Agnel Charities

Fr. C. Rodrigues Institute of Technology

Sector 9A, Vashi, Navi Mumbai, 400703, Maharashtra, India

www.fcrit.ac.in

An Autonomous Institute Affiliated to the University of Mumbai

Department of Computer Engineering

Curriculum Structure –

Honours / Minor Degree Program

Prepared by: Board of Studies for Computer Engineering

Approved By: Academic Council of Fr. C. Rodrigues Institute of Technology

Effective from :2025-26

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Contents- Honours/Minor Track

Honours/Minor Track: Artificial Intelligence & Machine Learning (AIML)

Curriculum Structure for Honours/Minor Degree Program : *Artificial Intelligence & Machine Learning*

Course Type	Sem	Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
				L	P	T	L	P	T	Total
HMC	V	HMCAL501	Knowledge Engineering	3	--	--	3	--	--	3
HMC	VI	HMCAL602	Foundation of Machine Learning	3	--	--	3	--	--	3
HMC	VII	HMCAL703	Deep Learning	4	--	--	4	--	--	4
HML	VII	HMLAL701	Artificial Intelligence & Machine Learning Laboratory	--	4	--	--	2	--	2
HMC	VIII	HMCAL804	Advanced AI	4	--	--	4	--	--	4
HMP	VIII	HMPAL801	Mini Project	--	6	--	--	2	--	2
			Total	**14**	**10**	**--**	**14**	**04**	**--**	**18**

Examination Scheme for Honours/Minor Degree Program

				Examination Scheme					
Course Type	Sem	Course Code	Course Name	In-Semester Assessment		End Sem Exam (ESE)	Exam. Duration for Theory (in Hrs)		Total
				Continuous Assessment	Mid Sem Exam		Mid Sem	End Sem	
HMC	V	HMCAL501	Knowledge Engineering	20	30	50	1.5	2	100
HMC	VI	HMCAL602	Foundation of Machine Learning	20	30	50	1.5	2	100
HMC	VII	HMCAL703	Deep Learning	20	30	50	1.5	2	100
HML	VII	HMLAL701	Artificial Intelligence & Machine Learning Laboratory	50	--	--	--	--	50
HMC	VIII	HMCAL804	Advanced AI	20	30	50	1.5	2	100
HMP	VIII	HMPAL801	Mini Project	50	--	50	--	--	100
			Total	**180**	**120**	**250**	**--**	**--**	**550**

Course Type	Course Code	Course Name	Credits
HMC	HMCAL501	KNOWLEDGE ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. CEPCC304 Database Management System
2. CEPCC405 Engineering Math IV
3. CEPCC406 Analysis of Algorithms

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigation of Complex Problems
5. PO6: The Engineer and The World
6. PO7: Ethics
7. PO11: Lifelong learning

Course Objectives:

1. To conceptualize the basic ideas underlying the design of Knowledge Based Systems.
2. To make students understand and explore tasks involved in Knowledge Engineering
3. To make students understand how to deal with uncertain and incomplete information
4. To make students understand the life cycle of Knowledge Based Systems

Module	Details	Hrs.
	Course Introduction Knowledge engineering is a field within artificial intelligence (AI) that focuses on capturing, representing, and integrating human expertise into computer systems to create intelligent systems that can perform complex tasks and make human-like decisions. The importance of the course lies in focusing on building systems that can emulate the judgment and behavior of a human expert in a specific domain.	**01**
01.	**Introduction to Knowledge Engineering** ***Learning Objective:*** *Familiarize learner with fundamental concepts, such as knowledge acquisition, representation, reasoning, and inference.*	**4-6**

	Contents:
	• Data, Information and Knowledge
	• Knowledge Based Systems
	• Overview of KE activities
	  o Knowledge acquisition
	  o Knowledge validation
	  o Knowledge representation
	  o Inference, Explanation and Justification	

	Self-Learning Topics: *Applications in Education, Healthcare, Logistics, Manufacturing*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply computer science theory to understand the differences between data, information, knowledge and wisdom, and be able to provide examples of each. (PI 1.4.1) (PI 11.3.1)* *LO 1.2: Apply statistics and numerical techniques to transform data into meaningful information (PI 1.1.1), (PI 11.2.2)* *LO 1.3: Compare different mechanism of data extraction and representation (PI 2.2.4)* *LO 1.4: Analyze results based on the inferences drawn on the given data along with proper explanation and justification. (PI 2.4.2), (PI 11.2.2)*	
02.	**Knowledge Based Systems** ***Learning Objective:*** ***Define and explain the concept of Knowledge-Based Systems and Identify and describe the different types of Knowledge-Based Systems***	**8-10**

	Contents:
	• Types of Knowledge Based Systems
	  o Expert Systems
	  o Intelligent Agents
	  o Data Mining
	  o Case Based Reasoning
	  o Genetic Algorithms
	  o Neural Networks	

	Self-Learning Topics: *Medical Diagnostic System, Robotic Navigation System, Raw Neural Network*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Design expert system and intelligent agents and identify their components along with a brief assessment of their social and economic impact. (PI 3.2.2) (PI 6.3.2)* *LO 2.2 Explore the design mechanism of data mining and case based reasoning techniques and explore advancements in the respective fields ensuring ongoing competence in evolving applications. (PI 3.2.1), (PI 11.2.2)* *LO 2.3 Develop the ability to explore and investigate genetic algorithms and neural networks and identify the risk, impact on various processes, professions and domains along with the trends and advancements in the field. (PI 6.3.1), (PI 11.2.1)*	

03.	**Knowledge Acquisition and Representation** ***Learning Objective:*** *Define and explain the concept of knowledge acquisition and representation along with identifying and describing the different methods of the same.*	**6-8**

	Contents:
	• Knowledge Acquisition
	  o Sources of Knowledge
	  o Structured and Unstructured Knowledge
	  o Principles of Knowledge Acquisition Systems
	  o Knowledge Acquisition Systems Measurements, Modules and Methods
	  o Types of Knowledge Acquisition Systems
	  o Applications and Benefits of Knowledge Acquisition Systems
	• Knowledge Representation
	  o Types of Knowledge: Declarative, Structural, Meta, Procedural, Heuristic
	  o Database and Knowledge base
	  o Textual and Visual Representation Tools
	  o Acquisition Efficiency and Representational Accuracy	

	Self-Learning Topics: *Automated Knowledge Extraction*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Develop skills to identify appropriate techniques to acquire and represent knowledge along with integrating sustainable development principles and consider socio-economic and environmental impacts in the design (PI 4.3.1), (PI 6.3.2)* *LO 3.2 Analyze real-world applications and assess the efficiency of knowledge acquisition processes and the accuracy of knowledge representation considering sustainability and technological advancement in the field. (PI 4.3.3), (PI 6.4.2)* *LO 3.3: Address privacy concerns in knowledge acquisition and representation and adopt ethical ways of knowledge acquisition and representation (PI 1.4.1), (PI 7.1.1)*	
04.	**Knowledge Based Reasoning** ***Learning Objectives:*** *Define and explain the concept of knowledge-based reasoning, including its importance and applications in artificial intelligence and computer science.*	**8-10**

	Contents:
	• Representation in First Order Logic
	  o Logic, Rules and Laws of Logic
	  o Learning and Reasoning
	  o Inference in First Order Logic
	  o Rule Based Systems
	  o Semantic Networks	

	Self-Learning Topics: *Fuzzy Logic Controllers*	

	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply discrete structures to represent knowledge in first order logic and analyze results of logical simplification. (PI 1.1.1)* *LO 4.2: Apply mathematical knowledge to model learning systems and derive conclusions from FOL knowledge bases. (PI 1.1.2)* *LO 4.3: Draw inferences from knowledge bases and represent inference results graphically along with identification of socio economic impacts of automated reasoning systems (PI 4.3.3), (PI 6.3.2)* *LO 4.4: Develop methodologies for rule based system implementation along with identifying risks in their deployment. (PI 4.2.1), (PI 6.3.1)* *LO 4.5: Analyze semantic network queries to solve knowledge base problems (PI 2.4.2)*	
05.	**Uncertain Knowledge and Reasoning** ***Learning Objective/s:*** *Understand the concept of uncertainty in knowledge representation and reasoning, analyse and evaluate the different approaches to handling uncertainty in knowledge representation and reasoning*	**7-9**
	Contents: • Acting under Uncertainty • Basic Probability Notation • Inference Using Full Joint Distributions • Independence, Bayes‘ Rule and Its Use, • Representing Knowledge in an Uncertain Domain • Bayesian Belief Network • Hidden Markov Model	
	Self-Learning Topics: *BBN and HMM Applications*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply engineering mathematics to solve problems based on the concept of uncertainty and its implications on critical thinking in decision-making process.* *(PI 1.1.2), PI 11.3.1)* *LO 5.2: Choose and use the correct procedure based on the principles of Bayesian belief networks to model complex systems and draw inferences in uncertain domain. (PI 1.4.1), (PI 11.2.2)* *LO 5.3: Employ correct procedure on the principles of Hidden Markov models to predict the best sequence of states that led to current observation states. (PI 1.4.1), (PI 11.2.2)* *LO 5.4: Explore ethical procedures for sustainable deployment of Bayesian belief networks and Hidden Markov Models. (PI 6.3.2), (PI 7.3.2)*	
06.	**Life Cycles and Methodologies** ***Learning Objective/s:*** ***Understand the different life cycles of knowledge engineering along with different methodologies leading to integration of life cycle and methodologies.***	**4-6**
	Contents:	

