video Lectures (e – Resources)	
1	Threat Intelligence, IIT Kanpur: https://www.youtube.com/watch?v=APoSgdq2uJg
2	Cyber security and privacy NPTEL sorted: Cyber Security and Privacy – Course https://onlinecourses.nptel.ac.in/noc25_cs116/preview

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	3	2	1	1	1			2		2	2
CO2	3	3	2	2	2			2		1	2
CO3	2	3	2	3	3			2	1	2	3
CO4	2	3	2	3	2	1		2	1	2	3
CO5	2	2	3	2	3	1		3	2	3	3

Semester: VI					
MLOps					
Course Code	**:**	BCI624A	**Credits**	**:**	3
Hours/Week (L: T:P)	**:**	3:1:0	**CIE**	**:**	50 Marks
Total Hours	**:**	40L	**SEE**	**:**	50 Marks
Course Type	**:**	PEC	**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Basics of MLOps concepts and lifecycle
Knowledge on Fundamental Concepts	Understand the fundamental concepts of MLOps
Knowledge on Connected Tools (If any)	

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the need, challenges, risk mitigation, and scalability of MLOps, and to identify the roles and responsibilities of key stakeholders involved in MLOps systems.
CLO2	Infer the concepts of end-to-end MLOps lifecycle, from business understanding and model development to deployment, monitoring, governance, and responsible AI practices.
CLO3	Explore the machine learning model development and production deployment, including data exploration, experimentation, evaluation, versioning, CI/CD pipelines, containerization, and scalable deployment strategies.
CLO4	Demonstrate the model retraining, drift detection, and feedback loops, along with MLOps governance, risk-based controls, regulatory requirements, and responsible AI practices.
CLO5	Illustrate the application of MLOps in real-world use cases, including consumer credit risk management and marketing recommendation systems, covering model development.

Module – 1	**08 Hrs.**
What and Why: Why Now and Challenges: Defining MLOps and Its Challenges, MLOps to Mitigate Risk, MLOps for Scale. **People of MLOps**: Subject Matter Experts, Data Scientists, ata Engineers, Software Engineers, DevOps, Model Risk Manager/Auditor, Machine Learning Architect**.** **Textbook: Ch 1:1.1-1.3 Ch 2: 2.1-2.7**	
Module – 2	**08 Hrs.**
Key MLOps Features: Model Development, Establishing Business Objectives, Data Sources and Exploratory Data Analysis, Feature Engineering and Selection, Training and Evaluation, Reproducibility, Responsible AI, Productionalization and Deployment, Monitoring, Iteration and Life Cycle, Governance. **Textbook : Ch: 3: 3.1-3.6**	
Module – 3	**08 Hrs.**
Developing Models: What Is a Machine Learning Model?, Data Exploration, Feature Engineering and Selection, Experimentation, Evaluating and Comparing Models, Version Management and Reproducibility **Deploying to Production:** CI/CD Pipelines, Building ML Artifacts, Deployment Strategies, Containerization, Scaling Deployments, Requirements and Challenges.	

Textbook: Ch 4: 4.1-4.6 Ch 6: 6.1-6.6	
Module – 4	**08 Hrs.**
Feedback Loop: How Often Should Models Be Retrained? Understanding Model Degradation, Drift Detection in Practice, The Feedback Loop. **Model Governance**:Who decides what governance organization needs, Matching governance with Risk Level, Current regulations driving MLOps governance, Key elements of responsible AI, Template of MLOps Governance **Textbook: Ch 7: 7.1-7.4 Ch 8: 8.1-8.7**	
Module – 5	**08 Hrs.**
MLOps in Consumer Credit Risk Management: Model Development, Model Bias Considerations, Prepare for Production, Deploy to Production **MLOps in Marketing Recommendation Engines:** The Rise of Recommendation Engines, Data Preparation, design and Manage Experiments, Model Training and Deployment, Pipeline Structure and Deployment Strategy, Monitoring and Feedback. **Textbook: Ch 9: 9.1.1-9.4 Ch 10: 10.1-10.6**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Identify and apply various ML-Ops techniques to deploy machine learning models for real-world problems.
CO2	Understand and implement key MLOps features across the end-to-end machine learning lifecycle.
CO3	Design CI/CD Pipelines for Deploying Machine Learning Models.
CO4	Illustrate the need for model governance and feedback loop.
CO5	Apply MLOps practices to real-world applications such as consumer credit risk management and marketing recommendation systems.

