

# **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<br>(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         |
| <b>Total</b> |      |             |                                                       | <b>14</b>                          | <b>10</b> | <b>--</b> | <b>14</b>        | <b>04</b> | <b>--</b> | <b>18</b> |

## 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        |
| <b>Total</b> |      |             |                                                       | <b>180</b>             | <b>120</b>   | <b>250</b>         | <b>--</b>                          | <b>--</b> | <b>550</b> |

| Course Type | Course Code | Course Name   | Credits |
|-------------|-------------|---------------|---------|
| HMC         | HMCAL703    | DEEP LEARNING | 04      |

| 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. HMCAL501- Knowledge Engineering
2. HMCAL602- Foundation of Machine Learning

**Program Outcomes addressed:**

1. PO1: Engineering knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO5: Engineering Tool Usage
5. PO6: The Engineer & The World
6. PO11: Life-long learning

**Course Objectives:**

1. To acquaint with the fundamentals of Neural Network.
2. To facilitate in depth understanding of training Deep Neural Networks.
3. To acquire knowledge of Convolution Neural Networks, Auto encoders and Recurrent Neural Networks.
4. To encourage in exploring emerging trends in Deep Learning to develop intelligent applications.

| Module | Detailed Contents                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Hrs. |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|        | <b>Course Introduction</b><br>This course provides students with a comprehensive understanding of deep learning, focusing on both foundational concepts and advanced architectures. Students will gain hands-on and conceptual proficiency in key deep learning paradigms, including Convolutional Neural Networks (CNNs) for supervised learning, Auto encoders for unsupervised representation learning, and Recurrent Neural Networks (RNNs) for sequence modelling. The course also explores recent trends such as Generative Adversarial Networks (GANs), preparing students to apply deep learning methods to real-world, research-oriented, and industry-driven applications in an evolving AI landscape. | 01   |
| 01.    | <b>Fundamentals of Neural Network</b><br><br><i>Learning Objective:</i><br>To explore the composition of biological neuron underlying the structure of deep neural network, key terminologies and historical evolution of deep learning.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4-6  |

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|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|     | <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Fundamentals of Neural Network: Biological neuron</li> <li>• Mc-Culloch Pitts Neuron, Perceptron, Multilayer Perceptron</li> <li>• Perceptron Learning, Delta learning</li> <li>• Linearly separable, linearly non-separable classes</li> <li>• Deep Networks: Fundamentals, Brief History</li> <li>• Basic Terminologies of Deep Learning</li> <li>• Classes of Deep Learning</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |       |
|     | <p><b>Self-Learning Topics:</b><br/>Transfer Learning</p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p>LO 1.1: Apply linear-algebraic and discrete-mathematical techniques to model and interpret the mathematical representation of biological neurons and the McCulloch–Pitts neuron. (P.I.-1.1.1)</p> <p>LO 1.2: Apply principles of computer engineering to determine linear separability of given dataset using perceptron-based model. (P.I - 1.4.1 )</p> <p>LO 1.3: Apply foundational and specialized engineering concepts to classify core terminologies and major categories of Deep Learning models.(P.I.-1.3.1)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |       |
| 02. | <p><b>Training, Optimization and Regularization of Deep Neural Network</b></p> <p><b>Learning Objective:</b><br/>To construe the training of deep networks, analyze and apply appropriate learning parameters and optimization techniques, and evaluate and implement effective regularization strategies for improved model performance.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Training Feedforward DNN: Multi Layered Feed Forward Neural Network, Learning Factors</li> <li>• Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, Leaky ReLU</li> <li>• Loss functions: Squared Error loss, Cross Entropy</li> <li>• Choosing output function and loss function</li> <li>• Optimization: Learning with backpropagation</li> <li>• Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Nesterov Accelerated GD, AdaGrad, Adam, RMSProp.</li> <li>• Regularization: Overview of Overfitting, Types of biases, Bias Variance Tradeoff.</li> <li>• Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, adding noise to input and output.</li> </ul> | 10-12 |

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|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|     | <p><b>Self-Learning Topics:</b><br/> <i>Advanced Regularization Techniques in Modern Deep Learning Architectures.</i><br/> <i>Hyperparameter Tuning Strategies for Efficient Deep Learning Model Optimization.</i></p> <p><b>Learning Outcomes:</b><br/> A learner will be able to<br/> LO 2.1: Apply linear-algebraic and discrete-mathematical techniques to mathematically represent Multi Layered Feed Forward Neural Network. (P.I.-1.1.1)<br/> LO 2.2: Apply engineering knowledge to formulate computational modules with suitable activation and loss functions for a given problem context. (P.I.-1.3.1)<br/> LO 2.3: Identify optimization algorithms of a computer based system and tune learning parameters by applying mathematical foundations of gradient-based methods to Enhance convergence and model performance. (P.I.- 2.1.2)<br/> LO 2.4: Compare and contrast alternative methods to select appropriate regularization technique to reduce over-fitting and improve model generalization using engineering fundamentals. (P.I.- 2.2.4)</p>                                                                                                                            |      |
| 03. | <p><b>Convolutional Neural Networks (CNN): Supervised Learning</b></p> <p><b>Learning Objective:</b><br/> <i>To interpret supervised learning concepts in CNNs, apprehend convolution operations and architectural components, and interpret foundational models for effective feature extraction and classification.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 8-10 |
|     | <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• <b>Supervised Learning:</b> Convolution operation, Padding, Stride, Relation between input, output and filter size</li> <li>• CNN architecture: Convolution layer, Pooling Layer, Weight Sharing in CNN</li> <li>• Fully Connected NN vs CNN</li> <li>• Variants of basic Convolution function</li> <li>• LeNET: Architecture</li> <li>• AlexNET: Architecture</li> </ul> <p><b>Self-Learning Topics:</b><br/> <i>Evolution of CNN Architectures: From VGG to ResNet</i><br/> <i>Advanced CNN Architectures</i></p> <p><b>Learning Outcomes:</b><br/> LO 3.1: Apply fundamental knowledge of mathematics to compute convolution, padding and stride operations in CNNs. (P.I.- 1.1.1)<br/> LO 3.2: Apply theory and principles of supervised learning to determine the relationship between input, output, and filter size in CNNs. (P.I.- 1.3.1)<br/> LO3.3: Design a variety of potential CNN architecture design solutions suited for specified image data to meet functional requirements. (P.I.- 3.2.2)<br/> LO 3.4: Explore classical architectural designs for basic image-classification problems. (P.I.-3.2.1)</p> |      |
| 04. | <p><b>Autoencoders: Unsupervised Learning</b></p> <p><b>Learning Objective:</b><br/> <i>To construe the concepts of unsupervised learning and auto-encoder models for image processing tasks such as image compression and feature representation.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 8-10 |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|     | <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Unsupervised Learning: Introduction</li> <li>• Linear Autoencoder, Undercomplete Autoencoder, Overcomplete Autoencoders, Denoising Autoencoders, Sparse Autoencoders, Contractive Autoencoders</li> <li>• Autoencoders bottleneck and its impact.</li> <li>• Application of Auto-encoders: Image Compression, Image Denoising, Dimensionality Reduction.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |
|     | <p><b>Self-Learning Topics:</b><br/>Variational Autoencoders (VAEs)</p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p>LO 4.1: Apply fundamental knowledge of neural networks to interpret the working principles of autoencoder. (P.I.-1.3.1)</p> <p>LO 4.2: Apply foundational and specialized engineering concepts to categorize major autoencoder models. (P.I.-1.4.1)</p> <p>LO 4.3: Explore and design suitable autoencoder variants for image compression or denoising pipelines by evaluating multiple architectural alternatives. (P.I.-3.2.1)</p> <p>LO 4.4: Able to verify the functionalities influencing representation capacity and reconstruction quality for different datasets and validate design of auto-encoders. (P.I.-3.4.3)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |       |
| 05. | <p><b>Recurrent Neural Networks (RNN)</b></p> <p><b>Learning Objective:</b><br/>To construe the concepts of sequence learning that enhances usability of application.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 10-12 |
|     | <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Sequence Learning Problem, Unfolding Computational graphs</li> <li>• Recurrent Neural Network, Bidirectional RNN</li> <li>• Backpropagation Through Time (BTT), Vanishing and Exploding Gradients, Truncated BTT</li> <li>• Long Short-Term Memory: Selective Read, Selective write, Selective Forget, Gated Recurrent Unit.</li> </ul> <p><b>Self-Learning Topics:</b><br/>Attention Mechanisms in RNNs<br/>RNNs in Reinforcement Learning</p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p>LO 5.1: Apply fundamentals of engineering to solve sequencing learning problems. (P.I.-1.3.1)</p> <p>LO 5.2: Apply computer engineering principles to construe with working principles of Recurrent Neural Networks. (P.I. - 1.4.1)</p> <p>LO 5.3: Analyze and interpret the effect of vanishing and exploding gradient problems on learning performance in sequence modeling tasks.(PI.- 2.4.2)</p> <p>LO 5.4:Analyze sequence-learning problems to identify and conform suitable RNN variants and assess the strengths and limitations of relevant tools for their implementation. (P.I.- 2.1.2, 5.1.2, 5.2.1)</p> <p>LO 5.5: Interpret legislation and regulations relevant for the protection of the public and understand the relationship between the technical, socio-economic and environmental dimensions of sustainability while deploying RNN-based systems. (P.I.-6.2.1, 6.3.2)</p> |       |

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |            |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>06.</b>   | <b>Emerging Trends</b><br><br><i>Learning Objective:</i><br>Utilize emerging trends that enhance usability of generative models                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>6-8</b> |
|              | <b>Contents:</b> <ul style="list-style-type: none"> <li>Generative Adversarial Network (GAN) Architecture</li> <li>Image Generation and DeepFake</li> <li>Diffusion Models for Image Generation</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |            |
|              | <b>Self-Learning Topics:</b><br>Advanced GAN Variants: StyleGAN, CycleGAN, and BigGAN.<br>Responsible AI Practices for Generative Models<br><br><b>Learning Outcomes:</b><br>A learner will be able to<br>LO 6.1: Apply engineering fundamentals to interpret GAN architecture and training dynamics. (P.I.-1.3.1)<br>LO 6.2: Apply theory and principles of computer science and engineering to generate synthetic images with GAN architecture. (P.I.-1.4.1)<br>LO 6.3: Recognize ethical, legal and societal implications and understand the environmental dimensions of sustainability for image generation using Deep Fake technique. (P.I.-6.2.1, 6.3.2)<br>LO 6.4: Demonstrate continuous professional learning by tracking developments in generative models, including diffusion-based image generation techniques, and analyzing sourced technical information for feasibility and sustainability to propose diverse applications. (P.I.-11.2.2, 11.3.2) |            |
|              | <b>Course Conclusion:</b><br>Upon completion of the Deep Learning course, students will acquire the proficiency to design, train, and apply advanced neural network models to solve real-world, research-oriented, and industry-focused problems.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>01</b>  |
| <b>Total</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>60</b>  |

### Performance Indicators:

| <b>P.I No</b> | <b>P.I. Statement</b>                                                                                                                              |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| 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.                                                |
| 2.1.3         | Identify mathematical algorithmic knowledge that applies to a given problem                                                                        |
| 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.                                                                                        |
| 3.2.1         | Able to explore design alternatives.                                                                                                               |
| 3.2.2         | Able to produce a variety of potential design solutions suited to meet functional requirement                                                      |
| 3.4.3         | Able to verify the functionalities and validate the design                                                                                         |
| 5.1.2         | Adapt the tools and techniques to solve engineering problems.                                                                                      |
| 6.2.1         | Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public. |
| 6.3.2         | Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability.                                  |

- 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
- 11.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability etc.

**Course Outcomes:** A learner will be able to-

1. Apply engineering and mathematical foundations to interpret mathematical representation of biological neurons, differentiate linearly separable and linearly non-separable classes using perceptron-based methods, and categorize core terminologies and principal categories of deep learning models.(LO 1.1, LO 1.2, LO 1.3)
2. Formulate modules of a system with appropriate activation and loss functions for a given problem context, identify optimization algorithms to enhance model performance, and analyze alternative regularization techniques for more generalized model.(LO 2.1, LO 2.2, LO 2.3, LO 2.4)
3. Design variety of potential CNN architectures suited for specified image data and explore classical architectural designs- LeNet and AlexNet for image-classification problems.(LO 3.1, LO 3.2, LO 3.3, LO 3.4)
4. Design components of auto-encoder variants for image compression or denoising pipelines and dimensionality reduction across different datasets.(LO 4.1, LO 4.2, LO 4.3, LO 4.4)
5. Apply engineering principles to solve sequence learning problems by adapting appropriate Recurrent Neural Network (RNN) variants and tools, while considering ethical, legal, and sustainability impacts on society and the environment.(LO 5.1, LO 5.2, LO 5.3, LO 5.4, LO 5.5)
6. Apply principles of computer science and engineering to evaluate Generative Adversarial Network (GAN) architectures for synthetic image generation, while continuously tracking emerging trends with consideration of ethical, legal, and sustainability impacts on society and the environment.(LO 6.1, LO 6.2, LO 6.3, LO 6.4)

#### CO-PO Mapping Table with Correlation Level

| CO ID          | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| HMCAL703.1     | 3   | --  | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAL703.2     | 3   | 3   | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAL703.3     | 3   | --  | 3   | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAL703.4     | 3   | --  | 3   | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAL703.5     | 3   | 3   | --  | --  | 3   | 3   | --  | --  | --  | --   | --   |
| HMCAL703.6     | 3   | --  | --  | --  | --  | 3   | --  | --  | --  | --   | 3    |
| <b>Average</b> | 3   | 3   | 3   | --  | 3   | 3   | --  | --  | --  | --   | 3    |

**Text Books:**

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville. —Deep Learning, MIT Press Ltd, 2016
2. Li Deng and Dong Yu, —Deep Learning Methods and Applications||, Publishers Inc.
3. Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill.
4. JM Zurada —Introduction to Artificial Neural Systems||, Jaico Publishing House
5. M. J. Kochenderfer, Tim A. Wheeler. —Algorithms for Optimization||, MIT Press.