	• The Need for Methodologies • Problem Solving Methods • Knowledge Acquisition Design System (KADS) • The Hybrid Methodology and Hybrid Knowledge Based Systems	
	Self-Learning Topics: *Case study on any KADS*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Evaluate the role of methodologies in ensuring sustainable and ethical development of knowledge engineering solutions. (PI 6.3.2), (PI 7.1.1)* *LO 6.2: Analyze the limitations of selected problem-solving methods in real world scenarios and propose improvements or alternatives. (PI 2.4.3) (PI 11.2.2)* *LO 6.3: Identify the key concepts and techniques of KADS and hybrid knowledge based systems, including phases of the KADS methodology (PI 2.2.1)*	
	Course Conclusion Review of important concepts and highlighting importance of knowledge engineering.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply the knowledge of discrete structures, linear algebra, statistics, and numerical techniques to solve problems.
1.1.2	Apply the concepts of probability, statistics and queuing theory in modelling of computer-based system, data and network protocols.
1.4.1	Apply theory and principles of computer science and engineering to solve an engineering problem
2.2.1	Reframe the computer-based system into interconnected subsystems
2.2.4	Compare and contrast alternative solution/methods to select the best methods
2.4.2	Analyze and interpret the results using contemporary tools.
2.4.4	Arrive at conclusions with respect to the objectives
3.2.1	Able to explore design alternatives.
3.2.2	Able to produce a variety of potential design solutions suited to meet functional requirements.
4.2.1	Design and develop appropriate procedures/methodologies based on the study objectives
4.3.1	Use appropriate procedures, tools and techniques to collect and analyze data
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions
6.3.1	Identify risks/impacts in the life-cycle of an engineering product or activity
6.3.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
6.4.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
7.1.1	Identify situations of unethical professional conduct and propose ethical alternatives
11.2.1	Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Apply computer science theory and statistical techniques to transform data into meaningful information and analyse results. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4*)
2. Design and develop basic knowledge based systems, artificial neural networks, genetic algorithms and data mining techniques, and identify their components, risks, and impacts. *LO 2.1, LO 2.2, LO 2.3*)
3. Develop skills to acquire and represent knowledge, integrate sustainable development principles, and address privacy concerns in knowledge acquisition and representation. (*LO 3.1, LO 3.2, LO 3.3*)
4. Apply discrete structures and logical reasoning to represent knowledge, model learning systems, drawing inferences and assessing socio-economic risks of automated reasoning systems and their impact on the environment. *LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5)*
5. Model complex systems under uncertainty using Bayesian belief networks and Hidden Markov Models, applying engineering mathematics and ethical procedures to ensure sustainable decision-making. (*LO 5.1, LO 5.2, LO 5.3, LO 5.4)*
6. Evaluate the role of methodologies in ensuring sustainable development of knowledge engineering solutions, and analyse the limitations of problem-solving methods. (*LO 6.1, LO 6.2, LO 6.3)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HMCAL501.1	3	3	-	-	-	-	-	-	-	-	3
HMCAL501.2	-	-	3	-	-	3	-	-	-	-	3
HMCAL501.3	2	-	-	3	-	3	2	-	-	-	-
HMCAL501.4	3	2	-	3	-	3	-	-	-	-	-
HMCAL501.5	3	-	-	-	-	2	2	-	-	-	3
HMCAL501.6	-	3	-	-	-	2	2	-	-	-	2
Average	**3**	**3**	**3**	**3**	-	**3**	**2**	-	-	-	**3**

Text Books :

1. Guus Schreiber, et. el, "Knowledge Engineering and Management: The Common KADS Methodology", The MIT Press
2. Stuart Russell and Peter Norwig, "Artificial Intelligence: A Modern Approach", Prentice Hall

Reference Books :

1. Cornelius T. Leondes, “Knowledge Based Systems”, Academic Press
2. Deepak Khemani, Artificial Intelligence: Knowledge Representation And Reasoning,

Other Resources :

1. https://onlinecourses.nptel.ac.in/noc25_cs07/course

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment - Theory-(20 Marks)**

   Suggested break up of distribution

   i. Offline MCQ/Quiz as per GATE pattern/level – 05 Marks
   ii. Class test – 05 Marks
   iii. Open book/notes test – 05 Marks
   iv. Regularity and Active Participation – 05 Marks

2. **Mid Semester Exam (30 Marks)**

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
HMC	HMCAL602	FOUNDATIONS OF MACHINE LEARNING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. BSC101 Engineering Mathematics I
2. CEPCC301 Engineering Mathematics III
3. CEPCC405 Engineering Math IV
4. CEPCC406 Analysis of Algorithms

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigation of Complex Problems
5. PO6: The Engineer and The World
6. PO7: Ethics
7. PO11: Lifelong learning

Course Objectives:

1. To make students understand the basic techniques, methods and tools in Machine Learning.
2. To make students understand the characteristics of learning process.
3. To make students understand concepts of supervised and unsupervised. algorithms.
4. To make students dimensionality reduction techniques.

Module	Details	Hrs.
	Course Introduction Foundations of Machine Learning is a comprehensive course that covers the fundamental concepts and techniques of machine learning. The importance of this course lies in the groundwork laid for understanding essential topics in supervised and unsupervised learning. Students will learn to break down complex machine learning problems into more manageable parts, recognize relationships between different concepts, and apply mathematical tools to solve problems.	**01**
01.	**Introduction to Machine Learning** ***Learning Objective:***	**4-6**

	Familiarize learner with basics of machine learning by applying fundamental mathematical concepts, techniques, and metrics for performance evaluation and addressing overfitting and underfitting issues.	

	Contents:
	• Basics of Machine Learning
	  ○ Types of Machine Learning Algorithms
	  ○ Machine Learning Tasks
	  ○ Brief overview of ML Applications
	  ○ Steps in developing a Machine Learning Application
	• Testing Machine Learning Algorithms
	  ○ Training, Testing, Validation Sets
	  ○ Overfitting, Underfitting
	  ○ Accuracy and Precision Measurements
	  ○ Confusion Matrix
	  ○ Receiver Operator Characteristic Curve (ROC Curve)	

	Self-Learning Topics: *Pre-processing techniques on text and images.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply theory and principles of computer science and engineering to introduce machine learning as a computational approach and comprehend technical literature to be abreast with current developments in the field. (PI 1.4.1), (PI 11.3.1)* *LO 1.2: Differentiate between supervised, unsupervised, and reinforcement learning algorithms and their use cases. (PI 2.2.4)* *LO 1.3: Recognize real-world applications of ML in areas like healthcare, finance, computer vision, and natural language processing. (PI 11.2.2)* *LO 1.4: Comprehend the end-to-end process of developing an ML application, including data collection, preprocessing, model selection, training, and deployment. (PI 2.2.1)* *LO 1.5: Apply the concepts of probability, statistics in training, testing, and validation sets in ML model development and compute accuracy, precision, recall, and F1-score to evaluate ML models. (PI 1.1.2)*	
02.	**Supervised Learning: Regression and Classification** ***Learning Objective:*** *Apply linear regression and classification techniques, including multiple linear regression, logistic regression, Bayesian classification, and K-nearest neighbor algorithm, to solve problems in data analysis and machine learning, and optimize model performance using techniques such as sigmoid function optimization and regression coefficient estimation.*	**7-9**

	Contents:
	• Linear Methods for Regression
	  ○ The Model for Linear Regression
	  ○ Least Square Estimation methods
	  ○ Simple Linear Regression with one variable
	  ○ Accuracy of coefficients and the model
	  ○ Multiple Linear Regression
	• Linear Methods for Classification
	  ○ The Sigmoid function
	  ○ The Model for Logistic Regression	

	○ Optimization for best regression coefficients • Bayesian Classification • K-Nearest Neighbor Algorithm	
	Self-Learning Topics: *Ridge, Lasso and Elastic Net Regression*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Formulate the linear regression model, understand assumptions, and interpret parameters. (PI 4.3.4)* *LO 2.2: Use appropriate methods, (namely, least squares, maximum likelihood, gradient based methods), to estimate regression coefficients. (PI 4.3.1)* *LO 2.3: Apply mathematical functions to model probability outputs.by using sigmoid function in transforming linear outputs to probabilities. (PI 1.1.1)* *LO 2.4: Apply probability and statistics to model binary outcomes by formulating and interpreting logistic regression for binary classification. (PI 1.1.2)* *LO 2.5: Analyze Bayesian methods for probabilistic classification. (PI 2.4.2)* *LO 2.6: Identify appropriate algorithms, (namely, KNN, Naïve Bayes, and nearest centroid) for classification and regression. (PI 2.1.2)* *LO 2.7: Analyze convergence and computational efficiency and perform optimization techniques to estimate regression coefficients.(PI 4.3.2)*	
03.	**Supervised Learning: Support Vector Machines** ***Learning Objective:*** *Apply Support Vector Machine (SVM) algorithms to solve classification problems, including finding maximum margin linear separators, using kernels to handle non-linearly separable data, and optimizing the SVM algorithm to achieve optimal classification performance.*	**9-11**
	Contents: • Maximum Margin Linear Separators • Finding the Maximal Margin Hyperplane • The Support Vector Classifier • Kernels • The SVM Algorithm	
	Self-Learning Topics: ***Non Linear SVM***	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply knowledge of linear algebra (e.g., vector spaces, dot products) and numerical techniques (optimization) to formulate and solve the problem of finding the optimal hyperplane. (PI 1.1.1)* *LO 3.2: Analyze the results (e.g., margin size, support vectors) using computational tools in solving an optimization problem to find the hyperplane (PI 2.4.2)* *LO 3.3: Apply computer engineering principles to formulate the soft margin optimization problem and to design the classifier. (PI 1.4.1)* *LO 3.4: Compare kernel types to select the best for a given dataset. (PI 2.2.4)* *LO 3.5: Critically analyze kernel performance for trends (e.g., overfitting with high-degree polynomials) and limitations. (PI 4.3.2)*	