Text Book	
1	Introducing MLOps, O'Reilly. Author, Mark Treveil & Dataiku Team. First Edition, illustrated. Publisher O'Reilly Media, 2020. ISBN(s): 978-1492083290.

Reference Books	
1	Noah Gift and Alfredo Deza, Practical MLOps, O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472 , 1st Edition, 2021, ISBN: 9781098103019
2	David Sweenor, Steven Hillion, Dan Rope, Dev Kannabiran, Thomas Hill, Michael O'Connell, "MLOps: Operationalizing Data Science", O'Reilly Media, Inc., 1 st Edition , 2020, ISBN : 9781492074656

Web links and Video Lectures (e–Resources)	
1	https://martinfowler.com/articles/microservices.html
2	https://www.coursera.org/specializations/mlops

CO – PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	2	3	1					2
CO2	3	2	2	2	3						1
CO3	2	2	3		2			1	1	2	1
CO4	2	2		2		2	2				
CO5	3	3	2	2	3	2	1	1		2	2

Semester: VI					
HUMAN COMPUTER INTERACTION **Stream: CSE(AI&ML)**					
Course Code	**:**	BCI624B	**Credits**	**:**	3
Hours/Week(L:T:P)	**:**	3:0:0	**CIE**	**:**	50 Marks
Total Hours	**:**	40L	**SEE**	**:**	50 Marks
Course Type	**:**	PEC	**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Programming Fundamentals, Data Structures, Introduction to Artificial Intelligence
Knowledge on Fundamental Concepts	Computer fundamentals, software development lifecycle, and basic user interface concepts
Knowledge on Connected Tools	

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the principles of human cognition, perception, and computer technologies that influence user interaction.
CLO2	Analyze interaction models, interface paradigms, and usability principles for designing effective user interfaces.
CLO3	Apply user-centered design methodologies, design rules, and usability engineering practices in interface development.
CLO4	Design and evaluate interactive systems using appropriate evaluation techniques, accessibility principles, and universal design approaches.
CLO5	Examine advanced HCI concepts, cognitive models, task analysis techniques, and emerging interaction paradigms.

Module – 1	**08 Hrs**
Foundations of Human Computer Interaction The Human: Input–Output Channels, Human Memory, Thinking: Reasoning and Problem Solving, Emotion and Human Error. The Computer: Text Entry and Pointing Devices, Display Devices, Devices for Virtual Reality and Interaction, Physical Controls, Sensors and Special Devices. **Textbook 1: Ch 1: 1.1 to 1.6, Ch 2: 2.1 to 2.6**	
Module – 2	**08 Hrs**
The Interaction, Paradigms and Interaction Design Basics Models of Interaction, Frameworks and Ergonomics, Interaction Styles, Interactivity, Paradigms for Interaction, The Design Process, User Focus, Scenarios, Navigation Design and Screen Design. **Textbook 1: Ch 3: 3.1 to 3.6, Ch 4: 4.1 to 4.2, Ch 5: 5.1 to 5.6**	
Module – 3	**08 Hrs**
HCI in the Software Process, Design Rules and Implementation Support Software Lifecycle, Usability Engineering, Iterative Design and Prototyping, Design Rationale, Principles to Support Usability, Standards, Guidelines and Heuristics, Windowing Systems, Interaction Toolkits and User Interface Management Systems. **Textbook 1: Ch 6: 6.1 to 6.5, Ch 7: 7.1 to 7.5, Ch 8: 8.1 to 8.4**	

Module – 4	**08 Hrs**
Evaluation Techniques, Universal Design and User Support: Goals of Evaluation, Evaluation Through Expert Analysis, Evaluation Through User Participation, Evaluation in Controlled Settings, Universal Design Principles, Designing for Diversity, User Support, Help and Documentation, Adaptive Help Systems. **Textbook 1: Ch 9: 9.1 to 9.5, Ch 10: 10.1 to 10.3, Ch 11: 11.1 to 11.4**	
Module – 5	**08 Hrs**
Cognitive Models, Socio-Organizational Issues and Task Analysis Cognitive Models, Hierarchical Models, Linguistic Models, Socio-Organizational Issues, Stakeholder Requirements, Task Analysis, Task Decomposition, Knowledge-Based Techniques and Entity-Relationship Based Techniques. **Textbook 1: Ch 12: 12.1 to 13.4, Ch 13: 13.1 to 13.3, Ch 15: 15.1 to 15.5,**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Interpret human cognitive characteristics and computer technologies influencing human-computer interaction.
CO2	Analyze interaction models, interface paradigms, and user-centered design principles.
CO3	Apply usability engineering techniques, design standards, and implementation support tools for interface development.
CO4	Evaluate interactive systems using usability testing, heuristic evaluation, and accessibility guidelines.
CO5	Design human-centered solutions using cognitive models, task analysis methods, and emerging HCI concepts.