**Reference Books:**

1. Fundamentals of deep learning: Designing next-generation machine intelligence algorithms, Buduma, N. and Locascio, N.,2017, O'Reilly Media, Inc.
2. Deep learning with Python ,François Chollet,(Vol. 361). 2018 New York,Manning.
3. Deep Learning Cookbook, Douwe Osinga,O'REILLY, SPD Publishers, Delhi.
4. Neural Network- A Comprehensive Foundation,Simon Haykin, Prentice Hall International, Inc
5. Principles of soft computing,S.N.Sivanandam and S.N.Deepa, Wiley India

**Other Resources:**

1. <https://nptel.ac.https://deeplearning.cs.cmu.edu/S21/index.html>
2. <http://www.cse.iitm.ac.in/~miteshk/CS6910.html>
3. <https://nptel.ac.in/courses/106/106/106106184/>
4. <https://www.deeplearningbook.org>

**IN-SEMESTER ASSESSMENT (50 MARKS)****1. Continuous Assessment (20 Marks)**

1. Assignment on live problems/case studies: 10 Marks  
(Assignment on live problems/ case studies, wherein problems are given prior. Students are expected to research and collect required resources. They can use the resources and solve the problem on assigned date and time in Institute premises in presence of faculty member.)
2. Article reading and summarization: 05 Marks
3. 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 |
|-------------|-------------|-------------------------------------------------------|---------|
| HML         | HMLAL701    | ARTIFICIAL INTELLIGENCE & MACHINE LEARNING LABORATORY | 02      |

| Examination Scheme    |                                |       |
|-----------------------|--------------------------------|-------|
| Continuous Assessment | End Semester Examination (ESE) | Total |
| 50                    | --                             | 50    |

**Pre-requisite:**

CESBL301/ MESBL301/ ECSBL301/ EESBL301/ ITSBL301 Python Laboratory

**Program Outcomes addressed:**

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct investigations of complex problems
5. PO5: Engineering tool usage
6. PO6: The Engineering and The World
7. PO7: Ethics
8. PO8: Individual and Collaborative Team work
9. PO9: Communication
10. PO11: Life-long learning

**Course Objectives:**

1. Apply data preprocessing, visualization, and supervised learning techniques for structured data.
2. Design and train deep neural networks using modern optimization and regularization methods.
3. Implement advanced architectures such as CNNs, RNNs, and Auto encoders for real-world problems.
4. Foster self-learning through global guided projects and reflective certification-based enrichment.

| Modu | Detailed Contents                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Hrs. |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|      | <p><b>Course Introduction</b></p> <p>This laboratory offers hands-on exposure to building, training, and optimizing Machine Learning and Deep Learning models. Students begin with foundational ML workflows and progress to advanced neural network architectures such as CNNs, RNNs, Autoencoders, and GANs. Each lab turn builds upon the previous one, ensuring cumulative learning and skill integration for real-world AI problem-solving. Additionally, it includes a self-learning guided project (Coursera/online platform) to foster independent exploration and global certification exposure.</p> |      |
| 01.  | <p><b>Machine Learning Pipeline Development and Model Evaluation</b></p> <p><i>Learning Objectives:</i></p> <p>To build ethical, privacy-preserving machine-learning pipelines and evaluate regression and classification models.</p>                                                                                                                                                                                                                                                                                                                                                                         | 10   |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |    |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
|     | <p><b>Contents:</b> Data cleaning, visualization, and splitting into training/testing sets feature engineering; Linear Regression, Logistic Regression, SVM, XGBoost, confusion matrix, ROC curve.</p> <p><b>Task 1:</b> Create an ethical, privacy-preserving machine-learning pipeline using a healthcare dataset (either custom-collected or sourced from public repositories), involving data loading, preprocessing (cleaning, imputation, scaling), exploratory visualization, feature engineering, and regression modeling, while ensuring responsible data handling, documenting societal/clinical implications, and providing collaborative project artifacts.</p> <p><b>Learning Outcomes:</b></p> <p>1.1 A learner will be able to create an ethical, privacy-preserving machine-learning pipeline for healthcare data by applying data loading, preprocessing, exploratory visualization, and regression modeling techniques. (PI- 1.1.1, 1.4.1, 2.1.2, 2.4.1, 5.1.1, 5.2.2, 6.3.1, 7.1.1, 7.2.1, 8.2.1)</p> <p><b>Task 2:</b> Evaluate the performance of Logistic Regression, Support Vector Machine, and XGBoost classifiers—including pre-trained models sourced from repositories such as Hugging Face/ Model Zoo—on a fintech dataset using confusion-matrix-based metrics and by plotting ROC and AUC curves to compare and interpret model effectiveness.</p> <p><b>Learning Outcomes:</b></p> <p>1.2 A learner will be able to evaluate and compare the performance of different classification models, including those obtained from pre-trained sources, on a fintech dataset using confusion-matrix metrics and ROC–AUC analysis to interpret model effectiveness. ( PI-1.1.1, 1.4.1, 2.1.2, 2.4.1, 5.1.1, 5.2.2, 6.3.1,6.3.2 7.1.1, 7.2.1, 8.2.1)</p> |    |
| 02. | <p><b>Designing, Optimizing, and Evaluating Neural Networks</b></p> <p><b>Learning Objective:</b></p> <p>To design and train single layer and multilayer perceptrons for classification tasks, experiment with activation functions, optimizers, and learning rates, and optimize deep neural networks using regularization to improve generalization and real-world applicability.</p> <p><b>Contents:</b></p> <p>Neural architecture, activation functions, forward and backward propagation, ReLU, Sigmoid, Softmax; optimizers—SGD, Adam, RMSProp. L1/L2 regularization, dropout, early stopping, bias–variance tradeoff.</p> <p><b>Task 3:</b> Build a simple neural network using Perceptron and MLP models in Keras, train it on both linearly (iris/moon dataset) and non-linearly separable datasets (e.g., XOR), and visualize learning curves and decision boundaries to analyze model performance.</p> <p><b>Learning Outcome:</b></p> <p>2.1 Learners will design and train neural networks using modern tools (Keras), analyze performance using learning curves and decision boundaries, and compare linear vs non-linear decision capability. (PI: 2.4.2, 3.2.1, 3.4.2, 4.3.1, 4.3.3, 5.1.1, 5.2.2)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 20 |

|    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |    |
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|    | <p><b>Task 4:</b> Design and train a Deep Neural Network (DNN) using multiple activation functions (ReLU, Sigmoid, Softmax) and optimizers (SGD, Adam, RMSProp) on handwritten digit datasets such as MNIST—commonly used in bank cheque processing and postal sorting—and on image datasets such as CIFAR-10 representing real-world domains like medical imaging, surveillance, and autonomous vehicles. Experiment with learning rates, evaluate training and validation performance, visualize accuracy/loss curves, and critically analyze the technical, societal, ethical, and environmental implications of deploying such deep learning systems.</p> <p><i>Learning Outcome:</i></p> <p>2.2 Learners will be able to design, implement, optimize, and evaluate Deep Neural Networks for real-world image classification tasks such as handwritten digit recognition (e.g., cheque processing, postal sorting) and object recognition (e.g., medical imaging, surveillance, autonomous vehicles), and interpret technical performance as well as societal, ethical, environmental, and professional implications of deploying such systems.(PI- 2.4.2, 2.4.4, 3.2.2, 3.4.1, 4.2.1, 4.3.2, 6.3.1, 7.1.1, 8.2.1, 9.1.2, 9.2.2)</p> <p><b>Task 5:</b> Extend the previously developed Deep Neural Network by incorporating regularization techniques such as dropout and weight decay to control overfitting, compare the network’s training behavior with and without regularization, and plot training versus validation loss curves to analyze generalization performance. Finally, interpret how the improved robustness and reliability of the regularized DNN model influence its suitability for real-world applications relevant to the chosen dataset domain (e.g., cheque handwriting recognition, postal automation, medical imaging, surveillance, or autonomous vehicle perception), and evaluate its broader impact on society, ethics, and the environment.</p> <p><i>Learning Outcome:</i></p> <p>2.3 Learners will be able to apply regularization techniques to improve the generalization, robustness, and reliability of Deep Neural Networks, analyze training–validation behavior, and evaluate the societal, ethical, and environmental implications of deploying such models in real-world applications. (PI- 2.4.2, 2.4.3, 4.3.1, 4.3.4, 5.1.1, 5.1.2,5.2.2, 6.3.1, 6.3.2, 7.1.1,7.2.1 8.2.1, 9.1.2, 9.2.2)</p> |    |
| 03 | <p><b>Design and Implementation of Advanced Deep Learning Models for Classification, Forecasting, and Generation</b></p> <p><b>Learning Objective:</b></p> <p>Design CNN architectures for image classification. Implement RNN and LSTM for sequence modeling. Implement unsupervised deep learning models for representation and generation.</p> <p><b>Contents:</b> Convolution, pooling, feature extraction, LeNet/AlexNet overview. ,Sequence learning, vanishing gradients, BPTT, Autoencoders, GAN basics, generative tasks.</p> <p><b>Task 6: Build and train CNN models on healthcare image datasets</b> (e.g., X-ray, MRI, or histopathology images). <b>Compare the performance of CNNs on image data with traditional machine learning models trained on corresponding tabular (CSV) healthcare datasets to analyze predictive improvement.</b> Experiment with convolutional and pooling layers, activation functions (ReLU, Softmax), optimizers (SGD, Adam, RMSProp), and learning rates. Evaluate training and validation performance, visualize accuracy/loss curves, and critically analyze how image-based feature extraction enhances prediction accuracy. Reflect on technical, societal, ethical, and environmental implications of deploying CNN-based diagnostic systems in real-world healthcare applications</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 20 |

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |    |
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|   | <p><b>Learning Outcome:</b><br/> 3.1 Learners will be able to <b>design, implement, and optimize CNNs for healthcare image classification, critically compare image-based predictions with tabular models, interpret performance improvements, and evaluate the technical, societal, ethical, and environmental impact of deploying robust CNN models in medical diagnostics.</b> (PI- 3.2.2, 4.3.2, 6.3.1, 7.2.1, <b>8.2.1, 9.1.2, 9.2.2</b>)</p> <p><b>Task 7: Develop RNN and LSTM models for financial time-series forecasting (e.g., stock prices, cryptocurrency trends) in FinTech, where accurate predictions are critical as money is involved and decisions have societal and ethical implications. Compare their predictive performance with traditional machine learning models</b> (e.g., Linear Regression, Random Forest) previously applied to the same dataset. Experiment with hyperparameters, sequence length, and optimizers to evaluate model behavior. Analyze how RNNs capture temporal dependencies and how LSTM's memory gates further improve prediction accuracy and stability over RNNs. Visualize predicted vs actual sequences and quantify performance using metrics such as RMSE, MAE, or MAPE, and discuss the advantages of sequence-based deep learning models over traditional ML approaches for time-series prediction.</p> <p><b>Learning Outcome:</b><br/> 3.2 Learners will be able to design, implement, and optimize RNN and LSTM models for financial time-series forecasting, critically compare their performance with traditional ML models, interpret improvements in prediction accuracy and temporal modeling, and evaluate practical, ethical, and societal implications in FinTech applications. (PI- 2.4.2, 2.4.3, 3.2.1, 3.4.1, 4.2.1, 4.3.2, 6.3.1, 6.3.2, 7.2.1, 8.2.1, 9.1.2, 9.2.2)</p> <p><b>Task 8: Build an Autoencoder for medical image denoising</b> (e.g., chest X-ray noise removal or MRI artifact reduction) to understand unsupervised feature learning, visualize latent-space representations to interpret how clinically relevant features are compressed and encoded, and demonstrate the concept of Generative Adversarial Networks (GANs) using a pre-trained medical-image GAN example to showcase how synthetic samples can support data augmentation and research—while critically considering the technical, ethical, and societal implications of generating medical images.</p> <p><b>Learning Outcomes:</b><br/> 3.3 Learners will be able to design and implement Autoencoders for medical image denoising, interpret latent-space representations, understand GAN-based synthetic image generation, and evaluate the technical, ethical, and societal implications of using generative models in healthcare. (PI- 3.2.2, 3.4.2, 4.3.1, 4.3.3, 2.4.2, 2.4.4, 8.2.1, 9.1.2, 9.2.2)</p> |    |
| 4 | <p><b>Self-Learning &amp; Professional Enrichment</b></p> <p><b>Learning Objective:</b><br/> To promote <b>independent learning, global exposure, and honors-level enrichment</b> through completion of an <b>industry-recognized guided project or Coursera capstone</b> in ML/DL/AI.</p> <p><b>Activity Guidelines</b></p> <ol style="list-style-type: none"> <li><b>Enroll</b> in one guided project or Coursera course related to <i>TensorFlow, CNNs, NLP, Explainable AI, Generative Models, or Applied ML etc.</i></li> <li><b>Complete the hands-on component</b>, demonstrating practical application of learned concepts.</li> <li><b>Submit the following:</b> <ol style="list-style-type: none"> <li>Certificate of Completion</li> <li>One-page Reflection Report including: <ul style="list-style-type: none"> <li>Title of the course/project</li> <li>Skills acquired</li> <li>Application relevance to real-world domains</li> <li>Key technical and ethical takeaways</li> </ul> </li> </ol> </li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 10 |