	LO 3.6: Synthesize knowledge from results to reach conclusions about the support vector machine algorithm's effectiveness. (PI 4.3.4) *LO 3.7: Source SVM algorithm research papers to understand algorithm advancements. (PI 11.3.1)*	
04.	**Supervised Learning: Trees** ***Learning Objectives:*** *Apply decision tree algorithms to solve classification and regression problems, including constructing trees using various splitting criteria, extracting rules from trees, and improving model performance using ensemble methods such as bagging, boosting, and random forests.*	**7-9**

	Contents:
	• Decision Trees
	  o Classification Trees
	  o Regression Trees
	• Rule Extraction from Trees
	• Tree Construction
	  o Entropy, Information Gain
	  o Gini Index
	  o Chi-Square
	  o Reduction in Variance
	• Bagging, Boosting, Random Forests	

	Self-Learning Topics: *Multivariate Adaptive Regression Splines Algorithm*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply discrete structures and statistics to model decision-making processes and solve classification and regression problems. (PI 1.1.1) (PI 11.3.1)* *LO 4.2: Use statistics and numerical techniques for splitting and pruning classification trees. (PI 1.1.1) (PI 11.3.1)* *LO 4.3: Analyze results of classification tree algorithms for categorical data problem. (PI 2.4.2)* *LO 4.4: Identify regression tree algorithms for numerical prediction problems.* *(PI 2.1.2)* *LO 4.5: Extract interpretable rules from decision trees for decision-making and knowledge representation and synthesize knowledge from extracted rules to draw conclusions. (PI 4.3.4)* *LO 4.6: Choose appropriate tree construction algorithms for a given dataset to master the process of building decision trees, including selecting features, splitting criteria, and stopping conditions. (PI 4.1.2)* *LO 4.7: Use ensemble methods (bagging, boosting, Random Forests) to improve decision tree performance and reduce overfitting. (PI 4.3.1)* *LO 4.8: Assess socio-economic impacts of automated decision-making in tree based models. (PI 6.3.2)* *LO 4.9: Identify ethical issues in tree-based models (e.g., fairness in predictions).* *(PI 7.1.1)*	
05.	**Unsupervised Learning Algorithms** ***Learning Objective/s:***	**7-9**

	Apply unsupervised learning algorithms, including K-means clustering, hierarchical clustering, and association rule mining using the Apriori algorithm, to discover patterns and relationships in data, and interpret the results in the context of real-world problems.	
	Contents: • K-means clustering • Hierarchical Clustering • Apriori Algorithm	
	Self-Learning Topics: *DBSCAN, GMM*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply knowledge of linear algebra (e.g., distance metrics like Euclidean distance) and statistics (e.g., mean calculation) to implement K-means and hierarchical clustering. (PI 1.1.1)* *LO 5.2: Identify limitations (e.g., sensitivity to initialization, assumption of equal-sized clusters) and their causes in implementing K-means clustering. (PI 2.4.3)* *LO 5.3: Interpret and validate clustering (both K-means and hierarchical) results graphically to facilitate analysis. (PI 4.3.3)* *LO 5.4: Identify limitations (e.g., computational complexity for large datasets, sensitivity to noise) and their causes in hierarchical clustering. PI 2.4.3)* *LO 5.5: Apply mathematical knowledge to Apriori algorithm to mine association rules* *(PI 1.1.1)* *LO 5.6: Synthesize conclusions about item relationships while interpreting and validating association rules (PI 4.3.4)*	
06.	**Dimensionality Reduction** ***Learning Objective/s:*** *Apply dimensionality reduction techniques, including Principal Component Analysis (PCA), to reduce the complexity of high-dimensional data, retain relevant information, and improve model performance.*	**3-5**
	Contents: • Types of Dimensionality Reduction Techniques • Principal Component Analysis	
	Self-Learning Topics: *Linear Discriminant Analysis*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply basic mathematics concepts to implement various dimensionality techniques. (PI 1.1.1)* *LO 6.2: Apply linear algebra (e.g., covariance matrix, eigenvalue decomposition) and statistics (e.g., variance maximization) to implement PCA. (PI 1.1.1)* *LO 6.3: Evaluate the appropriateness of PCA for a given dataset. (PI 2.1.1)* *LO 6.4: Identify limitations (e.g., assumes linear relationships, sensitive to scaling) and their causes in implementation of PCA. (PI 2.4.3)*	

	LO 6.5: Interpret and validate PCA results and represent results graphically (e.g., scree plots, 2D scatter plots of principal components) to facilitate analysis. (PI 4.3.3) *LO 6.6: Synthesize conclusions about data variance and feature importance based on PCA outcomes. (PI 4.3.4)*	
	Course Conclusion Review of important concepts and highlighting importance of Machine Learning.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.1.1	Apply the knowledge of discrete structures, linear algebra, statistics and numerical techniques to solve problems
1.1.2	Apply the concepts of probability, statistics and queuing theory in modelling of computer-based system, data and network protocols.
1.4.1	Apply theory and principles of computer science and engineering to solve an engineering problem
2.1.1	Evaluate problem statements and identifies objectives
2.1.2	Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.2.1	Reframe the computer-based system into interconnected subsystems
2.2.4	Compare and contrast alternative solution/methods to select the best methods
2.4.2	Analyze and interpret the results using contemporary tools.
2.4.3	Identify the limitations of the solution and sources/causes.
4.1.2	Able to choose appropriate procedure/algorithm, dataset and test cases.
4.3.1	Use appropriate procedures, tools and techniques to collect and analyze data
4.3.2	Critically analyze data for trends and correlations, stating possible errors and limitations
4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions
4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions
6.3.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
7.1.1	Identify situations of unethical professional conduct and propose ethical alternatives
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Apply theory and principles of computer science and engineering to introduce machine learning as a computational approach and comprehend technical literature to be abreast with current developments in the field. (LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 1.5)
2. Formulate and optimize regression and classification models using statistical and mathematical techniques to solve predictive problems efficiently. (LO 2.1, LO 2..2, LO 2.3, LO 2.4, LO 2.5, LO 2.6, LO 2.7)
3. Design and analyze support vector machine classifiers using linear algebra, optimization, and kernel methods to achieve effective classification while evaluating algorithm advancements. (LO 3.1, LO 3..2, LO 3.3, LO 3.4, LO 3.5, LO 3.6, LO 3.7)
4. Build and enhance decision tree models for classification and regression, applying ensemble methods and addressing ethical and socio-economic implications. (LO 4.1, LO 4..2, LO 4.3, LO 4.4, LO 4.5, LO 4.6, LO 4.7, LO 4.8, LO 4.9)

5. Implement and validate clustering and association rule mining techniques using linear algebra and statistics, interpreting results to uncover data relationships. (LO 5.1, LO 5..2, LO 5.3, LO 5.4, LO 5.5, LO 5.6)
6. Apply linear algebra and statistical techniques to perform and evaluate principal component analysis, synthesizing conclusions about data variance and feature importance. (LO 6.1, LO 6..2, LO 6.3, LO 6.4, LO 6.5, LO 6.6)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HMCAL602.1	3	3	-	-	-	-	-	-	-	-	3
HMCAL602.2	3	3	-	3	-	-	-	-	-	-	
HMCAL602.3	3	3	-	3	-	-	-	-	-	-	2
HMCAL602.4	2	3	-	3	-	2	2	-	-	-	2
HMCAL602.5	3	3	-	3	-	-	-	-	-	-	-
HMCAL602.6	3	3	-	3	-	-	-	-	-	-	-
Average	**3**	**3**	-	**3**	-	**2**	**2**	-	-	-	**2**

Text Books :

1. Ethem Alpaydin, “Introduction to Machine Learning”, The MIT Press
2. Peter Harrington, “Machine Learning in Action”, Manning

Reference Books :

1. Tom Mitchell, “Machine Learning”, Mc-Graw Hill
2. Balaraman Ravindran, “Introduction to Machine Learning”

Other Resources :

1. https://onlinecourses.nptel.ac.in/noc22_cs29

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment - Theory-(20 Marks)**

Suggested breakup of distribution

i. Offline MCQ/Quiz as per GATE pattern/level – 05 Marks
ii. Class test – 05 Marks
iii. Open book/notes test – 05 Marks
iv. Regularity and Active Participation – 05 Marks

2. **Mid Semester Exam (30 Marks)**

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Honours/Minor Track: Blockchain

Curriculum Structure for Honours/Minor Degree Program : *Blockchain*

Course Type	Sem	Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
				L	P	T	L	P	T	Total
HMC	V	HMCBC501	Introduction to Blockchain & cryptocurrency	3	--	--	3	--	--	3
HMC	VI	HMCBC602	Blockchain Platforms	3	--	--	3	--	--	3
HMC	VII	HMCBC703	Blockchain Development	4	--	--	4	--	--	4
HML	VII	HMCBL701	Blockchain Laboratory	--	4	--	--	2	--	2
HMC	VIII	HMCBC804	Decentralized Applications	4	--	--	4	--	--	4
HMP	VIII	HMPBC801	Mini Project	--	6	--	--	2	--	2
			Total	**14**	**10**	**--**	**14**	**04**	**--**	**18**

Examination Scheme for Honours/Minor Degree Program

				Examination Scheme					
Course Type	Sem	Course Code	Course Name	In-Semester Assessment		End Sem Exam (ESE)	Exam. Duration for Theory (in Hrs)		Total
				Continuous Assessment	Mid Sem Exam		Mid Sem	End Sem	
HMC	V	HMCBC501	Introduction to Blockchain & cryptocurrency	20	30	50	1.5	2	100
HMC	VI	HMCBC602	Blockchain Platforms	20	30	50	1.5	2	100
HMC	VII	HMCBC703	Blockchain Development	20	30	50	1.5	2	100
HML	VII	HMCBL701	Blockchain Laboratory	50	--	--	--	--	50
HMC	VIII	HMCBC804	Decentralized Applications	20	30	50	1.5	2	100
HMP	VIII	HMPBC801	Mini Project	50	--	50	--	--	100
			Total	**180**	**120**	**250**	**--**	**--**	**550**

Course Type	Course Code	Course Name	Credits
HMC	HMCBC501	INTRODUCTION TO BLOCKCHAIN AND CRYPTOCURRENCY	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. *NIL*

Program Outcomes addressed:

1. PO 1: Engineering knowledge
2. PO 2: Problem analysis
3. PO 5: Engineering Tool Usage
4. PO 6: The Engineer & The World
5. PO 7:Ethics
6. PO 11: Life-long learning

Course Objectives:

1. To get acquainted with cryptographic techniques and their role in data security.
2. To explore blockchain technology, its components, and applications across domains.
3. To examine consensus mechanisms and mining in distributed systems with environmental impact.
4. To familiarize about cryptocurrencies, wallet types, and secure, ethical practices.
5. To introduce Bitcoin, its network, transaction processes, and associated challenges.