Text Books	
1	Human Computer Interaction, Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, 3rd Edition, Pearson Education, 2004, ISBN-13: 9780130461094

Reference Books	
1	*The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications,* Julie A. Jacko and Andrew SearsLawrence Erlbaum Associates, Inc., Publishers, First Edition (1st Ed.)**,** 2003**,** ISBN-13: 978-0805838389
2	Interaction Design: Beyond Human-Computer Interaction, Yvonne Rogers, Helen Sharp, Jenny Preece, John Wiley & Sons, Inc. 6th Edition, 2023. ISBN-13: 978-1119901097
3	Human-Computer Interaction: Developing Effective Organizational Information Systems, Dov Te'eni, Jane Carey, Ping Zhang, John Wiley & Sons, Inc. 1st Edition, 2007. ISBN-13: 978-0470082803

Web links and Video Lectures (e – Resources)	
1	https://nptel.ac.in/courses/106106177
2	https://nptel.ac.in/courses/106103115
3	https://freevideolectures.com/course/4491/nptel-introduction-humancomputer-interaction
4	https://www.iare.ac.in/sites/default/files/lecture_notes/HCI%20
5	https://mrcet.com/pdf/Lab%20Manuals/IT/R15A0562%20HCI.pdf

2024 Scheme
CO – PO MAPPING

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2									
CO2	2	3	2								
CO3	2	2	3	2	3			1			
CO4	2	3	2	3	2	1		2			
CO5	2	2	3	2	2	2	1	2	1	1	2

Semester: VI					
Robotics and Autonomous System					
Course Code	**:**	BCI624C	**Credits**	**:**	3
Hours/Week (L: T:P)	**:**	3:0:0	**CIE**	**:**	50 Marks
Total Hours	**:**	40 Hrs	**SEE**	**:**	50 Marks
Course Type	**:**	PEC	**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Introduction to Robotics
Knowledge on Fundamental Concepts	Basic principles, structure, and functioning of robotics.
Knowledge on Connected Tools (If any)	

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the background and evolution of robotics, and analyze robot arm kinematics and dynamics, including direct and inverse kinematics and motion equations using Lagrange–Euler formulation.
CLO2	Describe the fundamentals of robotic sensing, including range, proximity, touch, force, and torque sensing techniques.
CLO3	Illustrate the basics of robot programming languages and their characteristics at both robot-level and task-level.
CLO4	Identify the robot intelligence and task planning, including problem-solving, state space search, logic-based reasoning, learning, and task planning techniques.
CLO5	Explore the concepts ROS navigation stack, including Nav2 architecture, map generation, and implementing ROS 2 clients for mobile robot navigation.

Module – 1	**08 Hrs**
Introduction: Background, Historical Development. **Robot Arm Kinematics:** Introduction, The Direct Kinematics Problem & Inverse Kinematics Solutions. **Robot Arm Dynamics:** Introduction, Lagrange-Euler Formulation, Generalized D'Alembert Equations of Motion. **Text Book 1: Ch 1: 1.1-1.2 , Ch 2: 2.1-2.3 , Ch 3: 3.1-3.4**	
Module – 2	**08 Hrs**
Sensing: Introduction, Range Sensing, Proximity Sensing, Touch Sensing, Force Sensing, Torque Sensing. **Text Book 1: Ch 6: 6.1-6.5**	
Module – 3	**08 Hrs**
Robot Programming Languages: Introduction, Characteristics of Robot-Level Languages, Characteristics of Task-Level Languages **Text Book 1: Ch 9: 9.1-9.3**	
Module – 4	**08 Hrs**

Robot Intelligence and Task Planning: Introduction, State Space Search, Problem Reduction, Use of Predicate Logic, Means-Ends Analysis, Problem-Solving, Robot Learning, Robot Task Planning, Basic Problems in Taks Planning. **Text Book 1: Ch 10: 10.1-10.9**	
Module – 5	**08 Hrs**
Navigation stack in ROS: Introduction, Structure, Nav2 Architecture Overview, setting up Nav2 for your Mobile Robot, Starting with Map Generation Using Nav2, Implement a ROS 2 Client for Nav2 **Text Book 2: Ch 5: 5.1-5.7**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand robot arm kinematics and dynamics using direct/inverse kinematics and Lagrange Euler formulations.
CO2	Describe the various robotic sensing methods, including range, proximity, touch, force, and torque sensing.
CO3	Identify the the basics and characteristics of robot-level and task-level programming languages.
CO4	Apply robot intelligence and task planning techniques to solve problems, perform state space searches, use logic-based reasoning, and implement robot learning strategies.
CO5	Analyze the ROS Navigation Stack, Nav2 architecture, and the map generation process for mobile robot navigation.