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|  | <p><b>4. Faculty Evaluation:</b> Reflection + practical understanding will be reviewed during viva voce.</p> <p><b>Learning Outcomes:</b></p> <p><i>4.1 Learners will independently complete an industry-recognized ML/DL project, demonstrating self-directed lifelong learning, individual professional growth, and the ability to apply and reflect on advanced technical concepts by following ethical practices. (PI – 7.1.1,7.2.1, 8.1.1, 8.2.1, 9.1.2, 9.1.2, ,11.1.1, 11.2.2)</i></p> |           |
|  | <b>Total Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>60</b> |

### 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
- 1.4.1 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
- 2.4.1 Applies engineering mathematics to implement the solution
- 2.4.2 Analyse and interpret the results using contemporary tools.
- 2.4.3 Identify the limitations of the solution and sources/causes
- 2.4.4 Arrive at conclusions with respect to the objectives.
- 3.2.2 Able to produce a variety of potential design solutions suited to meet functional requirements.
- 3.4.1 Able to perform systematic evaluation of the degree to which several design concepts meet the criteria.
- 3.4.2 Able to implement and integrate the modules.
- 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
- 5.1.1 Identify modern engineering tools such as computer aided drafting, modeling and analysis; techniques and resources for engineering activities
- 5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems
- 5.2.2 Demonstrate proficiency in using discipline-specific tools
- 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
- 7.2.1 Examine and apply moral & ethical principles to known case studies
- 8.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
- 8.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills
- 9.1.2 Produce clear, well-constructed, and well-supported written engineering documents
- 9.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear

- 11.1.1 Describe the rationale for the requirement for continuing professional development
- 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

**Course Outcomes (COs):** Learner will be able to:

1. Create and evaluate end-to-end machine-learning solutions by implementing responsible data handling, pre-processing, modelling, and performance assessment techniques across different domains. (LO1.1, LO1.2)
2. Design and train neural networks and deep neural networks, optimize their generalization using regularization, and analyse performance and real-world implications of robust models. (LO 2.1, LO 2.2, LO 2.3)
3. Design and evaluate advanced deep learning models (CNNs, RNNs/LSTMs, Autoencoders, GANs) for real-world healthcare and financial tasks, compare them with traditional methods, interpret results, and assess ethical and societal impacts. (LO 3.1, LO 3.2, LO3.3 )
4. Independently complete an industry-recognized ML/DL guided project, demonstrating lifelong learning, individual skill enhancement, and real-world application of advanced AI concepts. (LO 4.1)

**CO-PO Mapping Table with Correlation Level**

| CO ID          | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| HMLAL701.1     | 3   | 3   | --  | 3   | 3   | 3   | --  | --  | 3   | --   | --   |
| HMLAL701.2     | --  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 3   | --   | --   |
| HMLAL701.3     | --  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 3   | --   | --   |
| HMLAL701.4     | --  | --  | --  | 3   | 3   | 3   | 3   | 3   | 3   | --   | 3    |
| <b>Average</b> | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 3   | --   | 3    |

**Text Books :**

1. Aurélien Géron, “*Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*”, O’REILLY, ISBN: 978-1-492-03264-9, 2nd Edition, October 2019.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “*Deep Learning*”, MIT Press, ISBN: 978-0-262-03561-3, 1st Edition, November 2016.
3. Kevin P. Murphy, “*Machine Learning: A Probabilistic Perspective*”, MIT Press, ISBN: 978-0-262-01802-9, 1st Edition, August 2012.

### Reference Books:

1. Christopher M. Bishop, “*Pattern Recognition and Machine Learning*”, Springer, ISBN: 978-0-387-31073-2, 1st Edition, 2006.
2. Michael A. Nielsen, “*Neural Networks and Deep Learning*”, Determination Press, ISBN: 978-1-524-56590-1, 1st Edition, 2015.
3. Stuart Russell, Peter Norvig, “*Artificial Intelligence: A Modern Approach*”, Pearson, ISBN: 978-0-13-461099-3, 3rd Edition, December 2015.

### Other Resources:

1. Aston Zhang, Zachary C. Lipton, Mu Li, Alexander J. Smola, “*Dive into Deep Learning (D2L)*”, Online Interactive Course + Notebook Library, Available at: <https://d2l.ai>, Continuously Updated Edition, 2024.
2. Andrew Ng, “*Deep Learning Specialization*”, Coursera, Offered by DeepLearning.AI, URL: <https://www.coursera.org/specializations/deep-learning>, Last Updated: 2024.
3. IBM Skills Network, “*Machine Learning with Python*”, Coursera Guided Project, URL: <https://www.coursera.org/learn/machine-learning-with-python>, Last Updated: 2023.
4. Google Developers, “*TensorFlow Tutorials & Model Garden*”, TensorFlow Official Resource, URL: <https://www.tensorflow.org/tutorials>, Version Updated: 2024.
5. PyTorch Team, “*PyTorch Official Tutorials*”, PyTorch.org, URL: <https://pytorch.org/tutorials/>, Version Updated: 2024.
6. Kaggle Learn, “*Machine Learning, Deep Learning & Computer Vision Micro-courses*”, Kaggle.com, URL: <https://www.kaggle.com/learn>, Updated Continuously, 2024.

### A. IN-SEMESTER ASSESSMENT (50 MARKS)

*Suggested breakup of distribution*

- a) Task Evaluation: 20 Marks
- b) Guided Project Evaluation: 20 marks
- c) Regularity & Active participation: 10 Marks

### B. END SEMESTER EXAMINATION –No end semester examination.

# **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         |
| <b>Total</b> |      |             |                                             | <b>14</b>                       | <b>10</b> | <b>--</b> | <b>14</b>        | <b>04</b> | <b>--</b> | <b>18</b> |

### 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        |
| <b>Total</b> |      |             |                                             | <b>180</b>             | <b>120</b>   | <b>250</b>         | <b>--</b>                          | <b>--</b> | <b>550</b> |

| Course Type | Course Code | Course Name            | Credits |
|-------------|-------------|------------------------|---------|
| HMC         | HMCBC703    | BLOCKCHAIN DEVELOPMENT | 04      |

| 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 & Cryptocurrency
2. HMCBC602: Blockchain Platforms

**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 familiarize with Ethereum architecture and blockchain system components.
2. To evaluate blockchain programming languages and development tools.
3. To design and implement smart contracts using Solidity.
4. To explore private blockchain networks using Hyperledger Fabric.
5. To evaluate blockchain integration, security, sustainability, and ethical issues.

| Module     | Details                                                                                                                                                                                                                                                            | Hrs        |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
|            | <b>Course Introduction</b><br>A course that covers blockchain programming, smart contracts, DApp deployment, Hyperledger Fabric network setup, and integration with emerging technologies, with emphasis on security, sustainability, and real-world applications. | <b>01</b>  |
| <b>01.</b> | <b>Ethereum Ecosystem</b>                                                                                                                                                                                                                                          | <b>6-8</b> |
|            | <b>Learning Objective:</b><br><i>To explore Ethereum architecture, components, and transaction model.</i>                                                                                                                                                          |            |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |       |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|     | <p><b>Contents:</b></p> <p>Ethereum Architecture, Miner and Mining Node, Ethereum Virtual Machine (EVM), Ether, Gas, Transactions, Accounts (EOA &amp; Contract Account), Swarm, Whisper, Ethash, End-to-End Ethereum Transaction Process, Layer-2 Solutions: Polygon, Arbitrum, Account Abstraction (ERC-4337), CBDC Basics.</p> <p><b>Self-Learning Topics:</b> Emerging blockchain platforms (Avalanche, Cardano, Solana)</p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <ol style="list-style-type: none"> <li>1. LO1.1 Apply knowledge of Ethereum architecture, miners, mining nodes, and the Ethash consensus mechanism to analyze blockchain operations.(PI 1.4.1)</li> <li>2. LO1.2 Apply the concepts of EVM, Ether, Gas, and account to understand Ethereum operations.(PI 1.3.1)</li> <li>3. LO1.3 Apply Ethereum transaction lifecycle concepts with Layer-2 enhancements and Account Abstraction.(PI 1.4.1)</li> </ol> <p>LO1.4 Assess societal, financial, and governance implications of CBDC and decentralized identity. (PI 1.4.1, 6.3.2)</p> <p>LO1.5 Recognize emerging Ethereum trends including Layer-2 scalability, Account Abstraction, and CBDCs. (PI 11.2.2, 11.3.1)</p>                                                                                                                                                                                                                                                                         |       |
| 02. | <p><b>Blockchain Programming Languages</b></p> <p><b>Learning Objective:</b><br/>To explore blockchain programming languages, smart contract environments, and security tools.</p> <p><b>Contents:</b></p> <p>Blockchain Programming Paradigms: Solidity, GoLang, Vyper, Java, Simplicity, Rholang; Smart Contract Security Concepts; Game Theory &amp; Cryptonomics; IPFS for Decentralized Storage; Smart Contract Analysis Tools: MythX, Slither; Emerging Languages: Rust, Move, Cairo.</p> <p><b>Self-Learning Topics:</b> Compare programming languages used in Ethereum, Hyperledger, Solana.</p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p>LO2.1 Apply features and programming paradigms of Solidity, GoLang, Vyper, Java, Rust, and Move in blockchain development contexts. (PI 1.4.1) LO2.2 Compare blockchain programming languages based on syntax, execution models, security, and use cases.(PI 2.1.2)</p> <p>LO2.3 Apply concepts of Game Theory and Cryptonomics to smart contract logic and incentive design. (PI 1.3.1)</p> <p>LO2.4 Identify the strengths and limitations of IPFS for decentralized file management and content addressing. (PI 5.2.1)</p> <p>LO2.5 Identify smart contract security issues and demonstrate conceptual use of audit tools (MythX, Slither). (PI 2.2.3,5.3.1)</p> <p>LO2.6 Recognize and apply emerging blockchain programming trends and languages such as Cairo, Simplicity, and Rholang.(PI 1.4.1, 11.3.1)</p> | 11-13 |
| 03. | <p><b>Smart Contract Development</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 11-13 |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |      |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|     | <b>Learning Objective:</b><br><i>To design, implement, audit, and deploy smart contracts using Solidity.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |      |
|     | <b>Contents:</b><br>Solidity Contract Structure, Deployment Tools (Remix, Truffle, Hardhat), ERC20, ERC721 Standards, ICO, STO, SoulBound Tokens (ERC-5192), Smart Contract Wallets, Transaction Modifiers, Mappers, Events, Error Handling, Reentrancy, Vulnerability & Audit Concepts.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |
|     | <b>Self-Learning Topics:</b> <i>Cryptocurrencies and their security issues, Consensus mechanisms, Digital Signatures</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |      |
|     | <b>Learning Outcomes:</b><br><i>A learner will be able to</i><br><br>LO3.1 Identify and use Solidity constructs such as state variables, functions, modifiers, events, and mappings through simple code examples. (PI 1.4.1)<br>LO3.2 Demonstrate use of Remix, Truffle, or Hardhat for writing and testing smart contract snippets. (PI 5.2.1)<br>LO3.3 Write template-based contract structures for ERC20, ERC721, and ERC5192 token standards. (PI 1.3.1)<br>LO3.4 Apply analytical reasoning to identify common smart contract vulnerabilities and suggest ethical mitigation practices. (PI 1.3.1)<br>LO3.5 Identify and apply emerging smart contract trends such as SoulBound Tokens, Account Abstraction, and gas-efficient coding practices.<br>(PI 1.4.1, 5.3.1) |      |
| 04. | <b>Blockchain Deployment and DApp Development</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 9-11 |
|     | <b>Learning Objectives:</b><br><i>To deploy blockchain networks and integrate smart contracts with DApps..</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |      |
|     | <b>Contents:</b><br>Ethereum Client Setup, Go-Ethereum (Geth), Private Network Creation, Ganache, Truffle Suite, Hardhat, DApp Architecture, Web3.js, Use of Metamask, Connecting Smart Contracts, Testing Contracts, DAO Concepts, NFT Marketplace Deployment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |      |
|     | <b>Self-Learning Topics:</b> <i>Ganache/Truffle deployment practices.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |      |
|     | <b>Learning Outcomes:</b><br><i>A learner will be able to</i><br><br>LO4.1 Identify Ethereum client types and apply conceptual setup using Go-Ethereum (Geth) and Ganache. (PI 1.4.1, 5.2.1)<br>LO4.2 Configure a private blockchain network and conceptually deploy smart contracts using Truffle or Hardhat. (PI 5.3.1)<br>LO4.3 Apply DApp architecture concepts and trace contract interactions using Web3.js and MetaMask.(PI 1.3.1, 5.2.1)<br>LO4.4 Trace testing process of smart contracts using contract events, logs, and debugging tools. (PI 5.3.1)<br>LO4.5 Recognize and apply DAO concepts and NFT marketplace deployment while evaluating their societal impact. (PI 1.4.1, 11.2.2)                                                                        |      |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|     | LO4.6 Identify emerging deployment tools and frameworks such as Foundry and Wallet-as-a-Service (WaaS) and analyze their relevance in modern blockchain ecosystems. (PI 1.4.1, 11.2.2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |       |
| 05. | <p><b>Hyperledger Application Development</b></p> <p><b>Learning Objective/s:</b><br/>To develop enterprise blockchain applications using Hyperledger Fabric.</p> <p><b>Contents:</b><br/>Hyperledger Fabric Architecture, Network Configuration, Certificate Authorities, Chaincode Development, Transactions, Deployment, Testing, Hyperledger Besu Basics, Hyperledger Aries for Digital Identity, Hyperledger Caliper for Performance Benchmarking.</p> <p><b>Self-Learning Topics:</b> Hyperledger Sawtooth, Hyperledger Explorer.</p> <p><b>Learning Outcomes :</b><br/>A learner will be able to</p> <p>LO5.1 Apply Hyperledger Fabric concepts to identify architecture components and outline network configuration. (PI 1.4.1)</p> <p>LO5.2 Apply analytical reasoning to conceptual chaincode development and trace transaction flow in a Fabric network. (PI 1.3.1)</p> <p>LO5.3 Trace deployment and testing procedures using Hyperledger Fabric toolsets and simulators. (PI 5.2.1)</p> <p>LO5.4 Discuss the role of Hyperledger Aries in decentralized identity and certificate-based authentication. (PI 5.3.1)</p> <p>LO5.5 Identify performance benchmarking concepts using Hyperledger Caliper. (PI 5.3.1)</p>                  | 10-12 |
| 06. | <p><b>Blockchain Integration and Research Challenges</b></p> <p><b>Learning Objective/s:</b><br/>To understand blockchain integration with emerging technologies and research trends.</p> <p><b>Contents:</b><br/>Blockchain with IoT, AI, Cloud, ERP; End-to-End Integration; Decentralized Identity (DID), Verifiable Credentials, Zero-Knowledge Proof Systems, ESG &amp; Green Blockchain; Sustainability, Governance, Risks, AML/KYC, Ethical Blockchain Adoption.</p> <p><b>Self-Learning Topics:</b> RegTech, Blockchain for Healthcare &amp; Supply Chain.</p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p>LO6.1 Apply suitable conceptual frameworks to explore blockchain integration with IoT, AI, Cloud, and ERP systems. (PI 1.4.1)</p> <p>LO6.2 Apply theoretical concepts of decentralized identity (DID) and Verifiable Credential frameworks to interpret trust, authentication, and digital governance mechanisms. (PI 1.4.1)</p> <p>LO6.3 Apply theoretical perspectives to analyze sustainability, ESG, and green blockchain practices. (PI 1.4.1, 6.1.1, 6.3.2)</p> <p>LO6.4 Identify ethical implications in AML/KYC compliance, data privacy, and responsible blockchain usage. (PI 7.1.1, 7.2.2)</p> | 5-7   |