Module	Details	Hrs
	Course Introduction Introduction to blockchain technology and cryptocurrency. Foundational concepts, applications, and impact on various industries. Insights into the transformative potential of blockchain systems in solving real-world problems.	**01**
01.	**Fundamentals Of Cryptography**	**4-6**
	Learning Objective: *To explore cryptographic techniques and their role in securing data.*	
	Contents: Introduction to Cryptography, Symmetric Vs Asymmetric Cryptography, Cryptographic Hash Functions, Properties of Secure Hash Function, Secure Hash Algorithms, Digital Signature: Public, Private Keys, Role of Cryptography in Security	

	Self-Learning Topics: *Use online tools to hash different inputs using SHA-256*	
	Learning Outcomes: *A learner will be able to* *LO 1.1 Applying the engineering fundamentals, Interpret the difference between symmetric and asymmetric cryptography and their use cases. (PI 1.3.1)* *LO 1.2 Explore the properties and functions of cryptographic hash functions and secure hash algorithms. (PI 1.3.1)* *LO 1.3 Demonstrate the use of public and private keys in digital signatures for secure communication. (PI 1.3.1, PI 1.4.1)* *LO 1.4 Assess the role of cryptography in ensuring data security and integrity across systems. (PI 1.3.1, PI 1.4.1)*	
02.	**Introduction To Blockchain**	**4-6**
	Learning Objective: *To introduce blockchain technology, its components, and applications across industries*	
	Contents: What Is Blockchain, Origin of Blockchain, Block in Blockchain, Merkle Tree, Components of Blockchain, Types of Blockchain, Pros and Cons of Blockchain, Potential Applications in Industry. Blockchain for Social Good: Identity, Healthcare, Transparent Governance, Ethical concerns: Privacy, security, and misuse of technology.	
	Self-Learning Topics: *Blockchain demo, Role of blockchain in smart cities*	
	Learning Outcomes: *A learner will be able to* *LO 2.1. Define blockchain and understand its origin, structure, and components. (PI 1.4.1)* *LO 2.2 Identify the role of Merkle trees in blockchain and Their applicability in ensuring data integrity. (PI 1.1.1, PI 2.1.2, PI 2.3.1)* *LO 2.3 Identify different types of blockchain and their respective use cases. (PI 2.1.2, PI 2.2.3)* *LO2.4 Analyze the pros and cons of blockchain technology. (PI 1.3.1, PI 2.2.5, PI 6.3.2)* *LO 2.5 Identify potential applications of blockchain across different sectors. (PI 2.2.3,PI 11.2.2, PI 1.3.1)* *LO 2.6 Identify blockchain's role in social good (identity, healthcare, governance). (PI 6.1.1, PI 6.3.2, PI 11.3.1)* *LO 2.7 Assess ethical concerns related to privacy, security, and potential misuse. (PI 6.1.1, PI 6.3.2, PI 7.1.1)*	
03.	**Consensus And Mining**	**8-10**
	Learning Objective: *To examine consensus mechanisms and mining processes in distributed ledger technology*	

	Contents: Decentralization Vs Distribution, Distributed Ledger Technology, Working of Consensus Protocol, Types of Consensus Protocols, Mining Process: Mining Nodes, Aggregating Transactions into Blocks, Constructing The Block Header, Validating A New Block, Mining Difficulty, Mining Pool and Its Methods. Environmental Impact of Mining and Sustainable alternatives.	
	Self-Learning Topics: *Study different consensus algorithms, Carbon Footprint of Blockchain Mining & Sustainable Solutions*	
	Learning Outcomes: *A learner will be able to* *LO 3.1 Identify the difference between decentralization and distribution in blockchain systems. (PI 2.1.2)* *LO 3.2 Apply theory and principles of Computer Science to understand the concept and workings of distributed ledger technology. (PI 1.4.1)* *LO 3.3Analyze various types of consensus protocols and their applications in identifying blockchain implementation. (PI 2.2.3, PI 11.3.1)* *LO 3.5 Analyze the mining process, including nodes, transaction aggregation, block construction, and validation. (PI 1.3.1, PI 2.3.1)* *LO 3.6 Compute the mining difficulty and methods used in mining pools. (PI 2.4.1)* *LO 3.7 Analyse the environmental impact of blockchain mining and explore sustainable alternatives for energy-efficient consensus mechanisms. (PI 6.3.2)*	
04.	**Cryptocurrency**	**7-9**
	Learning Objectives: *To provide an understanding of cryptocurrency fundamentals, types, and secure wallet practices*	
	Contents: Cryptocurrency Basics, Types of Cryptocurrency: Bitcoin, Altcoin, And Tokens (Utility and Security), Advantages and Disadvantages of Cryptocurrency, Double Spending Problem, Cryptocurrency Wallets: Hot and Cold Wallets, Nondeterministic (Random) Wallets, Deterministic (Seeded) Wallets, Wallet Best Practices, Cryptocurrency Usage**.** Ethical issues such as fraud, scams, and market manipulation.	
	Self-Learning Topics: *Different wallets and available cryptocurrencies*	
	Learning Outcomes:	
	A learner will be able to *LO 4.1 Apply Computer Engineering fundamentals to comprehend the basics of cryptocurrency and differentiate between Bitcoin, altcoins, and tokens (utility and security). (PI 1.4.1)* *LO 4.2 Analyze the advantages and disadvantages of cryptocurrency in the digital economy. (PI 2.2.5)* *LO 4.3 Analyze the double-spending problem and how cryptocurrencies address it. (PI 2.1.2)* *LO 4.4 Explore & identify strengths and limitations of various types of cryptocurrency wallets (hot, cold, nondeterministic, deterministic) and their functions. (PI 5.2.1)*	

	LO 4.5 Apply best practices for securely managing cryptocurrency wallets. (PI 5.3.1) *LO 4.6 Identify the real-world usage and applications of cryptocurrencies.* *(PI 2.2.3)* *LO 4.7 Assess ethical issues in blockchain, including fraud, scams, and market manipulation (PI 7.1.1)*	
05.	**Bitcoin** ***Learning Objective/s:*** *To explore the fundamentals of Bitcoin, its operations, security, and associated challenges*	**6-8**
	Contents: What Is Bit Coin and The History of Bit Coin, Bit Coin Addresses, Transaction Outputs and Inputs, Transaction Fees, Bitcoin Mining, Bitcoin Security: Security Principles, User Security Best Practices, Environmental Concerns, Regulations and Legal Issues, Challenges and Limitations of Bitcoin	
	Self-Learning Topics: *Visit and use https://bitcoin.org/en/* ***Learning Outcomes :*** *A learner will be able to* *LO 5.1 Apply Computer engineering fundamentals to understand the concept of Bitcoin, its history, and the evolution of digital currency. (PI 1.4.1)* *LO 5.2 Explain the structure of Bitcoin addresses, transaction inputs, outputs, and transaction fees. (PI 2.1.2)* *LO 5.3 Analyze the Bitcoin mining process and the security principles involved in safeguarding the network. (PI 2.3.1)* *LO 5.4 Identify best practices for securing Bitcoin transactions and addresses. (PI 5.3.1)* *LO 5.5 Assess the environmental concerns, regulatory challenges, and legal issues surrounding Bitcoin. (PI 6.1.1, PI 6.3.2)* *LO 5.6 Analyze the challenges and limitations of Bitcoin in terms of scalability, security, and adoption. (PI 2.2.5)* *LO 5.7: Compute the transaction fees (PI 2.4.1)*	
06.	**Bitcoin Network** ***Learning Objective/s:*** *To study the architecture, operations, and roles of nodes in the Bitcoin network*	**8-10**
	Contents: Peer-To-Peer Network Architecture, Node Types And Roles, Incentive Based Engineering, The Extended Bitcoin Network, Bitcoin Relay Networks, Network Discovery, Full Nodes, Exchanging "Inventory", Simplified Payment Verification (SPV) Nodes, Bloom Filters, SPV Nodes And Privacy, Encrypted And Authenticated Connections, Transaction Pools	