Text Books	
1	Robotics: Control Sensing Vision & Intelligence, Ks Fu, Csg Lee, Rafael C Gonzalez , McGraw-Hill Education (ISE Editions) , ISBN 9780071004213
2	Cacace, Jonathan. Ultimate Robotics Programming with ROS 2 and Python, Orange Education, 1st Edition, December 2024, ISBN- 978-9348107954

Reference Books	
1	Mastering ROS2 and Python for Robotics: Develop Intelligent Autonomous Systems with Real-World Applications, Carter, Thompson; Sanders, Rafael; Farmer, Miguel. Amazon Kindle Direct Publishing, 1st Edition, February 2025, ISBN-
2	“Robotics and Control” R. K. Mittal, I. J. Nagrath, Tata-McGraw-Hill Publications, 1 July 2017, ISBN-978-0070482937.

Web links and Video Lectures (e–Resources)	
1	Robotics Specialization https://www.coursera.org/specializations/robotics
2	Introduction to Robotics https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/syllabus/
3	INTRODUCTION TO ROBOTICS https://nptel.ac.in/courses/107/106/107106090/

2024 Scheme

4	https://coral.ise.lehigh.edu/optml/files/2019/10/OptML_CV_tutorial_1_compressed.pdf

CO – PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2		2	1						1
CO2	2	2		2	2	1					1
CO3	2	1	2		3			1			1
CO4	2	3	3	2	2	1		1			2
CO5	2	2	2	2	3	1		1	1		2

Semester: VI					
Cloud Security and Software Defined Networking					
Course Code	:	BCI624D	**Credits**	:	03
Hours/Week (L:T:P)	:	3:0:0	**CIE**	:	50 Marks
Total Hours	:	40 Hrs	**SEE**	:	50 Marks
Course Type	:	PEC	**SEE Duration**	:	03 Hours

Prerequisites:	
Courses	-
Knowledge on Fundamental Concepts	Computer Networks, Cloud Computing and Information Security
Knowledge on Connected Tools (If any)	-

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the fundamentals of cloud computing, cloud security challenges, and secure data management techniques.
CLO2	Summarize the cloud data protection mechanisms including encryption, access control, identity management, and secure storage.
CLO3	Utilize advanced cloud security concepts such as data accountability, secure multiparty computation, cyber resilience, and authentication mechanisms.
CLO4	Illustrate the architecture, components, protocols, and applications of Software Defined Networking.
CLO5	Analyse SDN virtualization, NFV, SDN security challenges, and cloud-edge integration in modern networks.

Module – 1	**08 Hrs.**
Secure Data Management in Cloud Environments: Collaborative Cloud: Safeguarding Sensitive Information through Innovative Secure Data-Sharing Practices, Orchestrating Data Integrity through Remote Auditing and Compliance Assurance, Navigating the Abyss – Illuminating Data Leakage Threats, Mitigations, and Future Horizons. **Textbook 1: Ch 1, Ch 2, Ch3**	
Module – 2	**08 Hrs.**
Cloud Data Protection and Identity Management: Decoding the Cloud: A Comprehensive Exploration of Data Loss Scenarios, Resilient Storage Architectures, and Advanced Backup Strategies in Cloud Environments. **Cryptographic Bastions:** Mastering Cloud Security through Advanced Access Control and Encryption Strategies. **Identity Threads in the Cloud Tapestry:** A Comprehensive Study of Federated Identity Management and Its Role in Ensuring Cloud Security. **Textbook 1: Ch 4, Ch 5, Ch 7**	