|  |                                                                                                                                                           |           |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|  | <i>LO6.5 Recognize emerging trends such as Zero-Knowledge Proof (ZKP), digital identity wallets, and green blockchain innovations. (PI 11.3.1,11.3.2)</i> |           |
|  | <b>Course Conclusion</b>                                                                                                                                  | <b>01</b> |
|  | <b>Total</b>                                                                                                                                              | <b>60</b> |

**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 solution/methods to solve the problem, including forming justified approximations and assumptions
- 5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modelling 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
- 6.3.2 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
- 7.2.2 Examine and apply moral & ethical principles to known case studies
- 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
- 11.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

**Course Outcomes:** A learner will be able to -

- Analyze Ethereum architecture, transaction flow, Layer-2 solutions, and CBDC implications.(LO1.1, LO1.2, LO1.3, LO1.4, LO1.5)
- Compare blockchain programming languages, apply Solidity constructs, and identify smart contract vulnerabilities with ethical mitigation. (LO2.1, LO2.2, LO2.3, LO2.4, LO2.5, LO2.6, LO3.1, LO3.2, LO3.3, LO3.4, LO3.5)
- Configure blockchain clients, connect smart contracts with DApps, test deployments, and assess DAO and NFT applications. (LO4.1, LO4.2, LO4.3, LO4.4, LO4.5)
- Analyze Hyperledger Fabric architecture, trace chaincode execution, and evaluate identity and governance using Aries and Caliper.(LO5.1, LO5.2, LO5.3, LO5.4, LO5.5)
- Assess blockchain integration with AI, IoT, and ERP, ESG sustainability, AML/KYC, and emerging trends like ZKP and identity wallets.(LO6.1, LO6.2, LO6.3, LO6.4, LO6.5)

## CO-PO Mapping Table with Correlation Level

| CO ID      | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| HMCBC703.1 | 3   | --  | --  | --  | --  | 2   | --  | --  | --  | --   | 3    |
| HMCBC703.2 | 3   | 3   | --  | --  | 3   | --  | --  | --  | --  | --   | 2    |
| HMCBC703.3 | 3   | --  | --  | --  | 3   | --  | --  | --  | --  | --   | 3    |
| HMCBC703.4 | 3   | --  | --  | --  | 3   | --  | --  | --  | --  | --   | --   |
| HMCBC703.5 | 2   | --  | --  | --  | --  | 3   | 3   | --  | --  | --   | 3    |
| Average    | 3   | 3   | --  | --  | 3   | 3   | 3   | --  | --  | --   | 3    |

### Text Books :

1. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
2. Blockchain Technology, Chandramouli Subramanian, Asha A George, Abhillash K. A and Meena Karthikeyan, Universities press

### Reference Books :

1. Blockchain enabled Applications, Vikram Dhillon,, Devid Metcalf, Max Hooper, Apress
2. Building Blockchain Projects, Narayan Prusty, Packt

### Other Resources :

1. NPTEL: Introduction to Blockchain Technology and Applications By Prof. Sandip Chakraborty & Prof. Bikramaditya Prasad, IIT Kharagpur, [https://onlinecourses.nptel.ac.in/noc20\\_cs01](https://onlinecourses.nptel.ac.in/noc20_cs01)
2. NPTEL: Blockchain and its Applications By Prof. Praveen Jayakumar & Prof. S. Santhosh, IIT Kharagpur, [https://onlinecourses.nptel.ac.in/noc22\\_cs44](https://onlinecourses.nptel.ac.in/noc22_cs44)
3. NPTEL: Blockchain Architecture Design and Use Cases By Prof. Sandeep Shukla, IIT Kanpur, [https://onlinecourses.nptel.ac.in/noc21\\_cs65](https://onlinecourses.nptel.ac.in/noc21_cs65)

## IN-SEMESTER ASSESSMENT (50 MARKS)

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

#### *Suggested breakup of distribution*

- a. Two Class tests: 05 marks each
- b. Article reading & summarization: 05 marks
- c. 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 |
|-------------|-------------|-----------------------|---------|
| HML         | HMLBC701    | BLOCKCHAIN LABORATORY | 02      |

| Examination Scheme    |                                |       |
|-----------------------|--------------------------------|-------|
| Continuous Assessment | End Semester Examination (ESE) | Total |
| 50                    | -                              | 50    |

**Pre-requisite:**

1. HMCBC501: Introduction to Blockchain & Cryptocurrency
2. HMCBC602: Blockchain Platforms
3. HMCBC703: Blockchain Development

**Program Outcomes addressed:**

1. PO 1: Engineering knowledge
2. PO 2: Problem analysis
3. PO3 : Design/Development of Solutions
4. PO 5: Engineering Tool Usage
5. PO 6: The Engineer & The World
6. PO 9: Communication

**Course Objectives:**

1. Configure blockchain development tools and test Ethereum environments.
2. Develop smart contracts using Solidity and deploy using Remix/Ganache
3. Implement token contracts and decentralized storage using IPFS.
4. Integrate smart contracts with Web3.js-based DApps.
5. Deploy and test private blockchain networks using Geth/Truffle/Ganache.

| Module | Details                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Hrs |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|        | <p><b>Course Introduction</b></p> <p>This laboratory course provides hands-on experience in developing Ethereum-based decentralized applications. Learners configure blockchain tools, develop and deploy smart contracts using Solidity, integrate DApps using Web3.js and Metamask, and test private blockchain networks using Ganache and Geth. The course focuses on practical implementation, debugging, contract evaluation, and real-world application of blockchain concepts.</p> |     |
| 01.    | <p><b>To set up the Ethereum development environment and deploy a smart contract while exploring accounts, transactions, gas usage, ABI, and bytecode on a local blockchain.</b></p> <p><i>Learning Objective:</i></p> <ul style="list-style-type: none"> <li>- To explore Ethereum development tools and blockchain network configuration.</li> <li>- To demonstrate wallet concepts, mining, gas, transactions, and block exploration.</li> </ul>                                       | 08  |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |    |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
|     | <p><b>Contents:</b></p> <ol style="list-style-type: none"> <li>1. Install and configure Metamask, Ganache CLI, Remix, Truffle, and VS Code.</li> <li>2. Create Ethereum test accounts; transfer Ether using Ganache, view gas usage, block info.</li> <li>3. Deploy a basic contract on Remix; view bytecode, ABI, and storage states.</li> </ol> <p><b>Learning Outcomes:</b><br/> <i>A learner will be able to set up an Ethereum development environment, create test accounts, and deploy a smart contract while interpreting transactions, gas usage, ABI, and bytecode on a local blockchain. (PI 1.3.1,1.4.1,2.1.2,2.2.2,,5.2.1,5.3.1)</i></p>                                                                                                                                                                                                                                                 |    |
| 02. | <p><b>To design and implement an advanced Solidity smart contract incorporating data structures, access control, CRUD operations, events, and robust error handling.</b></p> <p><b>Learning Objective:</b><br/> <i>To develop Solidity contracts using functions, data types, mappings, and events...</i></p> <p><b>Contents:</b></p> <ol style="list-style-type: none"> <li>1. Write a smart contract with variables, functions, and access modifiers.</li> <li>2. Implement mappings, arrays, structs, and CRUD functions in a contract.</li> <li>3. Implement event logging, require/revert, and error handling using modifiers.</li> </ol> <p><b>Learning Outcomes:</b><br/> <i>A learner will be able to design and implement an advanced Solidity smart contract using data structures, access control, CRUD operations, events, and error-handling mechanisms. (PI 1.4.1, 5.2.1,5.2.2)</i></p> | 12 |
| 03. | <p><b>To design and deploy ERC20 and ERC721 token contracts and integrate IPFS-based metadata storage for NFTs using content hashes.</b></p> <p><b>Learning Objective:</b><br/> <i>To build custom ERC20 and ERC721 tokens and integrate decentralized file storage</i></p> <p><b>Contents:</b></p> <ol style="list-style-type: none"> <li>1. Create an ERC20 token contract and test transfer functions.</li> <li>2. Deploy ERC721 (NFT) contract with metadata and royalty features.</li> <li>3. Upload files to IPFS using Pinata or local IPFS node; link hash in token metadata.</li> </ol> <p><b>Learning Outcomes:</b><br/> <i>A learner will be able to design and deploy ERC20 and ERC721 token contracts and integrate IPFS-based decentralized metadata storage for NFTs using content hashes. (PI 5.1.1, 5.2.1)</i></p>                                                                   | 10 |
| 04. | <p><b>To build a basic decentralized application (DApp) by integrating a Solidity smart contract with a Web3.js/React frontend and Metamask for account access and transaction signing on a local Ganache network.</b></p> <p><b>Learning Objectives:</b><br/> <i>To design interactive Blockchain DApps by integrating frontend with smart contracts.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 12 |