	Learning Outcomes: *A learner will be able to* *LO 6.1 Comprehend the peer-to-peer network architecture and the roles of different node types in the Bitcoin network which will help identifying blockchain network components and their roles. (PI 2.1.2)* *LO 6.2 Analyze incentive-based engineering and how it sustains the Bitcoin network. (PI 2.2.3)* *LO 6.3 Apply Computer Engineering fundamentals to illustrate the extended Bitcoin network, including relay networks and network discovery. (PI 2.3.1)* *LO 6.4 Differentiate between full nodes and Simplified Payment Verification (SPV) nodes and their functions in transaction validation. (PI 2.1.2)* *LO 6.5 Analyze the use of bloom filters, SPV nodes' impact on privacy, and the role of encrypted and authenticated connections. (PI 6.1.1 PI 6.3.1)* *LO 6.6 Interpret the concept of transaction pools which will help in analyzing bitcoins efficiency and scalability. (PI 2.2.3)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply the knowledge of discrete structures, linear algebra, statistics, and numerical techniques to solve problems.
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science and engineering to solve an engineering problem
2.1.2	Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.2.3	Identify existing solutions/methods to solve problems, including forming justified approximations and assumptions.
2.2.5	Compare and contrast alternative solution processes to select the best process.
2.3.1	Able to apply computer engineering principles to formulate modules of a system with required applicability and performance
2.4.1	Applies engineering mathematics to implement the solution
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
5.3.1	Discuss limitations and validate tools, techniques and resources
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level
6.3.1	Identify risks/impacts in the life-cycle of an engineering product or activity
6.3.2	Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
7.1.1	Identify situations of unethical professional conduct and propose ethical alternatives
11.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
11.3.1	Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Apply mathematical & cryptographic techniques to ensure data security in blockchain systems. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4).*
2. Explore blockchain architecture along with its components, and applications in industry and social good, emphasizing ethics and inclusivity. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6, LO 2.7)*
3. Analyse consensus mechanisms, mining processes, and their sustainable alternatives. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6, LO 3.7)*
4. Interpret cryptocurrency fundamentals, also identify security best practices, and ethical concerns. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6, LO 4.7)*
5. Analyse Bitcoin's functionality, security, network structure, and its societal impact. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 5.6, LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HMCBC501.1	3	-	-	-	-	-	-	-	-	-	-
HMCBC501.2	3	3	-	-	-	3	2	-	-	-	3
HMCBC501.3	3	3	-	-	-	2	-	-	-	-	2
HMCBC501.4	2	3	-	-	3	-	2	-	-	-	-
HMCBC501.5	2	3	-	-	2	3	-	-	-	-	-
Average	**3**	**3**	**-**	**-**	**3**	**3**	**2**	**-**	**-**	**-**	**3**

Text Books :

1. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press
2. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly
3. Blockchain with Hyperledger Fabric,Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

Reference Books :

1. Imran Bashir, Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing
2. Blockchain Basics, A non-Technical Introduction in 25 Steps, Daniel Drescher, Apress
3. Blockchain for Beginners, Yathish R and Tejaswini N, SPD

Other Resources :

1. NPTEL: Blockchain Architecture Design and Use Cases
   By Prof. Sandip Chakraborty & Dr. Praveen Jayachandran, IIT Kharagpur and IBM
   https://onlinecourses.nptel.ac.in/noc19_cs63/preview
2. Blockchain and its Applications
   By Prof. Sandip Chakraborty, Prof. Shamik Sural, IIT Kharagpur
   https://onlinecourses.nptel.ac.in/noc22_cs44/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

Class test 1: 05 Marks

Class test 2: 05 Marks

Article Reading & Summarization: 05 marks

Regularity and active participation: 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
HMC	HMCBC602	BLOCKCHAIN PLATFORMS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. HMCBC501: Introduction to Blockchain and Cryptocurrency

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO 2: Problem analysis
3. PO 5: Engineering tool usage
4. PO 6: The Engineer & The World
5. PO 9: Communication
6. PO 11: Life-long learning

Course Objectives:

1. To explore the architecture and applications of public, private, consortium, and hybrid blockchains.
2. To delve into Ethereum's ecosystem, including transactions, accounts, and frameworks
3. To analyse consensus mechanisms and fault tolerance strategies for blockchain reliability.
4. To introduce blockchain interoperability protocols and scaling solutions for cross-platform efficiency.
5. To examine emerging blockchain platforms and their impact on industries like DeFi.

Module	Details	Hrs.
1.	**Course Introduction** Overview of blockchain platforms and their role in modern technology focusing on public, private, consortium, and hybrid blockchains, emerging blockchain platforms and their transformative impact on industries like DeFi, healthcare, and supply chain.	**01**
01.	**Public Blockchain System** ***Learning Objective:*** *To understand public blockchains and Ethereum's architecture and applications.*	**9-11**
	Contents: Introduction to public blockchain, Key characteristics of public blockchain, Popular Public Blockchains, Ethereum and its Components, mining in Ethereum, Ethereum Virtual Machine (EVM), Transaction, Accounts, Architecture and Workflow, Comparison between Bitcoin and Ethereum, Types of test-networks used in Ethereum, Transferring Ethers	

	using Metamask, Mist Wallet, Ethereum frameworks, Case study of Ganache for Ethereum blockchain. Exploring etherscan.io, Ethereum block structure	
	Self-Learning Topics: *Advanced features of Etherscan.io.*	
	Learning Outcomes: *A learner will be able to* *LO1.1 Apply engineering fundamentals to comprehend public blockchain concepts and characteristics. (PI 1.3.1)* *LO1.2Explore Ethereum's architecture & identify essential components, and workflow. (PI 2.1.2)* *LO 1.3 Learn Ethereum transactions, accounts, and wallets. (PI 1.4.1)* *LO 1.4 Compare Ethereum and Bitcoin in structure and functionality. (PI 2.2.5)* *LO 1.5 Explore Ethereum test-networks and frameworks like Ganache. (PI 5.2.2)*	
02.	**Private Blockchain System**	**7-9**
	Learning Objective: *To understand private blockchains, their characteristics, and consensus mechanisms*	
	Contents: Introduction to private blockchain, Key characteristics of private blockchain, Need of Private Blockchain, Smart Contract in a Private Environment, State Machine Replication, Consensus Algorithms for Private Blockchain - PAXOS and RAFT, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT.	
	Self-Learning Topics: *Challenges and solutions in achieving Byzantine Fault Tolerance.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1 Apply engineering fundamentals to Illustrate the concept and key characteristics of private blockchains. (PI 1.3.1)* *LO 2.2 Identify the need and applications of private blockchain systems. (PI 2.1.2)* *LO 2.3 Analyze use of smart contracts in private blockchain environments. (PI 2.3.1)* *LO 2.4 Identify the use of state machine replication in blockchain consensus. (PI 2.2.3)* *LO 2.5 Compare consensus algorithms like PAXOS, RAFT, and their applications. (PI 2.2.5)* *LO 2.6 Analyze Byzantine Fault Tolerance (BFT) and Practical BFT. (PI 2.2.5)*	
03.	**Consortium Blockchain** ***Learning Objective:*** *To explore consortium blockchains and the Hyperledger platform's frameworks and tools.*	**4-6**
	Contents: Introduction to Consortium blockchain, Key characteristics of Consortium blockchain, Need of consortium blockchain, Hyperledger platform: Fabric, INDY, Sawtooth, Grid, Hyperledger tools	
	Self-Learning Topics: *Real-world applications of consortium blockchains in industries like supply chain, Governance and banking.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1 Apply engineering fundamentals to Illustrate the concept and key characteristics of consortium blockchains. (PI 1.3.1)*	

	LO 3.2 Identify the need and applications of consortium blockchain systems. (PI 2.1.2) *LO 3.3 Compare the Hyperledger platform and its frameworks: Fabric, Indy, Sawtooth, and Grid. (PI 2.2.3)* *LO3.4 Identify Hyperledger tools and their roles in blockchain development. (PI 5.2.1)*	
04.	**Hybrid Blockchain Platforms**	**6-8**
	Learning Objectives: *To understand hybrid blockchains, their characteristics, platforms, and real-world use cases.*	
	Contents: Introduction to Hybrid Blockchains, Key Characteristics of Hybrid Blockchains, Popular Hybrid Blockchain Platforms: Dragonchain, Polygon, Use Cases of Hybrid Blockchains: Cross-industry collaboration, Government Applications, Digital Identity Systems	
	Self-Learning Topics: *Case studies of hybrid blockchain use in real-world scenarios.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1 Apply engineering fundamentals to Summarize the concept and key characteristics of hybrid blockchains (PI 1.3.1).* *LO 4.2 Identify popular hybrid blockchain platforms (PI 2.2.3)* *LO 4.3 Analyze use cases of hybrid blockchains in cross-industry collaboration, government applications, and digital identity systems. (PI 2.1.2)*	
05.	**Cross-Platform Interoperability and Scaling Solutions** ***Learning Objective/s:*** *To explore blockchain interoperability, protocols, and scaling solutions for enhanced connectivity and efficiency.*	**6-8**
	Contents: Blockchain Interoperability: Importance and methods of connecting different blockchain platforms, Interoperability Protocols: Polkadot, Cosmos, blockchain bridges, Scaling Solutions: Layer 2 Solutions: Optimism, Arbitrum for Ethereum, Sharding and Sidechains: Concepts and applications.	
	Self-Learning Topics: *Comparative analysis of sidechains vs. Layer 2 solutions.*	
	Learning Outcomes: *A learner will be able to* *LO 5.1 Apply engineering fundamentals & theory and principles of Computer Engineering to Summarize the importance and methods of blockchain interoperability. (PI 1.3.1, PI 1.4.1)* *LO 5.2 Identify interoperability protocols like Polkadot, Cosmos, and blockchain bridges. (PI 2.2.3)* *LO 5.3 Learn scaling solutions, including Layer 2 solutions like Optimism and Arbitrum for Ethereum with respect to applicability & performance. (PI 2.3.1)* *LO 5.4 Identify the need & applications of sharding and sidechains. (PI 2.1.2)*	
06.	**Emerging Blockchain Platforms** ***Learning Objective/s:*** *To explore emerging blockchain platforms and their applications in decentralized finance (DeFi)*	**5-7**