Module – 3	**08 Hrs.**
Advanced Cloud Security and Emerging Technologies: Anticipating the Evolution of Data Accountability through Technological Advancements and Regulatory Landscape Changes, Secure Multiparty Computation: Protocols, Collaborative Data Processing, and Real-World Applications in Industry, Role-Based Virtuosity in Virtual Environments – A Technical Exploration of Access Control and Authentication Mechanisms. **Textbook 1: Ch 8, Ch 9, Ch 10**	
Module – 4	**08 Hrs.**
Software Defined Networking Fundamentals and Applications: Introduction to SDN, Terminology and Architecture, The role of Network Operating Systems, SDN versus NFV, The Role of NFV into SDN-Based IoT Systems, SDN Architecture, Functionalities of SDN, SDN versus Traditional Hardware-Based Networks, Load Balancing in SDN, SDN Security, SDN Applications, SDN vs Traditional Networks, Implementation Architecture, Pros and Cons of SDN. **Textbook 2: Ch 1: 1.1 to 1.5, Ch 2: 2.2 to 2.7, Ch 3: 3.2, 3.3, 3.5, 3.6**	
Module – 5	**08 Hrs.**
Advanced SDN Technologies, Virtualization and Security: Introduction, Types of Virtualizations, Network Functions Virtualization and Software-Defined Network, Importance of SDN in Network Function Virtualization (NFV), SDN and Network Virtualization Role in Evolution of Next-Generation Wi-Fi and Mobile Networks, SDN and NFV Role in 5G and Smart Cities, Security Issues in Software-Defined Networking, Potential Attacks in Software-Defined Networking, Solutions to Security Issues and Attacks in Software Defined Networking. **Textbook 2: Ch 7: 7.1 to 7.2, 7.4, Ch 8: 8.3 to 8.5, Ch 9: 9.4 to 9.6**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Infer secure data-sharing mechanisms, remote auditing techniques, and data leakage mitigation strategies in cloud environments.
CO2	Interpret cloud data protection techniques including resilient storage architectures, backup strategies, encryption, and access control mechanisms.
CO3	Identify federated identity management, secure multiparty computation, data accountability, and cyber resilience techniques for cloud security.
CO4	Analyze the architecture, components, protocols, and applications of Software Defined Networking (SDN).
CO5	Evaluate SDN virtualization, NFV, SDN security challenges, and SDN-enabled cloud and edge computing infrastructures.

Text Books	
1	Cloud Security: Concepts, Applications and Practices, Jamuna S. Murthy, Siddesh G. M, Srinivasa K. G, 1st Edition, CRC Press, 2024, ISBN: 9781032596112.

2	Software Defined Networks: Architecture and Applications. Anand Nayyar, Bhawna Singla, Preeti Nagrath, 1st Edition, Wiley, 2022, ISBN: 9781119857303.

Reference Books	
1	Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance. Tim Mather, Subra Kumaraswamy, Shahed Latif, 1st Edition, O'Reilly Media, 2009, Inc, ISBN: 9780596802769.
2	Software Defined Networking: Design and Deployment. Authors: Patricia A. Morreale, James M. Anderson, 1st Edition, CRC Press, 2014, Taylor & Francis Group, ISBN: 9781482235623.
3	Network Function Virtualization (NFV) with a Touch of SDN. Authors: Ken Gray, Thomas D. Nadeau, 1st Edition, O'Reilly Media, 2016, Inc, ISBN: 9781491923214.

Web links and Video Lectures (e – Resources)	
1	Cloud security: https://www.youtube.com/watch?v=Ijkvx1u0w6o
2	Software-defined networking: https://www.youtube.com/watch?v=nUN40N91fJ4&list=PLJ6vZHpRUoJNn-3F918wKpAtr6gGUOixc
3	Cloud Security complete course: https://www.udemy.com/course/cloud-security-complete-course/?srsltid=AfmBOoo36uqdIuBxzPEuKxn34BkeDItoM2FudR2AHmIqdB5jZgWnB85K&couponCode=CP2511241BG1
4	Software-defined networking course: https://www.coursera.org/learn/sdn

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	3	3		2	2			1			
CO2	3	3	2	2	3			1			
CO3	3	3	2	2	2	2		1			
CO4	3	3	2	2	3						
CO5	3	3	3	2	3	2		1			2

Semester: VI					
Cloud Computing Lab					
Course Code	**:**	BCIL607	**Credits**	**:**	3
Hours/Week(L:T:P)	**:**	0:0:2	**CIE**	**:**	50 Marks
Total Hours	**:**	15 L	**SEE**	**:**	50 Marks
Course Type	**:**	PCCL	**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	Computer Networks, Operating Systems, Virtualization Technologies, Cloud Computing, Linux Fundamentals
Knowledge on Fundamental Concepts	Basics of cloud computing, virtualization, Linux, and computer networks.
Knowledge on Connected Tools (If any)	Ubuntu/Linux, OpenStack (Horizon & CLI), Docker, Kubernetes, Python.