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|              | <p><b>Contents:</b></p> <ol style="list-style-type: none"> <li>1. Configure Web3.js and fetch account, balance, block info from Ganache.</li> <li>2. Connect a Solidity contract with frontend via Web3.js/React.</li> <li>3. Implement Metamask-based transaction signing, custom RPC connection.</li> </ol> <p><b>Learning Outcomes:</b></p> <p><i>A learner will be able to build a basic decentralized application by integrating a Solidity smart contract with a Web3.js/React frontend and implement Metamask-based account access and transaction signing on a local Ganache network. (PI 3.3.1,3.4.2,5.1.1,5.2.1)</i></p>                                                                                                                                                                                                                                                                                                                   |           |
| 05.          | <p><b>To configure a private Ethereum network with Geth, deploy and test smart contracts using Truffle, and analyze gas usage, bytecode size, and performance on the custom chain.</b></p> <p><b>Learning Objective/s:</b></p> <p><i>To deploy smart contracts on private Ethereum network using Geth or Truffle.</i></p> <p><b>Contents:</b></p> <ol style="list-style-type: none"> <li>1. Set up a private Ethereum node using Geth and mine blocks.</li> <li>2. Deploy contract using Truffle on private network; test state changes.</li> <li>3. Analyze gas cost, contract bytecode size, and performance metrics.</li> </ol> <p><b>Learning Outcomes :</b></p> <p><i>A learner will be able to configure a private Ethereum network using Geth, deploy and test smart contracts with Truffle, and analyze gas usage, bytecode size, and performance metrics on a custom blockchain. (PI 5.2.1, 5.3.1)</i></p>                                  | 08        |
| 06.          | <p><b>Case Study Analysis and Demonstration of Blockchain-Based DApps</b></p> <p><b>Learning Objective/s:</b> <i>To assess blockchain frameworks and contract-based DApps..</i></p> <p><b>Contents:</b></p> <p>Case Study Viva:</p> <p>Choose a blockchain DApp case study either from</p> <ol style="list-style-type: none"> <li>(1) a peer-reviewed research paper, or</li> <li>(2) a real-world open-source/lived DApp.</li> </ol> <p>Map its architecture. Deconstruct the smart contract logic. Trace end-to-end transaction flow. Demonstrate / explain its working in viva. Reflect on impact, risks, and governance.</p> <p><b>Learning Outcomes:</b></p> <p><i>A learner will be able to analyze and demonstrate the working of a blockchain-based DApp through case studies such as Ethereum voting, NFT, or supply chain contracts, explaining architecture, logic, and functional behavior. .( PI 6.1.1, 6.3.2, PI 9.1.1, 9.3.1)</i></p> | 10        |
|              | By the end of this course, learners will be able to configure Ethereum development environments, build and deploy smart contracts, integrate DApps using Web3.js, and test private blockchain networks. They will demonstrate the ability to analyze contract performance, apply decentralized storage solutions, and understand security, ethical, and real-world implications of blockchain-based applications.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |
| <b>Total</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>60</b> |

**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
- 2.2.2 Identify functionalities and computing resources.
- 3.3.1 Able to perform systematic evaluation of the degree to which several design concepts meet the criteria
- 3.4.2 Able to implement and integrate the modules.
- 5.1.1 Identify modern engineering tools, techniques and resources for engineering activities
- 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
- 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
- 6.3.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
- 9.1.1 Read, understand and interpret technical and non- technical information
- 9.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations

| <b>Course Outcomes:</b> A learner will be able to - |                                                                                                                                                       |
|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.                                                  | Apply Ethereum development tools to set up a local blockchain, create accounts, deploy contracts, and interpret transactions, gas, ABI, and bytecode. |
| 2.                                                  | Design and implement Solidity smart contracts using appropriate data structures, access control, events, and error-handling mechanisms.               |
| 3.                                                  | Develop ERC20 and ERC721 tokens and integrate decentralized metadata storage using IPFS.                                                              |
| 4.                                                  | Build a basic decentralized application by integrating smart contracts with a Web3.js/React frontend and MetaMask for transaction signing.            |
| 5.                                                  | Configure and analyze private Ethereum networks and evaluate blockchain DApps through architectural, functional, and governance-based case studies.   |

## CO-PO Mapping Table with Correlation Level

| CO ID          | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| HMLBC701.1     | 3   | 3   | --  | --  | 3   | --  | --  | --  | --  | --   | --   |
| HMLBC701.2     | 2   | --  | --  | --  | 3   | --  | --  | --  | --  | --   | --   |
| HMLBC701.3     | --  | --  | --  | --  | 3   | --  | --  | --  | --  | --   | --   |
| HMLBC701.4     | --  | --  | 3   | --  | 3   | --  | --  | --  | --  | --   | --   |
| HMLBC701.5     | --  | --  | --  | --  | 3   | 3   | --  | --  | 3   | --   | --   |
| <b>Average</b> | 3   | 3   | 3   | --  | 3   | 3   | --  | --  | 3   | --   | --   |

### Text Books :

1. *Solidity Programming Essentials* — Ritesh Modi, Packt Publishing
2. *Hands-On Smart Contract Development with Solidity and Ethereum* — Michael Floyd, Packt Publishing
3. *Mastering Ethereum: Building Smart Contracts and DApps* — Andreas M. Antonopoulos & Gavin Wood, O'Reilly Media
4. *Mastering Blockchain* — Imran Bashir, Packt Publishing

### Reference Books :

1. *Building Blockchain Projects* — Narayan Prusty, Packt Publishing
2. *Blockchain Basics: A Non-Technical Introduction in 25 Steps* — Daniel Drescher, Apress
3. *Blockchain for Business: A Practical Guide to Understanding Blockchain* — Nitin Gaur, Addison-Wesley (Pearson)

### Other Resources :

1. <https://geth.ethereum.org/downloads/>
2. <https://medium.com/@agrawalmanas09/how-to-setup-private-ethereum-blockchain-on-windows-10-machine-ab497e03d6b8>
3. <https://geth.ethereum.org/docs/dapp/>
4. <https://www.edureka.co/blog/ethereum-private-network-tutorial>
5. <https://docs.soliditylang.org/en/develop/index.html>
6. <https://metamask.io>
7. <https://medium.com/publicaio/a-complete-guide-to-using-metamask-updated-version-cd0d6f8c338f>
8. <https://docs.aws.amazon.com/blockchain-templates/latest/developerguide/blockchain-templates-create-stack.html>

## IN-SEMESTER ASSESSMENT (50 MARKS)

### Suggested breakup of distribution

- a. Laboratory Exercises: 15 Marks
- b. Internal Assessment: 10 Marks
- c. Regularity and active participation: 05 Marks
- d. Practical Test: 20 Marks

| Course Type | Course Code | Course Name                | Credits |
|-------------|-------------|----------------------------|---------|
| HMC         | HMCBC804    | DECENTRALISED APPLICATIONS | 04      |

| 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 & Cryptocurrency
2. HMCBC602: Blockchain Platforms
3. HMCBC703: Blockchain Development

**Program Outcomes addressed:**

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

**Course Objectives:**

1. To familiarize with decentralized application (DApp) architecture and Web3 development frameworks.
2. To explore smart contract-driven DApps using blockchain and IPFS integration.
3. To deploy and test DApps using Ethereum, Hardhat, Web3.js, and wallet interfaces.
4. To evaluate decentralized identity, interoperability, security, and governance models.
5. To identify future DApp trends including DeFi, DAO, Metaverse, and ZKP-based Web3 applications.

| Module | Details                                                                                                                                                                            | Hrs |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|        | <b>Course Introduction</b><br>Overview of decentralized computing, browser-based blockchain apps, Web3 evolution, smart contract-driven apps, wallets, and blockchain interaction. | 01  |
| 01.    | <b>DApp Architecture and Web3 Fundamentals</b>                                                                                                                                     | 6-8 |
|        | <i>Learning Objective:</i><br>To analyze decentralized architecture, client-chain interaction, and Web3 frameworks..                                                               |     |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|     | <p><b>Contents:</b></p> <p>Centralized vs Decentralized Apps, Web1–Web2–Web3 evolution, DApp Architecture Layers, Smart Contracts, Wallets, Blockchain Node (RPC), Web3 Provider, Event Listeners, REST vs RPC, Gas Payment Models, Public vs Private DApps.</p> <p>Latest Trends: Web3 UI frameworks: Ether.js, Moralis, RainbowKit, Wagmi.</p> <p><b>Self-Learning Topics:</b> Metamask vs WalletConnect vs Coinbase Wallet.</p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p>LO1.1 Apply analytical reasoning to differentiate centralized and decentralized applications and trace the evolution from Web1 to Web3.<br/>(PI 1.3.1)</p> <p>LO1.2 Apply theoretical principles to interpret DApp architecture layers, including smart contracts, wallets, blockchain nodes (RPC), and Web3 providers.(PI 1.4.1)</p> <p>LO1.3 Apply analytical reasoning to compare REST and RPC communication models and illustrate gas payment models in public and private DApps.<br/>(PI 1.3.1)</p> <p>LO1.4 Apply wallet interaction, event listeners, and token interface concepts for frontend–contract communication. (PI 1.4.1)</p> <p>LO1.5 Recognize emerging Web3 UI frameworks such as Ether.js, Moralis, RainbowKit, and Wagmi for DApp integration. (PI 11.2.2, 11.3.1)</p>                                 |       |
| 02. | <p><b>Smart Contract–Driven Dapps</b></p> <p><b>Learning Objective:</b><br/>To design smart contract logic for decentralized application use cases..</p> <p><b>Contents:</b></p> <p>DApp Logic, Contract Interface, ABI, Frontend Interaction, State Syncing, Events, Mappers, Tokenized Assets, DeFi DApps (Lending, Staking), NFT DApps (Minting, Trading).<br/>Use Cases: Decentralized Voting, Identity Verification, Supply Chain Tracking.</p> <p><b>Self-Learning Topics:</b> Real-time EtherScan transaction analysis.</p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p>LO2.1 Apply theoretical concepts to interpret contract interfaces, ABI, events, and mappers in smart contract–driven DApps.(PI 1.4.1)</p> <p>LO2.2 Apply DApp logic, event handling, and state syncing concepts to illustrate tokenized assets, DeFi lending, and staking workflows. (PI 5.2.1)</p> <p>LO2.3 Discuss NFT minting, ownership mapping, and transfer using conceptual contract templates and event logs.(PI 5.3.1)</p> <p>LO2.4 Map decentralized voting, identity verification, and supply chain tracking to smart contract–based DApp architectures. (PI 1.4.1,6.1.1)</p> <p>LO2.5 Evaluate governance, transparency, and ethical implications of smart contract–driven DApp use cases. (PI 1.3.1,6.3.2)</p> | 9-11  |
| 03. | <p><b>Web3 Interaction and Wallet Integration</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 11-13 |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |       |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
|     | <b>Learning Objective:</b><br><i>To develop and test DApps using Ethereum tools and Web3 interfaces</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |
|     | <b>Contents:</b><br>Web3.js, Ether.js, Hardhat, Truffle, Gas Estimation, Frontend Frameworks (React, Vue), Wallet Connection, MetaMask API, Web3 Provider Setup, Event Handling, Transaction Monitoring, Alchemy, Infura, QuickNode APIs.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |
|     | <b>Self-Learning Topics:</b> <i>Usage of Moralis Dashboard for DApp Analytics.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |       |
|     | <b>Learning Outcomes:</b><br><i>A learner will be able to</i> <p>LO3.1 Apply analytical reasoning to interpret the roles of Web3.js, Ether.js, Hardhat, and Truffle in smart contract interaction and DApp development. (PI 1.3.1)</p> <p>LO3.2 Apply wallet connection, MetaMask API, and Web3 provider setup for DApp interaction and transaction initiation. (PI 5.2.1)</p> <p>LO3.3 Discuss event handling and transaction monitoring for tracking contract responses and user actions. (PI 5.3.1)</p> <p>LO3.4 Apply analytical reasoning to interpret gas-estimation approaches and blockchain API providers such as Alchemy, Infura, and QuickNode. (PI 1.3.1)</p> <p>LO3.5 Recognize emerging frontend frameworks (React, Vue) and Web3 libraries for user interface integration in DApps. (PI 11.2.2, 11.3.1)</p> |       |
| 04. | <b>Decentralized Identity and Interoperability</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 12-14 |
|     | <b>Learning Objectives:</b><br><i>To analyze digital identity, cross-chain interactions, and authentication in DApps.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |
|     | <b>Contents:</b><br>Decentralized Identity (DID), Verifiable Credentials, Zero-Knowledge Proofs, SoulBound Tokens, Cross-Chain Bridges (Polkadot, Cosmos, Polygon), Oracle Networks (Chainlink), Interoperability Standards (ERC-5169, ERC-5564).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |       |
|     | <b>Self-Learning Topics:</b> <i>Introduction to W3C DID specs.</i><br><br><b>Learning Outcomes:</b><br><i>A learner will be able to</i> <p>LO4.1 Identify decentralized identity (DID), verifiable credentials, and SoulBound tokens for responsible identity management. (PI 6.1.1)</p> <p>LO4.2 Apply Zero-Knowledge Proof concepts in identity authentication and privacy-preserving DApps. (PI 1.4.1)</p> <p>LO4.3 Identify cross-chain communication approaches using Polkadot, Cosmos, and Polygon bridges. (PI 5.2.1)</p> <p>LO4.4 Discuss the role of Oracle networks such as Chainlink in decentralized data integration. (PI 5.3.1)</p> <p>LO4.5 Recognize interoperability standards such as ERC-5169 and ERC-5564 for cross-network DApp interaction. (PI 11.2.2, 11.3.1)</p>                                  |       |
| 05. | <b>Advanced DApp Use Cases &amp; Enterprise Applications</b><br><br><b>Learning Objective/s:</b><br><i>To assess enterprise blockchain DApp solutions.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 8-10  |