	Contents: Corda, Ripple, Quorum and other Emerging Blockchain Platforms, Blockchain in DeFi: Case Study on any of the Blockchain Platforms, Green blockchain initiatives	
	Self-Learning Topics: *popular DeFi projects and protocols like Uniswap, Aave, and Compound. Green blockchain initiatives like Algorand*	
	Learning Outcomes: *A learner will be able to* *LO 6.1 Compare key features and applications of emerging blockchain platforms like Corda, Ripple, and Quorum. (PI 2.2.5)* *LO 6.2 Identify & Analyze platform-specific use cases in industries such as finance, healthcare, and supply chain. (PI 2.1.2, PI 6.1.1, PI 9.1.1, PI 9.1.3, PI 11.2.2, PI 11.3.1)* *LO 6.3 Identify the role of blockchain in transforming financial services through DeFi by applying theory and principles of Computer Engineering. (PI 1.4.1, PI 6.1.1)* *LO 6.4 Analyze real-world case studies on blockchain applications in DeFi and other domains. (PI 9.1.1, PI 9.1.3 PI 11.2.2, PI 11.3.1)* *LO 6.5: Identify & Analyze the environmental impact of Blockchain Technologies (PI 6.1.1, PI 6.3.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply engineering fundamentals.
1.4.1	Apply theory and principles of computer science and engineering to solve an engineering problem
2.1.2	Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.2.3	Identify existing solutions/methods to solve problems, including forming justified approximations and assumptions.
2.2.5	Compare and contrast alternative solution processes to select the best process.
2.3.1	Able to apply computer engineering principles to formulate modules of a system with required applicability and performance
4.3.1	Use appropriate procedure, tools and techniques to collect and analyse data.
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
5.2.2	Demonstrate proficiency in using discipline specific tools.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level
9.1.1	Read, understand and interpret technical and non-technical information

9.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear

11.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field

11.3.1 Source and comprehend technical literature and other credible sources of information

Course Outcomes: A learner will be able to -

1. Comprehend blockchain architectures including public, private, consortium, and hybrid models & identify appropriate blockchain platforms for specific use cases. *(LO 1.1,1.2,1.3,1.4, 2.1, 2.2, 2.4, 3.1, 3.2,3.3,4.1)*
2. Analyse consensus mechanisms and fault tolerance strategies for blockchain reliability. *(LO 2.5, 2.6)*
3. Identify the applicability of smart contracts and explore interoperability protocols for decentralized applications. *(LO 2.3, 3.4, 5.1, 5.2, 5.3)*
4. Identify blockchain applications across industries like finance, healthcare, and supply chain. *(LO 1.5, 4.2, 4.3, 6.2, 6.4)*
5. Analyse scalability solutions and emerging blockchain trends for efficient system design. *(LO 5.3, 5.4, 6.1, 6.3, 6.5)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HMCBC602.1	3	3	-	-	-	-	-	-	-	-	-
HMCBC602.2	-	2	-	-	-	-	-	-	-	-	-
HMCBC602.3	3	3	-	-	2	-	-	-	-	-	-
HMCBC602.4	-	3	-	-	2	2	-	-	3	-	3
HMCBC602.5	2	3	-	-	-	3	-	-	-	-	-
Average	**3**	**3**	**-**	**-**	**2**	**3**	**-**	**-**	**3**	**-**	**3**

Text Books :

1. "Mastering Bitcoin, Programming The Open Blockchain", 2nd Edition by Andreas M. Antonopoulos, June 2017, O'Reilly Media, Inc. ISBN: 9781491954386.
2. "Blockchain Applications: A Hands-On Approach", by ArshdeepBahga, Vijay Madisetti, Paperback – 31 January 2017.
3. "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", July 19, 2016, by Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, Steven Goldfeder, Princeton University Press.

Reference Books :

1. "Mastering Blockchain", by Imran Bashir, Third Edition,Packt Publishing
2. "Mastering Ethereum: Building Smart Contracts and Dapps Paperback" byAndreas Antonopoulos, Gavin Wood, Publisher(s): O'Reilly Media
3. "Blockchain revolution: how the technology behind bitcoin is changing money, business and the world $ don tapscott and alex tapscot, portfolio penguin, 856157449

Other Resources :

1. Blockchain and its Applications, By Prof. Sandip Chakraborty, Prof. Shamik Sural, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc22_cs44/preview
2. Introduction to Blockchain Technology and Applications, By Prof. Sandeep Shukla, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc20_cs01/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment - Theory-(20 Marks)**

Suggested breakup of distribution

Class test 1: 05 Marks

Class test 2: 05 Marks

Think Pair Share: 05 marks

Regularity and active participation: 05 Marks

2. **Mid Semester Exam (30 Marks)**

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Honours/Minor Track: Augmented Reality/ Virtual Reality (AR-VR)

Curriculum Structure for Honours/Minor Degree Program- *Augmented Reality/ Virtual Reality*

Course Type	Sem	Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
				L	P	T	L	P	T	Total
HMC	V	HMCAV501	Virtual Reality	3	--	--	3	--	--	3
HMC	VI	HMCAV602	Augmented Reality & Mix Reality	3	--	--	3	--	--	3
HMC	VII	HMCAV703	Augmented Reality/ Virtual Reality Applications	4	--	--	4	--	--	4
HML	VII	HMCAV701	Augmented Reality/ Virtual Reality Laboratory	--	4	--	--	2	--	2
HMC	VIII	HMCAV804	Game Development with Virtual Reality	4	--	--	4	--	--	4
HMP	VIII	HMCAV801	Mini Project	--	6	--	--	2	--	2
			Total	**14**	**10**	**--**	**14**	**04**	**--**	**18**

Examination Scheme for Honours/Minor Degree Program

				Examination Scheme					
Course Type	Sem	Course Code	Course Name	In-Semester Assessment		End Sem Exam (ESE)	Exam. Duration for Theory (in Hrs)		Total
				Continuous Assessment	Mid Sem Exam		Mid Sem	End Sem	
HMC	V	HMCAV501	Virtual Reality	20	30	50	1.5	2	100
HMC	VI	HMCAV602	Augmented Reality & Mix Reality	20	30	50	1.5	2	100
HMC	VII	HMCAV703	Augmented Reality/ Virtual Reality Applications	20	30	50	1.5	2	100
HML	VII	HMCAV701	Augmented Reality/ Virtual Reality Laboratory	50	--	--	--	--	50
HMC	VIII	HMCAV804	Game Development with Virtual Reality	20	30	50	1.5	2	100
HMP	VIII	HMCAV801	Mini Project	50	--	50	--	--	100
			Total	**180**	**120**	**250**	**--**	**--**	**550**

Course Type	Course Code	Course Name	Credits
HMC	HMCAV501	VIRTUAL REALITY	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. CEPEC5013 - Computer Graphics and Animation

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO4: Conduct investigations of complex problems
4. PO5: Engineering Tool Usage
5. PO6: The Engineer and The World
6. PO8: Individual and Collaborative Team work
7. PO9: Communication

Course Objectives:

1. To comprehend the Fundamentals of Virtual Reality
2. To analyse relationships and Operations on physical and virtual world
3. To apply transformation Techniques for immersion into virtual reality
4. To analyse need of virtual reality representation Techniques and use it

Module	Details	Hrs.
	Course Introduction This course introduces to the principles, technologies, and applications of VR, exploring its impact on various domains and industries .course prepares to delve into immersive experiences and cutting-edge developments that are reshaping our perception of reality.	**01**
01.	***Introduction to Virtual Reality:*** ***Learning Objective:*** *Get familiarise with fundamental concepts, history, and applications of virtual reality, focusing on the role of human physiology and perception in creating immersive VR experiences*	**6-8**
	Contents: Fundamental concepts of Virtual Reality, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality.	

	Self-Learning Topics: *psychological factors that contribute to a strong sense of presence in VR experiences.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply principals of Human Physiology and Perception to appropriate procedures and key elements of virtual reality (P.I.- 1.2.1)* *LO 1.2: Use the knowledge of virtual world concepts to identify interfaces required to create specialized VR applications (P.I.- 1.4.1)* *LO 1.3: Identify the importance of VR in real-world applications. (P.I.- 2.3.1)* *LO 1.4: Identify the appropriate type of VR components required in given scenario(P.I.- 2.2.4)*	
02.	**Representing the Virtual World:** ***Learning Objective:*** ***Illustrate how visual, aural, and haptic representations are used to create realistic and immersive virtual world experiences.***	**7-9**
	Contents: Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR Sinification, Ambient Sounds, Markers, Index sounds. Haptic Representation in VR -Force Display, Tactile Display, Passive Haptic Feedback	
	Self-Learning Topics: GHOST (General Haptics Open Software Toolkit) software Development toolkit.	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply computer graphics fundamentals to Represent the Virtual World (P.I.- 1.3.1)* *LO 2.2: Apply knowledge of haptic representation to identify how haptic information is used in a VR (P.I.- 1.4.1,2.1.2)* *LO 2.3: Evaluate problem statements and identify Visual, Aural or Haptic Representation required in VR (P.I.- 2.1.1)* *LO 2.4: Compare and correlate Visual and Haptic virtual world representations (P.I.- 2.2.4)*	
03.	**The Geometry of Virtual Worlds & The Physiology of Human Vision:** ***Learning Objective:*** *Provide techniques of geometric modeling, transformations, and the physiology of human vision, emphasizing their impact on virtual world creation.*	**7-9**
	Contents: Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.	
	Self-Learning Topics:	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply Geometric Modeling techniques on given scenario (P.I-1.3.1)*	