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the practical aspects of cloud computing using the OpenStack platform.
CLO2	Deploy and manage virtual machines and cloud resources
CLO3	Configure cloud networking, storage, and identity management services.
CLO4	Develop and deploy scalable cloud applications
CLO5	Monitor, automate, and orchestrate cloud infrastructure using OpenStack services.

Sl. No.	**Experiments**
1.	Creating a Virtual Machine: Configure and deploy a virtual machine with specified CPU, RAM, storage, security groups, and floating IP using the OpenStack Horizon Dashboard.
2.	Getting Started with OpenStack CLI: Install and configure OpenStack CLI. Create, list, modify, and delete cloud resources using command-line tools.
3.	Managing OpenStack Images (Glance): Upload cloud images, create custom images, launch instances from images, and manage snapshots.
4.	Identity Management Using Keystone: Create projects, users, roles, and assign permissions using Keystone and Horizon Dashboard.
5.	Managing Object Storage Using OpenStack Swift: Create storage containers, upload/download objects, configure access permissions, and manage object storage.
6.	Cloud Networking Using Neutron: Create virtual networks, subnets, routers, security groups, floating IPs, and connect virtual machines.
7.	Cloud Functions and Workflow Automation: Implement event-driven cloud automation using OpenStack Mistral workflows for resource management.
8.	Deploying a Web Application: Deploy a web application on an OpenStack virtual machine and configure Load Balancer for scalable access.
9.	Cloud Monitoring Using OpenStack Telemetry: Monitor CPU, memory, storage, and network utilization using Ceilometer/Gnocchi/OpenStack Telemetry services.

10.	Container Deployment Using Kubernetes on OpenStack: Create a Kubernetes cluster on OpenStack virtual machines and deploy a containerized application.
11.	Block Storage Management Using Cinder: Create, attach, detach, resize, and snapshot block storage volumes.
12.	Cloud Orchestration Using Heat: Create and deploy cloud infrastructure using Heat Orchestration Templates (HOT).

Open Ended Experiment

Mini Project: Cloud Resource Deployment and Management Using OpenStack

Develop a complete cloud environment by integrating OpenStack services.

The project should include:

- Creating projects, users, and roles using Keystone.
- Uploading images using Glance.
- Creating virtual machines using Nova.
- Configuring networking using Neutron.
- Managing object storage using Swift.
- Creating block storage volumes using Cinder.
- Deploying a web application.
- Configuring load balancing.
- Monitoring cloud resources using Telemetry.
- Automating deployment using Heat or Mistral.
- Demonstrating Kubernetes deployment on OpenStack.

Course Outcomes: After completing the course, the students will be able to	
CO1	Create and configure virtual machines using OpenStack Horizon Dashboard and CLI.
CO2	Manage OpenStack compute, networking, storage, and identity services.
CO3	Deploy scalable applications using OpenStack cloud services.
CO4	Implement cloud automation, orchestration, monitoring, and container deployment.

CO – PO – PSO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	1	3				1	1		1	1
CO2	3	3	2	2	3				2	1		1	1
CO3	2	3	3	2	3		1		2	2	1	1	1
CO4	2	3	3	3	3		1	1	2	2	2	1	1

Institute Vision

Preparing Competent Engineering and Management Professionals to Serve the Society

Institute Mission

- Providing Students with a Sound Knowledge in Fundamentals of their branch of Study.
- Promoting Excellence in Teaching, Training, Research and Consultancy.
- Exposing Students to Emerging Frontiers in various domains enabling Continuous Learning.
- Developing Entrepreneurial acumen to venture into Innovative areas.
- Imparting Value based Professional Education with a sense of Social Responsibility.

Department Vision

Nurturing AI&ML technocrats to become proficient in solving real – world problems.

Department Mission

- Providing fundamentals to enhance niche expertise in AI&M, cognitive computing robotics and neural networks.
- Enhancing the Analytical and problem – solving abilities to meet the challenges of the future.
- Training the students with the latest technology to become sustainable professionals.
- Fostering a culture of collaboration and propagating industry – oriented innovation and research.
- Establishing a stimulating learning environment to create value – based and pioneering.

SJC INSTITUTE OF TECHNOLOGY

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P.B. No.20, B.B Road,

Chikkaballapur - 562 101, Karnataka