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|              | <p><b>Contents:</b></p> <p>DAO Governance, DeFi, Metaverse, NFTs, Smart Contract Wallets, Web3 Social DApps, Blockchain for Healthcare, Finance &amp; GovTech Applications, Hybrid Blockchain Platforms (Hyperledger Besu, Quorum, Avalanche).</p> <p><b>Self-Learning Topics:</b> Tokenomics &amp; Smart Contract Governance Models..</p> <p><b>Learning Outcomes :</b></p> <p>A learner will be able to</p> <p>LO5.1 Apply theoretical principles to interpret DAO governance, DeFi workflows, and smart contract wallet concepts in enterprise DApps.(PI 1.4.1)</p> <p>LO5.2 Apply theoretical concepts to illustrate blockchain-based applications in healthcare, finance, and GovTech.(PI 1.4.1, 6.1.1)</p> <p>LO5.3 Apply theoretical principles to analyze transparency, traceability, and risk mitigation in blockchain-based solutions.(PI 1.4.1, 6.3.1)</p> <p>LO5.4 Recognize the use of hybrid blockchain platforms such as Hyperledger Besu, Quorum, and Avalanche for enterprise integration. (PI 1.4.1,11.2.2, 11.3.1)</p> <p>LO5.5 Apply analytical reasoning to evaluate societal, ethical, and privacy implications of Web3 social DApps, NFTs, and Metaverse applications. (PI 1.3.1, 11.3.1, 11.3.2)</p>                                                                                                                       |           |
| 06.          | <p><b>Trends in DApps, Security, and Future Research</b></p> <p><b>Learning Objective/s:</b></p> <p>To explore emerging DApp technologies, risks, and future research directions..</p> <p><b>Contents:</b></p> <p>Web3 Security – MEV, Flash Loans, Smart Contract Audits, Layer-0 Protocols (Cosmos, Polkadot), Blockchain AI Integration, Green Blockchain (Energy Efficient), Quantum-Resistant Cryptography.</p> <p><b>Self-Learning Topics:</b> Ethereum Post-Shanghai and Ethereum 2.0 Sharding.</p> <p><b>Learning Outcomes:</b></p> <p>A learner will be able to</p> <p>LO6.1 Apply theoretical principles to discuss Web3 security concerns including MEV, flash loans, and auditing requirements.(PI 1.4.1, 5.3.1)</p> <p>LO6.2 Apply theoretical concepts to interpret Layer-0 protocols such as Cosmos and Polkadot for scalability and interoperability.(PI 1.4.1)</p> <p>LO6.3 Identify energy-efficient blockchain designs through green blockchain and sustainability concepts. (PI 6.3.1, 6.3.2)</p> <p>LO6.4 Apply theoretical principles to examine AI integration in blockchain for automation, analytics, and predictive governance.(PI 1.4.1, 11.3.1)</p> <p>LO6.5 Recognize and apply theoretical principles to understand the role of quantum-resistant cryptography in future blockchain security. (PI 1.4.1, 11.2.2)</p> | 6-8       |
|              | <b>Course Conclusion</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 01        |
| <b>Total</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>60</b> |

**Performance Indicators:**

| <b><u>P.I. No.</u></b> | <b><u>P.I. Statement</u></b>                                                                                                                                                             |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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 solution/methods to solve the problem, 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                                                               |
| 4.1.1                  | Define a problem for purposes of investigation, its scope and importance                                                                                                                 |
| 4.2.1                  | Design and develop appropriate procedures/methodologies based on the study objectives                                                                                                    |
| 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                                                                         |
| 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                                                                                                     |
| 11.3.2                 | Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.                                                                                       |

**Course Outcomes:** A learner will be able to -

1. Analyse decentralized architecture and Web3 application components.  
(LO1.1, LO1.2, LO1.3, LO1.4)
2. Design smart contract-based DApps with blockchain integration.  
(LO2.1, LO2.2, LO2.3, LO2.4, LO2.5)
3. Develop, deploy, and test DApps using Web3 tools and frameworks.  
(LO3.1, LO3.2, LO3.3, LO3.4)
4. Assess identity, interoperability, and governance models in decentralized applications.  
(LO4.1, LO4.2, LO4.3, LO4.4, LO5.1, LO5.2, LO5.3, LO5.4)
5. Analyze security, sustainability, ethics, and research trends in decentralized applications.  
(LO6.1, LO6.2, LO6.3, LO6.4)

## CO-PO Mapping Table with Correlation Level

| CO ID          | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| HMCBC804.1     | 3   | --  | --  | --  | --  | --  | --  | --  | --  | --   | 3    |
| HMCBC804.2     | 3   | --  | --  | --  | 3   | 3   | --  | --  | --  | --   | --   |
| HMCBC804.3     | 3   | --  | --  | --  | 3   | --  | --  | --  | --  | --   | 3    |
| HMCBC804.4     | 3   | --  | --  | --  | 3   | 3   | --  | --  | --  | --   | 3    |
| HMCBC804.5     | 2   | --  | --  | --  | 2   | 3   | --  | --  | --  | --   | 3    |
| <b>Average</b> | 3   | --  | --  | --  | 3   | 3   | --  | --  | --  | --   | 3    |

### Text Books :

1. Ritesh Modi, *Solidity Programming Essentials*, Packt Publishing.
2. Michael Floyd, *Hands-On Smart Contract Development with Solidity and Ethereum*, Packt Publishing.
3. Nitin Gaur, *Blockchain for Business: A Practical Guide to Understanding the Blockchain*, Addison-Wesley Professional (Pearson).

### Reference Books :

1. Andreas M. Antonopoulos & Gavin Wood, *Mastering Ethereum: Building Smart Contracts and DApps*, O'Reilly Media.
2. Imran Bashir, *Mastering Blockchain*, Packt Publishing.
3. Narayan Prusty, *Building Blockchain Projects*, Packt Publishing.
4. Daniel Drescher, *Blockchain Basics: A Non-Technical Introduction in 25 Steps*, Apress.

### Other Resources :

1. NPTEL: Blockchain Architecture, Design and Use Cases By Prof. Sandeep Shukla, IIT Kanpur  
[https://onlinecourses.nptel.ac.in/noc21\\_cs65](https://onlinecourses.nptel.ac.in/noc21_cs65)
2. NPTEL: Blockchain and its Applications By Prof. Praveen Jayakumar, IIT Kharagpur  
[https://onlinecourses.nptel.ac.in/noc22\\_cs44](https://onlinecourses.nptel.ac.in/noc22_cs44)
3. Coursera: Decentralized Applications (Ethereum DApps) By University at Buffalo (SUNY) & ConsenSys

## IN-SEMESTER ASSESSMENT (50 MARKS)

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

#### *Suggested breakup of distribution*

- a. Assignment/Case study on live problem: 10 marks
- b. Article reading & summarization: 05 marks
- c. 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         |
| <b>Total</b> |      |             |                                                 | <b>14</b>                       | <b>10</b> | <b>--</b> | <b>14</b>        | <b>04</b> | <b>--</b> | <b>18</b> |

### 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        |
| <b>Total</b> |      |             |                                                 | <b>180</b>             | <b>120</b>   | <b>250</b>         | <b>--</b>                          | <b>--</b> | <b>550</b> |

| Course Type | Course Code | Course Name                                    | Credits |
|-------------|-------------|------------------------------------------------|---------|
| HMC         | HMCAV703    | AUGMENTED REALITY/VIRTUAL REALITY APPLICATIONS | 04      |

| 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
2. HMCAV501 Virtual Reality
3. HMCAV602 Augmented Reality & Mix Reality

**Program Outcomes addressed:**

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO5: Engineering Tool Usage
5. PO8: Individual and Collaborative Team work
6. PO9: Communication
7. PO11: Life-long learning

**Course Objectives:**

1. To apply user-cantered analysis to identify AR/VR design problems and define clear project objectives.
2. To refine AR/VR design concepts using ideation, prototyping, and visualization techniques aligned with user needs.
3. To integrate design fundamentals to create functional, usable, and effective AR/VR solutions
4. To evaluate and validate AR/VR applications systematically through testing, feedback, and iterative improvements to enhance user experience

| Module | Details                                                                                                                                                                                                                                                                                                                                                                                                                | Hrs.      |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|        | <p><b>Course Introduction</b></p> <p>This course introduces students to the complete AR/VR design thinking process from understanding user needs through empathy to ideating, prototyping, and evaluating immersive interactions. Through hands-on exploration of use cases, usability principles, and user-testing methods, learners develop the ability to design, test, and refine effective AR/VR experiences.</p> | <b>01</b> |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |      |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 01. | <p><b>Introduction to the Design Thinking Process:</b></p> <p><i>Learning Objective:</i></p> <p><i>Apply empathy-based techniques to identify user needs, constraints, and problem contexts for AR/VR application design.</i></p> <hr/> <p><b>Contents:</b></p> <p>Empathy, Human- and life-centered design approach, Need finding, Problem context, User personas, Observation of context, Talking to users, Identifying constraints, Formulating the problem statement</p> <hr/> <p><i>Self-Learning Topics: How global products use user personas to shape immersive experiences.</i></p> <hr/> <p><b>Learning Outcomes:</b></p> <p>A learner will be able to</p> <p><i>LO 1.1: Apply structured need-analysis techniques to decode user observations and derive measurable AR/VR design parameters. (P.I-1.1.1)</i></p> <p><i>LO 1.2: Apply design fundamentals to interpret user constraints and contextual factors when framing an AR/VR design problem. (P.I-1.3.1)</i></p> <p><i>LO 1.3: Evaluate preliminary AR/VR problem statements emerging from empathy studies and identify clear design objectives. (P.I-2.1.1)</i></p> <p><i>LO 1.4: Identify user processes, interactions, and environmental parameters required to formulate an accurate AR/VR problem definition. (P.I-2.1.2)</i></p>                                                              | 8-10 |
| 02. | <p><b>Ideation and Creative Thinking for AR/VR:</b></p> <p><i>Learning Objective:</i></p> <p><i>Generate, visualize, and synthesize diverse AR/VR design ideas using collaborative ideation and medium-specific evaluation techniques.</i></p> <hr/> <p><b>Contents:</b></p> <p>Ideation techniques, Mind maps, thinking visually, Collaborative ideation (whiteboards, Google Jamboard, Mural, Miro, etc.), Synthesis of ideas, Evaluating ideas from the perspective of the AR/VR medium</p> <hr/> <p><i>Self-Learning Topics: Exploring advanced online tools like Miro/Mural for creative design workflows.</i></p> <hr/> <p><b>Learning Outcomes:</b></p> <p>A learner will be able to</p> <p><i>LO 2.1: Apply structured techniques such as mind maps and visual thinking models to organize idea components and support AR/VR concept generation. (P.I-1.1.1)</i></p> <p><i>LO 2.2: Apply AR/VR ideation knowledge to evaluate feasibility of AR/VR ideas based on medium constraints. (P.I-1.4.1)</i></p> <p><i>LO 2.3: Reframe ideated AR/VR concepts into meaningful subsystems using synthesis of ideas from collaborative white boarding sessions. (P.I-2.2.1)</i></p> <p><i>LO 2.4: Compare and contrast multiple AR/VR ideation alternatives to select the most suitable approach based on functional and medium-specific criteria. (P.I-2.2.4)</i></p> | 9-11 |
| 03. | <p><b>Use Cases and Concept Definition:</b></p> <p><i>Learning Objective:</i></p> <p><i>Structure AR/VR use cases aligned with user needs and translate them into clear conceptual storyboards.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 9-11 |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |      |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|     | <p><b>Contents:</b></p> <p>Identifying and defining use cases, Summarizing ideas into key use cases, Aligning use cases with user needs and constraints, Storyboarding for AR/VR concepts</p> <p><b>Self-Learning Topics:</b> <i>Studying real AR/VR product storyboards and how they guide development.</i></p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p><b>LO 3.1:</b> Identify the key functionalities and computing resources required for AR/VR use cases derived from user needs. (P.I-2.2.2)</p> <p><b>LO 3.2:</b> Analyze multiple use-case alternatives and arrive at justified conclusions regarding their suitability for the AR/VR design objectives. (P.I-2.4.4)</p> <p><b>LO 3.3:</b> Define precise AR/VR use-case problem statements with clearly articulated objectives and scope aligned to user needs. (P.I-3.1.1)</p> <p><b>LO 3.4:</b> Produce a variety of potential AR/VR use-case storyboards that address functional requirements identified during synthesis. (P.I-3.2.2)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |
| 04. | <p><b>Prototyping for AR/VR Experiences:</b></p> <p><b>Learning Objectives:</b></p> <p><i>Create low- to high-fidelity AR/VR prototypes to model key interactions and validate early design decisions.</i></p> <p><b>Contents:</b></p> <p>Introduction to prototypes (low to high fidelity), Importance of prototyping, Paper prototypes, Physical prototypes, Digital prototypes, Prototyping key use cases</p> <p><b>Self-Learning Topics:</b> <i>Hands-on exploration of popular prototyping tools like Figma, Unity Mockups, or Tilt Brush.</i></p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p><b>LO 4.1:</b> Identify the functionalities and computing resources needed to construct appropriate low-, medium-, and high-fidelity AR/VR prototypes. (P.I-2.2.2)</p> <p><b>LO 4.2:</b> Apply engineering mathematics and structured procedures to implement prototype versions of key AR/VR use cases. (P.I-2.4.1)</p> <p><b>LO 4.3:</b> Refine AR/VR prototype architecture into a detailed low- to high-fidelity design within given constraints. (P.I-3.4.1)</p> <p><b>LO 4.4:</b> Prototype components (paper, physical, and digital etc) to model key AR/VR use-case interactions. (P.I-3.4.2)</p> <p><b>LO 4.5:</b> Apply structured prototyping processes to develop and refine a real-world AR/VR use case, while collaborating effectively as a team and communicating prototype outcomes through clear and professional presentations. (P.I-2.3.1, 8.2.1, 8.3.1, 9.2.2, 9.3.2)</p> | 9-11 |
| 05. | <p><b>Interaction Design and Usability Evaluation:</b></p> <p><b>Learning Objective/s:</b></p> <p><i>Apply usability principles and AR/VR interaction guidelines to systematically evaluate and refine user experience quality.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 9-11 |