	LO 3.2: Apply various Transformations to formulate modules for VR interactions (P.I-1.4.1) *LO 3.3: identify appropriate transformation techniques useful for given VR. (P.I.-2.1.2)* *LO 3.4: identify how Changing Position and Orientation is handled in VR world (P.I.-2.2.3)*	
04.	**Visual Perception & Rendering:** ***Learning Objectives:*** *Analyze the principles of visual perception and rendering techniques to optimize depth, motion, and color representation in virtual environments* **Contents:** Visual Perception - Perception of Depth, Perception of Motion, Perception of Color, Combining Sources of Information Visual Rendering -Ray Tracing and Shading Models, Rasterization, Correcting Optical Distortions, Improving Latency and Frame Rates ***Self-Learning Topics: Automatic stitching of panoramas in Virtual Reality*** ***Learning Outcomes:*** *A learner will be able to* *LO 4.1: Apply engineering principles to choose various Visual Perception techniques, based on Perception of Depth, Motion and Color for given scenario (P.I-1.3.1)* *LO 4.2: Apply Visual Rendering techniques such as Ray Tracing and Shading Models for effective VR representation (P.I-1.4.1)* *LO 4.3: Identify appropriate Visual Perception Rendering techniques used in given scenario (P.I-2.1.2)* *LO 4.4: Compare different visual rendering techniques lead for the improved latency and frame rate (P.I-2.2.4)*	**6-8**
05.	**Motion & Tracking:** ***Learning Objective/s:*** ***Apply the principles of motion, physics, and tracking systems in creating and analyzing realistic virtual world interactions.*** **Contents:** Motion in Real and Virtual Worlds- Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection Tracking- Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies ***Self-Learning Topics: Awake Heart: VR Learning Experience Case Study*** ***Learning Outcomes :*** *A learner will be able to* *LO 5.1: Apply VR principles to understand Physics in the Virtual World (P.I-1.3.1)* *LO 5.2: Apply Tracking techniques in 2D & 3D Orientation (P.I-1.4.1)* *LO5.3: Apply motion and tracking system concepts in preparation of virtual world experiences (P.I.- 2.3.1)* *LO 5.4: Identify difference of Motion in Real and Virtual Worlds using appropriate VR (P.I.-2.2.3)*	**6-8**

	LO 5.5: Apply Motion & Tracking techniques to virtual reality Scenario using appropriate VR tools, while effectively collaborating and communicating results to class. (P.I.- 2.3.1, 5.1.2, 5.2.2, , 8.3.1, 9.2.2)	
06.	**Interaction & Audio:** ***Learning Objective/s:*** *Give the foundation to understand role of motor programs, social interaction, and auditory rendering in enhancing the interactivity and sensory experience of virtual worlds*	**5-7**
	Contents: Interaction - Motor Programs and Remapping, Locomotion, Manipulation, Social Interaction. Audio -The Physics of Sound, The Physiology of Human Hearing, Auditory Perception, Auditory Rendering.	
	Self-Learning Topics: Side effects of using VR systems/ VR sickness.	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Apply the basic concepts of VR interaction on given scenario (P.I.- 1.3.1)* *LO 6.2: Apply Auditory Perception, Auditory Rendering techniques to solve the given problem. (P.I.-1.4.1)* *LO 6.3: Apply principals of Human Physiology and Perception to The Physics of Sound in preparation of virtual world experiences (P.I.- 2.3.1)* *LO 6.4: Identify the appropriate type of interaction and audio components useful in given scenario (P.I.- 2.2.3)* *LO 6.5: Apply various Interaction and Audio techniques to transform given problem into a virtual environment using suitable tools, collaborate effectively, and present results clearly to class. (P.I.- 2.3.2,5.2.2, 8.2.1, 9.3.2)*	
	Course Conclusion Throughout this course, students have delved into the dynamic realm of Virtual Reality (VR), exploring its diverse applications and technological advancements. Armed with a deeper understanding of immersive experiences, students are now prepared to innovate and lead in this rapidly evolving field	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.2.1	Apply laws of natural science to an engineering problem
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science and engineering to solve an engineering problem
2.1.1	Evaluate problem statements and identifies objectives
2.1.2	Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem

2.1.3 Identify mathematical algorithmic knowledge that applies to a given problem

2.2.2 Identify functionalities and computing resources.

2.2.4 Compare and contrast alternative solution/methods to select the best methods

2.3.1 Able to apply computer engineering principles to formulate modules of a system with required applicability and performance

2.1.2 Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem

2.2.3 Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions

5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems

5.2.2 Demonstrate proficiency in using discipline-specific tools

8.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

9.2.2 Deliver effective oral presentations to technical and non-technical audiences

9.3.2 Use a variety of media effectively to convey a message in a document or a presentation

Course Outcomes: A learner will be able to –

1. Apply computer graphics and haptic representation principles to design and analyse virtual world interactions, evaluating the need for visual, aural, or haptic modalities in VR environments. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4*)
2. Apply graphics and haptic techniques to design and analyse virtual environments with visual, aural, and haptic modalities. (*LO 2.1, LO 2.2, LO 2.3, LO 2.4*)
3. Apply geometric modelling and transformations to represent VR interactions and analyse their implications on human perception(*LO 3.1, LO 3.2, LO 3.3 LO,3.4*)
4. Apply visual perception and rendering techniques to enhance depth, motion, colour, and realism in VR environments(*LO 4.1, LO 4.2, LO 4.3, LO 4.4*)
5. Identify and apply VR interaction, auditory perception, and human physiology principles to design immersive virtual environments with appropriate interaction and audio components (LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5, LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5)
6. Apply learned VR techniques such as Motion, Tracking, Interaction, and Audio etc. techniques to design and develop a virtual reality solution for a given problem using appropriate VR tools, while collaborating effectively and clearly communicating the results to the class (LO 5.5,*LO 6.5*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HMCAV501.1	3	3	-	-	-	-	-	-	-	-	-
HMCAV501.2	3	3	-	-	-	-	-	-	-	-	-
HMCAV501.3	3	3	-	-	-	-	-	-	-	-	-
HMCAV501.4	3	3	-	-	-	-	-	-	-	-	-
HMCAV501.5	3	3	-	-	-	-	-	-	-	-	-
HMCAV501.6	-	3	-	-	3	-	-	3	3	-	-
Average	**3**	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**-**

Text Books :

1. M. LaValle, " Virtual Reality, Steven", Cambridge University Press, 2016
2. William R Sherman and Alan B Craig, "Understanding Virtual Reality", Interface, Application and Design, , (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002
3. Alan B Craig, William R Sherman and Jeffrey D Will, "Developing Virtual Reality Applications: Foundations of Effective Design", Morgan Kaufmann, 2009.

Reference Books :

1. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.
2. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces,Theory and Practice", Addison Wesley, USA, 2005.
3. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Merging Real and VirtualWorlds", 2005.
4. Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Inter science, India, 2003.

Other Resources :

1. NPTEL Course: Virtual Reality, IIT Madras by Prof. Steven LaValle Web link- https://nptel.ac.in/courses/106/106/106106138/
2. Coursera: Introduction to Virtual Reality Web link- https://www.coursera.org/learn/introduction-virtual-reality
3. Cambridge University Press, 2023 ebook http://lavalle.pl/vr/book.html

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution
Class test 1:5 marks

Class test 2:5 marks

Group discussion/public speaking/technical report writing: 05 Marks

Regularity and active participation: 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
HMC	HMCAV602	AUGMENTED REALITY & MIX REALITY	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

CEPEC5013 Computer Graphics and Animation

Program Outcomes addressed:

PO1: Engineering knowledge

PO2: Problem analysis

PO5: Engineering Tool Usage

PO8: Individual and Collaborative Team work

PO9: Communication

Course Objectives:

1. Introduce the fundamental concepts, principles, and working mechanisms of augmented and mixed reality
2. Explore the hardware, software, and tracking systems used in AR
3. Develop an understanding of marker-based and marker-less tracking approaches
4. Examine advanced concepts such as SLAM, and its integration in AR components and devices

Module	Details	Hrs
	Course Introduction This course provides an in-depth understanding of augmented reality, covering its working principles, essential components, and hardware. Students will explore AR techniques like marker-based and marker-less tracking, computer vision, and AR software, along with insights into mixed reality and AR devices..	**01**
01.	**Introduction to Augmented Reality (A.R) :** ***Learning Objective:*** *To understand the definition, working principles, and key components of augmented reality, and analyze its relationship with other technologies and applications across the spectrum between real and virtual worlds.*	**6-8**