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|              | <p><b>Contents:</b></p> <p>Usability principles, Usefulness and user experience considerations, Guidelines for interaction development (AR/VR specific), Evaluating usability against currently known guidelines</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |
|              | <p><b>Self-Learning Topics: Reviewing Nielsen's Usability Heuristics adapted for immersive technologies.</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |
|              | <p><b>Learning Outcomes :</b></p> <p>A learner will be able to</p> <p><b>LO 5.1:</b> Apply design fundamentals to interpret usability principles and assess the usefulness of AR/VR interactions. (P.I-1.3.1)</p> <p><b>LO 5.2:</b> Apply AR/VR interaction knowledge to evaluate user experience considerations in immersive environments. (P.I-1.4.1)</p> <p><b>LO 5.3:</b> Analyze user experience and usability metrics using appropriate tools to interpret AR/VR interaction performance. (P.I-2.4.2)</p> <p><b>LO 5.4:</b> Identify usability limitations and sources of performance issues in AR/VR interaction designs based on guideline-based evaluations. (P.I-2.4.3)</p>                                                                                                                                                                                                                                                                                                                                                                                                |           |
| 06.          | <p><b>User Testing and Design Critiques:</b></p> <p><b>Learning Objective/s:</b></p> <p><i>Conduct structured user-testing sessions, analyze feedback, and refine AR/VR designs through informed critiques.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 9-11      |
|              | <p><b>Contents:</b></p> <p>Collecting user feedback on prototypes, Think-Aloud protocol, Testing key use cases, Analyzing user testing insights, Conducting and receiving design critiques</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |
|              | <p><b>Self-Learning Topics: Think-Aloud protocol</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |
|              | <p><b>Learning Outcomes:</b></p> <p>A learner will be able to</p> <p><b>LO 6.1:</b> Analyze user testing data gathered through Think-Aloud sessions using appropriate tools to interpret performance and behavioral patterns. (P.I-2.4.2)</p> <p><b>LO 6.2:</b> Identify usability limitations and sources of errors by examining user feedback collected from testing key AR/VR use cases. (P.I-2.4.3)</p> <p><b>LO 6.3:</b> Perform systematic evaluation of tested AR/VR interaction concepts to determine which designs best meet user performance and comfort criteria. (P.I-3.3.1)</p> <p><b>LO 6.4:</b> Verify and validate AR/VR prototype functionalities by comparing test outcomes with defined design specifications and user expectations. (P.I-3.4.3)</p> <p><b>LO 6.5:</b> Apply structured user-testing methods using appropriate AR/VR evaluation tools to assess prototype performance, while collaborating effectively as a team and communicating insights through presentations and design critiques. (P.I-2.3.1, 5.1.2, 5.2.2, 8.2.1, 8.3.1, 9.2.2, 9.3.2)</p> |           |
|              | <p><b>Course Conclusion</b></p> <p>This course equips students with user-centered design thinking skills to conceptualize and prototype effective AR/VR applications. Through structured ideation, use-case definition, usability evaluation, and user-testing methods, learners refine and validate immersive interaction designs. By the end, students can collaboratively develop, critique, and communicate AR/VR solutions that address real-world needs.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 01        |
| <b>Total</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>60</b> |

### Performance Indicators:

| <u>P.I. No.</u> | <u>P.I. Statement</u>                                                                                                       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------|
| 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                             |
| 2.1.1           | 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                                                            |
| 2.2.2           | 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. |
| 2.4.1           | Applies engineering mathematics to implement the solution.                                                                  |
| 2.4.2           | Analyse and interpret the results using contemporary tools.                                                                 |
| 2.4.3           | Identify the limitations of the solution and sources/causes.                                                                |
| 2.4.4           | Arrive at conclusions with respect to the objectives.                                                                       |
| 3.1.1           | Able to define a precise problem statement with objectives and scope.                                                       |
| 3.2.2           | Able to produce a variety of potential design solutions suited to meet functional requirements.                             |
| 3.3.1           | Able to perform systematic evaluation of the degree to which several design concepts meet the criteria.                     |
| 3.4.2           | Able to implement and integrate the modules.                                                                                |
| 3.4.1           | Able to refine architecture design into a detailed design within the existing constraints.                                  |
| 3.4.3           | Able to verify the functionalities and validate the design.                                                                 |
| 6.3.2           | Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability            |
| 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                                      |
| 11.3.2          | Analyse sourced technical and popular information for feasibility, viability, sustainability, etc.                          |

**Course Outcomes:** A learner will be able to -

1. Apply empathy-driven analysis to interpret user needs, identify design objectives, and formulate clear AR/VR problem definitions. (*LO 1.1, LO 1.2, LO 1.3, LO 1.4*)
2. Analyse AR/VR design concepts using structured ideation and visual thinking techniques to select the most suitable solutions through collaborative tools. (*LO 2.1, LO 2.2, LO 2.3, LO 2.4*)
3. Design structured AR/VR use-case solutions by translating user needs into functional requirements and developing clear conceptual storyboards that guide further design. (*LO 3.1, LO 3.2, LO 3.3, LO 3.4*)
4. Apply structured prototyping methods to design, integrate, and refine low- to high-fidelity AR/VR solutions using appropriate tools while effectively collaborating and communicating outcomes. (*LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5*)
5. Analyse AR/VR interaction designs by applying usability principles, engineering fundamentals, and user experience assessment methods. (*LO 5.1, LO 5.2, LO 5.3, LO 5.4*)

- Design improved AR/VR solutions by conducting structured user testing, validating prototype performance, and integrating collaboratively communicated critique insights into iterative redesign. (LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5)

#### CO-PO Mapping Table with Correlation Level

| CO ID          | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| HMCAV703.1     | 3   | 3   | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAV703.2     | 3   | 3   | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAV703.3     | --  | 3   | 3   | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAV703.4     | --  | 3   | 3   | --  | --  | 3   | --  | 3   | 3   | --   | --   |
| HMCAV703.5     | 3   | 3   | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAV703.6     | --  | 3   | 3   | --  | --  | 3   | --  | 3   | 3   | --   | --   |
| <b>Average</b> | 3   | 3   | 3   | --  | --  | 3   | --  | 3   | 3   | --   | --   |

#### Text Books :

- Thomas Lockwood Design Thinking: Integrating Innovation, Customer Experience, and Brand, Allworth Press, ISBN-13 978-1581156683
- Don Norman, THE DESIGN OF EVERYDAY THINGS, BASIC BOOKS, 1st Edition, ISBN 978- 0465055715

#### Reference Books :

- Gershenfeld, N., Gershenfeld, A., & Cutcher-Gershenfeld, J. (2017). Designing reality: How to survive and thrive in the third digital revolution. Basic Books.
- Bartle, R. (2003). Designing virtual worlds. New Riders
- Nite, S. (2016). Virtual reality insider: Guidebook for the VR industry. Sky Nite.
- Jerald, J. (2015). The VR book: Human-centered design for virtual reality. Morgan & Claypool..

#### IN-SEMESTER ASSESSMENT (75 MARKS)

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

*Suggested breakup of distribution*

Assignment on live problem :10 marks

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

Regularity and active participation: 05 Marks

##### 1. 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 |
|-------------|-------------|----------------------------------------------|---------|
| HML         | HMLAV701    | AUGMENTED REALITY/VIRTUAL REALITY LABORATORY | 02      |

| Examination Scheme    |                                |       |
|-----------------------|--------------------------------|-------|
| Continuous Assessment | End Semester Examination (ESE) | Total |
| 50                    | --                             | 50    |

**Pre-requisite:**

1. CEPEC5013 Computer Graphics and Animation
2. HMCAV501 Virtual Reality
3. HMCAV602 Augmented Reality & Mix Reality

**Program Outcomes addressed:**

1. PO1: Engineering knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct investigations of complex problems
5. PO5: Modern tool usage
6. PO6: The Engineer and The World
7. PO7: Ethics
8. PO8: Individual and Collaborative Team work
9. PO9: Communication
10. PO10: Project management and finance
11. PO11: Life-long learning

**Course Objectives:**

1. To learn the setup and use of AR/VR development tools and frameworks for creating immersive applications.
2. To apply tracking, interaction, and user interface techniques in augmented and virtual reality environments.
3. To develop skills in designing, implementing, and evaluating immersive AR/VR systems considering usability, performance, and real-world application contexts.
4. To build practical competence in optimizing, deploying, and presenting immersive applications through collaborative, ethical, and project-oriented development practices.

| Module | Detailed Contents                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Hrs |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|        | <p><b>Course Introduction</b></p> <p>This laboratory course provides hands-on experience in developing Augmented Reality (AR) and Virtual Reality (VR) applications using modern immersive technologies. Students learn to design, implement, and evaluate interactive AR/VR systems by working on tracking, interaction design, immersive environment creation, performance optimization, and deployment. The course emphasizes practical problem-solving, usability, ethical considerations, and teamwork while building applications for real-world domains such as education, training, and visualization.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1   |
| 01.    | <p><b>Augmented Reality (AR) Foundations and Tracking</b></p> <p><b>Learning Objective:</b><br/>To apply AR development tools and tracking techniques for building marker-based and marker less augmented reality applications</p> <hr/> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• AR development workflow</li> <li>• Unity project setup for AR</li> <li>• AR SDK integration</li> <li>• Marker-based tracking</li> <li>• Marker less plane detection</li> </ul> <p>Task 1: Load and Configure the AR development environment in Unity by integrating required AR SDKs, managing project dependencies, validating platform compatibility, and examining practical contexts where AR solutions may be applied effectively.</p> <p><b>Learning Outcome:</b><br/>A learner will be able to</p> <p><i>LO 1.1: Configure and apply AR development tools to establish a functional project environment by integrating SDKs, organizing project architecture, validating platform compatibility, and recognizing real-world application contexts of AR systems. (P.I. – 1.4.1, 2.2.2, 3.4.1, 4.1.2, 5.1.1, 6.1.1)</i></p> <p>Task 2: Develop an AR application that performs marker-based detection and marker less plane tracking to place virtual objects for a practical scenario (e.g., visualization, instruction, or guidance) and evaluate tracking reliability under real environmental conditions.</p> <p><b>Learning Outcome:</b><br/>A learner will be able to</p> <p><i>LO 1.2: Design and implement AR tracking solutions using marker-based and marker less techniques by analysing spatial data, anchoring virtual objects, evaluating tracking performance through testing, and assessing the suitability of AR solutions in practical user contexts. (P.I. – 1.3.1, 2.3.1, 3.2.1, 4.2.1, 5.2.2, 6.3.1)</i></p> | 11  |
| 02.    | <p><b>Augmented Reality (AR) Interaction and Application Design:</b></p> <p><b>Learning Objective:</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 16  |