	Contents: Defining augmented reality, The Relationship Between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum Between Real and Virtual Worlds, applications of augmented reality Augmented Reality Concepts- working of Augmented Reality, Ingredients of an Augmented Reality Experience.	
	Self-Learning Topics: Timeline of evolution of AR from VR	
	Learning Outcomes: *A learner will be able to* *LO1.1: Apply the basic concepts and scope of Augmented Reality to identify its suitability in given socio economic scenario. (P.I.- 1.3.1)* *LO1.2: Apply Augmented Reality Concepts to identify Ingredients of an Augmented Reality Experience on given problem statement. (P.I.- 1.4.1)* *LO1.3: Illustrate the importance of AR in real-world applications. (P.I.- 2.3.1)* *LO1.4: Identify the relation between real and virtual AR world (P.I.- 2.2.4)*	
02.	**Augmented Reality Hardware:** ***Learning Objective:*** *Describe the components of augmented reality hardware, including displays, processors, and tracking systems, and analyze their roles in calibration, registration, and spatial modeling for AR experiences*	**7-9**
	Contents: Augmented Reality Hardware – Displays – Audio Displays, Haptic Displays, Visual Displays, Other sensory displays, Visual Perception, Requirements and Characteristics, Spatial Display Model. Processors – Role of Processors, Processor System Architecture, Processor Specifications. Tracking & Sensors - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion.	
	Self-Learning Topics: Study the design of an AR application with C# and Unity	
	Learning Outcomes: *A learner will be able to* *LO2.1: Apply appropriate type of Tracking mechanism & Sensors to the given scenario (P.I.- 1.3.1)* *LO2.2: Apply knowledge of augmented reality hardware, to identify AR components useful in given problem (P.I.- 1.4.1)* *LO2.3: Evaluate problem statements and identify Processors, Display Model, Sensors required in AR (P.I.- 2.1.1)* *LO 2.4: Apply Augmented Reality Hardware principles to formulate modules of a system for optimized applicability and performance. (P.I.- 2.3.1)*	
03.	**Computer Vision for Augmented Reality & A.R. Software:** ***Learning Objective:*** *Apply computer vision techniques, such as marker tracking and evaluate the role of software components in developing and managing augmented reality applications.*	**6-8**

	Contents: Computer Vision for Augmented Reality - Marker Tracking, Multiple-Camera Infrared Tracking, Natural Feature Tracking by Detection, Simultaneous Localization and Mapping, Outdoor Tracking Augmented Reality Software - Introduction, Major Software Components for Augmented Reality Systems, Software used to Create Content for the Augmented Reality Application.	
	Self-Learning Topics: Study all the available AR toolkits.	
	Learning Outcomes: *A learner will be able to* *LO3.1: Apply Tracking techniques on given Augmented Reality case (P.I.- 1.4.1)* *LO3.2: Apply Natural Feature Tracking by Detection on given situation (P.I.- 1.3.1)* *LO3.3: Apply knowledge of Computer Vision fundamentals to understand how Tracking tools are used in a AR for better AR experience (P.I.-2.3.1)* *LO3.4: Evaluate problem statements and identify required Augmented Reality Software component (P.I.- 2.1.2)*	
04.	**AR Techniques- Marker based & Marker less tracking**	**6-8**
	Learning Objectives: *Differentiate marker-based and marker-less tracking approaches, including types of markers and tracking methods, and apply mathematical and visual tracking techniques to implement augmented reality solutions.*	
	Contents: Marker-based approach- Introduction to marker-based tracking, types of markers, marker camera pose and identification, visual tracking, mathematical representation of matrix multiplication Marker types- Template markers, 2D barcode markers, imperceptible markers. Marker-less approach- Localization based augmentation, real world examples Tracking methods- Visual tracking, feature based tracking, hybrid tracking, and initialization and recovery.	
	Self-Learning Topics: Study on enhancement and improving markers with Vuforia engine ***Learning Outcomes:*** *A learner will be able to* *LO4.1: Illustrate the concept of marker-based tracking. (P.I.- 1.3.1)* *LO4.2: Apply mathematical representation of matrix multiplication to visual tracking of objects. (P.I.- 2.4.1)* *LO4.3: Apply Tracking methods effectively using various tracking AR tools. (P.I.- 1.4.1)* *LO4.4: Compare applicability of Marker based & Marker less tracking in terms of its applicability in real world scenarios. (P.I.- 2.1.1)* *LO 4.5: Apply Marker based & Marker less tracking techniques to AR Scenario using appropriate AR tools, while effectively collaborating and communicating results to class. (P.I.-2.3.1, 5.1.2, 8.3.1, 9.2.2)*	

05.	**AR Devices & Components** ***Learning Objective/s:*** *Describe the key components and devices of augmented reality systems, including scene generators, tracking systems, and various display technologies, and analyze their roles in creating immersive AR experiences*	**6-8**
	Contents: AR Components – Scene Generator, Tracking system, monitoring system, display, Game scene AR Devices – Optical See- Through HMD, Virtual retinal systems, Monitor bases systems, Projection displays, Video see-through systems	
	Self-Learning Topics: Case study on generating a scene using AR components *Learning Outcomes:* *A learner will be able to* *LO5.1: Apply tracking system on given scenario (P.I.- 1.3.1)* *LO5.2: Apply and illustrate working of Virtual retinal systems, Video see-through systems for given situation (P.I.- 1.4.1)* *LO5.3: Identify the appropriate type of AR Components useful in given problem (P.I.- 2.2.2)* *LO5.4: Evaluate problem statements and identify the use of AR Devices. (P.I.- 2.1.1)*	
06.	**Mixed Reality** ***Learning Objective/s:*** *Analyze the principles of mixed reality, its applications, and the role of computer vision techniques, including SLAM and its variants, in enhancing input and output interactions within mixed reality*	**6-8**
	Contents: Introduction to mixed reality, Applications of mixed reality, Input and Output in Mixed reality, Computer Vision and Mixed Reality, simultaneous localization and mapping (SLAM), variants of SLAM - dense tracking and mapping (DTAM), parallel tracking and mapping (PTAM) and semi-direct monocular visual odometry (SVO).	
	Self-Learning Topics: Study of Microsoft HoloLens. **Learning *Outcomes:*** *A learner will be able to* *LO6.1: Apply Computer Vision techniques in given scenario (P.I.-1.3.1)* *LO6.2: Apply Mixed Reality techniques to solve the given problem. (P.I.-1.4.1)* *LO6.3: Compare and contrast variants of SLAM on optimized performance in given situation (P.I.-2.2.4)* *LO6.4: Identify the appropriate Mixed Reality techniques applicable in given problem (P.I.- 2.2.2)* *LO 6.5: Apply various* Mixed reality techniques *to transform given problem into Augmented reality environment using suitable tools, collaborate effectively, and present results clearly to class. (P.I.- 2.3.2,5.2.2, 8.2.1, 9.3.2)*	

	Course Conclusion By the end of this course, students will be equipped to apply AR concepts, techniques, and hardware to design innovative and interactive augmented and mixed reality solutions.	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science and engineering to solve an engineering problem
2.1.1	Evaluate problem statements and identifies objectives
2.1.2	Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.1.3	Identify mathematical algorithmic knowledge that applies to a given problem
2.2.2	Identify functionalities and computing resources.
2.2.4	Compare and contrast alternative solution/methods to select the best methods
2.3.1	Able to apply computer engineering principles to formulate modules of a system with required applicability and performance
2.1.2	Identify processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions
2.3.2	Identify design constraints for required performance criteria.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2.2	Demonstrate proficiency in using discipline-specific tools
8.2.1	Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.2.2	Deliver effective oral presentations to technical and non-technical audiences

Course Outcomes: A learner will be able to -

1. To apply the principles of augmented reality to understand its components, working mechanisms, and applications across the real-to-virtual spectrum(LO 1.1,1.2,1.3,1.4)
2. To apply knowledge of AR hardware, processors, and tracking systems to spatial modelling solutions for immersive AR experiences.(LO 2.1,2.2,2.3)
3. To analyse the use of computer vision techniques and software components in creating and managing augmented reality applications.(LO 3.1,3.2,3.3)
4. To analyse the functionality of AR components and devices, such as displays and scene generators, to enhance user interaction in augmented reality.(LO 5.1,5.2,5.3,5.4)

5. Apply marker-based, marker-less, and mixed reality techniques, including SLAM and its variants, to design and evaluate augmented reality systems for seamless interaction between real and virtual environments. (LO 4.1,4.2,4.3,4.4,4.5,6.1,6.2,6.3,6.4,6.5)
6. Apply marker-based, marker-less, and mixed reality techniques to develop augmented reality solutions for given problems using appropriate tools, while collaborating effectively and clearly communicating results to the class (LO 4.5,*LO 6.5*)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
HMCAV602.1	3	3	-	-	-	-	-	-	-	-	-
HMCAV602.2	3	3	-	-	-	-	-	-	-	-	-
HMCAV602.3	3	3	-	-	-	-	-	-	-	-	-
HMCAV602.4	3	3	-	-	-	-	-	-	-	-	-
HMCAV602.5	3	3	-	-	-	-	-	-	-	-	-
HMCAV602.6	-	3	-	-	3	-	-	3	3	-	-
Average	**3**	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**-**

Text Books :

1. Allan Fowler-AR Game Development‖, 1st Edition, A press Publications, 2018, ISBN 978-1484236178
2. Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016),ISBN-10: 9332578494

Reference Books :

1. Designing for Mixed Reality, Kharis O'Connell Published by O'Reilly Media, Inc., 2016, ISBN: 9781491962381
2. Sanni Siltanen- Theory and applications of marker-based augmented reality. Julkaisija – Utgivare Publisher. 2012. ISBN 978-951-38-7449-0

Other Resources :

1.	https://www.vttresearch.com/sites/default/files/pdf/science/2012/S3.pdf Microsoft Documentation: https://docs.microsoft.com/en-us/windows/mixed-reality/ https://docs.microsoft.com/en-us/archive/msdn-magazine/2016/november/hololens-introduction-to-the-hololens
2.	MOOC Courses: https://www.coursera.org/learn/ar , https://www.udemy.com/share/101XPi/

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment - Theory-(20 Marks)**

Suggested breakup of distribution

Class test 1:5 marks

Class test 2:5 marks

Group discussion/public speaking/technical report writing: 05 Marks

Regularity and active participation: 05 Marks

2. **Mid Semester Exam (30 Marks)**

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.