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|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
|     | <p><i>To apply interaction techniques and interface design principles for developing usable and problem-oriented augmented reality applications.</i></p> <hr/> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• Gesture-based interaction in AR</li> <li>• AR user interface integration</li> <li>• Event-driven object behavior</li> <li>• Context-aware AR application design</li> <li>• Usability and interaction testing</li> </ul> <p>Task 3: Implement gesture-based interaction (tap, drag, rotate, scale) to control virtual objects in an AR environment and verify interaction responsiveness.</p> <p><b>Learning Outcome:</b><br/>A learner will be able to</p> <p><i>LO 2.1: Apply gesture-based interaction techniques to design responsive AR object behaviour by analysing user input mechanisms, testing interaction accuracy, and evaluating usability of interaction models.<br/>(P.I. – 2.1.2, 3.2.1, 4.2.1, 5.2.2, 6.1.1)</i></p> <p>Task 4: Integrate AR user interface (UI) elements such as buttons, instructions, or overlays to guide user interaction and improve accessibility and clarity of system operation.</p> <p><b>Learning Outcome:</b><br/>A learner will be able to</p> <p><i>LO 2.2: Design and implement AR user interface components by organizing interaction flow, integrating interface elements, testing usability, documenting interface design decisions, and considering ethical and collaborative development practices.<br/>(P.I. – 2.2.2, 3.4.2, 4.1.2, 5.1.1, 7.2.2, 8.1.1, 9.1.2)</i></p> <p>Task 5: Develop a problem-oriented AR application (education, maintenance, navigation, etc.) in teams by combining interaction, UI, and contextual feedback, ensuring ethical usage considerations and presenting the solution.</p> <p><b>Learning Outcome:</b><br/>A learner will be able to</p> <p><i>LO 2.3: Design and implement a domain-specific AR application by analysing requirements, integrating interactive modules, evaluating system performance, applying ethical considerations in AR usage, collaborating effectively in teams, and presenting the developed solution.<br/>(P.I. – 2.3.1, 3.3.1, 4.3.1, 5.2.2, 6.3.1, 7.1.1, 8.3.1, 9.2.2)</i></p> |    |
| 03. | <p><b>VR Foundations: Environment Creation, Interaction and Domain Application</b></p> <p><b>Learning Objective:</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 16 |

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|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
|     | <p><i>To apply virtual reality development techniques for creating immersive environments, implementing interaction mechanisms, evaluating system performance, and communicating usability aspects of VR systems.</i></p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• VR project setup and hardware configuration</li> <li>• Scene creation with lighting and physics</li> <li>• VR locomotion and controller-based interaction</li> <li>• VR usability and comfort considerations</li> <li>• Performance testing and evaluation</li> </ul> <p>Task 6: Configure a VR project environment in Unity and create an immersive 3D virtual scene with appropriate lighting, textures, and physics components.</p> <p><b>Learning Outcome:</b><br/>A learner will be able to</p> <p><i>LO 3.1:Configure and apply VR development tools to construct an immersive virtual environment by organizing scene elements, integrating hardware support, testing rendering stability, and documenting system configuration.</i><br/>(P.I. – 1.4.1, 2.2.2, 3.4.1, 4.1.2, 5.1.1, 9.1.2)</p> <p>Task 7: Implement VR navigation techniques such as teleportation or smooth locomotion and develop controller-based object interaction while analysing usability, user comfort, and accessibility</p> <p><b>Learning Outcome:</b><br/>A learner will be able to</p> <p><i>LO 3.2:Apply VR locomotion and interaction techniques to design navigation and object manipulation systems, analyze usability and user comfort factors, test interaction responsiveness, and document interaction design decisions.</i><br/>(P.I. – 2.1.2, 3.2.2, 4.2.1, 5.2.2, 6.1.1, 9.1.2)</p> <p>Task 8: Evaluate VR system performance by analysing frame rate, interaction latency, rendering behaviour, and potential user discomfort issues, and apply optimization strategies to improve system effectiveness. Present findings.</p> <p><b>Learning Outcome:</b><br/>A learner will be able to</p> <p><i>LO 3.3:Analyze VR system performance using appropriate evaluation methods, implement optimization strategies, assess user comfort and practical usability, and communicate system performance findings through structured reporting.</i><br/>(P.I. – 1.3.1, 2.4.2, 3.3.1, 4.3.1, 5.3.1, 6.3.1, 9.3.2)</p> |    |
| 04. | <p><b>Advanced VR Interaction, Optimization and Deployment</b></p> <p><b>Learning Objective:</b><br/><i>To apply advanced VR interaction techniques, evaluate and optimize system performance, manage development activities, and communicate technical outcomes effectively.</i></p> <p><b>Contents:</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 16 |

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|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|  | <ul style="list-style-type: none"> <li>• Advanced controller and hand-based interaction</li> <li>• World-space VR UI design</li> <li>• Performance optimization techniques</li> <li>• Usability and motion comfort evaluation</li> <li>• VR application build, deployment, and presentation</li> </ul> <p>Task 9: Implement advanced VR interaction mechanisms such as hand/controller-based actions and world-space UI elements to enhance user engagement and system usability.</p> <p><b>Learning Outcome:</b></p> <p><i>A learner will be able to</i></p> <p><i>LO 4.1: Design and implement advanced VR interaction systems by integrating input mechanisms, organizing immersive UI components, analyzing usability factors, testing functional performance, collaborating in development tasks, considering ethical use of immersive systems, and planning development activities.</i><br/>(P.I. – 2.1.2, 3.2.2, 4.2.1, 5.2.2, 6.1.1, 7.2.2, 8.1.1, 10.3.1)</p> <p>Task 10: Analyze and optimize the VR application by evaluating frame rate, rendering efficiency, interaction latency, user comfort, and ethical considerations, and document performance improvements</p> <p><b>Learning Outcome:</b></p> <p><i>A learner will be able to</i></p> <p><i>LO 4.2: Analyze VR system performance using evaluation methods, implement optimization strategies, assess user comfort and ethical usage aspects, and document performance findings using structured engineering reports.</i><br/>(P.I. – 2.4.2, 3.3.1, 4.3.1, 5.3.1, 6.3.1, 7.1.1, 9.1.2)</p> <p>Task 11: Plan, build, and deploy the VR application in teams, manage development tasks within constraints, explore new SDK features when required, and present the application workflow and results.</p> <p><b>Learning Outcome:</b></p> <p><i>A learner will be able to</i></p> <p><i>LO 4.3:</i><br/><i>Plan and manage VR application development by organizing project tasks, adapting to new tools or SDK updates, validating system functionality, collaborating effectively in teams, and communicating technical outcomes through structured presentation and demonstration.</i><br/>(P.I. – 2.2.2, 3.4.2, 4.1.2, 5.1.1, 8.3.1, 9.3.2, 10.3.1, 11.1.2)</p> |           |
|  | <b>Total Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>60</b> |

### **Performance Indicators:**

| <b>P.I. No.</b> | <b>P.I. Statement</b>                                                                                                                                             |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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                                                                |
| 2.2.2           | Identify functionalities and computing resources                                                                                                                  |
| 2.3.1           | Able to apply computer engineering principles to formulate modules of a system with required applicability and performance                                        |
| 2.4.2           | Analyze and interpret the results using contemporary tools                                                                                                        |
| 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                                                                    |
| 3.3.1           | Able to perform systematic evaluation of the degree to which several design concepts meet the criteria                                                            |
| 3.4.1           | Able to refine architecture design into a detailed design within the existing constraints                                                                         |
| 3.4.2           | Able to implement and integrate the modules                                                                                                                       |
| 4.1.2           | Able to choose appropriate procedure/algorithm, dataset and test cases                                                                                            |
| 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                                                                                      |
| 5.1.1           | Identify modern engineering tools, techniques and resources for engineering activities                                                                            |
| 5.2.2           | Demonstrate proficiency in using discipline-specific tools                                                                                                        |
| 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                                                                                    |
| 7.1.1           | Identify situations of unethical professional conduct and propose ethical alternatives                                                                            |
| 7.2.2           | Examine and apply moral & ethical principles to known case studies                                                                                                |
| 8.1.1           | Recognize a variety of working and learning preferences; appreciate the value of diversity on a team                                                              |
| 8.3.1           | Present results as a team, with smooth integration of contributions from all individual efforts                                                                   |
| 9.1.2           | Produce clear, well-constructed, and well-supported written engineering documents                                                                                 |
| 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                                                                            |
| 10.3.1          | Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks                                                 |
| 11.1.2          | Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap                                                     |

**Course Outcomes (COs):** Learner will be able to:

1. Configure AR development environments and design augmented reality applications using marker-based and marker less tracking techniques by analysing system requirements, implementing tracking solutions, evaluating performance, and recognizing practical application contexts of AR systems. ( LOs: 1.1, 1.2)
2. Design and implement interactive augmented reality applications by applying gesture-based interaction techniques, integrating user interface components, analysing system behaviour, evaluating usability, incorporating ethical and societal considerations, collaborating in teams, and communicating application outcomes effectively. ( LOs: 2.1, 2.2, 2.3)
3. Develop immersive virtual reality environments by configuring VR systems, implementing navigation and interaction mechanisms, analysing usability and user comfort, evaluating system performance, and communicating technical findings effectively. ( LOs: 3.1, 3.2, 3.3)
4. Design, optimize, and deploy advanced virtual reality applications by implementing immersive interaction techniques, evaluating and improving system performance, considering usability and ethical aspects, managing development activities, and communicating technical outcomes effectively. (LOs: 4.1, 4.2, 4.3)

**CO-PO Mapping Table with Correlation Level**

| CO ID     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| CELC609.1 | 3   | 3   | 3   | 3   | 3   | 3   | --  | --  | --  | --   | --   |
| CELC609.2 | --  | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | --   | --   |
| CELC609.3 | 3   | 3   | 3   | 3   | 3   | 3   | --  | --  | 3   | --   | --   |
| CELC609.4 | --  | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3    | 3    |
| Average   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3    | 3    |

**Text Books:**

1. Steve Aukstakalnis, “Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR”, Addison-Wesley Professional, September 2016,
2. Allan Fowler, William Sherif, “Beginning iOS AR Game Development: Developing Augmented Reality Apps with Unity and C#”, 1st Edition, Apress Publications, 2018

3. Steven M. LaValle, “Virtual Reality”, Cambridge University Press, 2016
4. William R Sherman and Alan B Craig, “Understanding Virtual Reality: Interface, Application and Design”, Morgan Kaufmann Publishers, San Francisco, CA, 2002
5. Alan B Craig, William R Sherman and Jeffrey D Will, “Developing Virtual Reality Applications: Foundations of Effective Design”, Morgan Kaufmann, 2009.
6. Allan Fowler, “AR Game Development”, 1st Edition, A press Publications, 2018.
7. Schmalstieg / Hollerer, “Augmented Reality: Principles & Practice” by, Pearson Education India; First edition 2016.

**Reference Books:**

1. Jesse Glover, Jonathan Linowes, “Complete Virtual Reality and Augmented Reality Development with Unity: Leverage the power of Unity and become a pro at creating mixed reality applications”, Packt publishing, 2019.
2. Jonathan Linowes, Krystian Babilinski, “Augmented Reality for Developers: Build practical augmented reality applications with Unity”, Packt Publishing, 2017.

**A. IN-SEMESTER ASSESSMENT (50 MARKS)**

*Suggested breakup of distribution*

- a) Task Evaluation: 20 Marks
- b) Guided Project Evaluation: 20 marks
- c) Regularity & Active participation: 10 Marks

**B. END SEMESTER EXAMINATION** –No end semester examination.

| Course Type | Course Code | Course Name                           | Credits |
|-------------|-------------|---------------------------------------|---------|
| HMC         | HMCAV804    | GAME DEVELOPMENT WITH VIRTUAL REALITY | 04      |

| 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. HMCAV501 Virtual Reality
2. HMCAV602 Augmented Reality & Mix Reality
3. HMCAV703 Augmented Reality/Virtual Reality Applications

**Program Outcomes addressed:**

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO6: The Engineer and The World
4. PO8: Individual and Collaborative Team work
5. PO9: Communication

**Course Objectives:**

1. To introduce the visual, tracking, and rendering foundations required to understand and build high-quality VR game environments.
2. To develop the ability to design VR game interactions, locomotion systems, and user experiences grounded in XR interaction principles.
3. To enable students to create optimized 3D assets, prototype VR environments, and integrate them using modern development pipelines
4. To enable students in applying user testing, HCI principles, and evaluation methods to refine VR gameplay and improve immersive experience quality

| Module     | Details                                                                                                                                                                                                                                                                                                                             | Hrs.      |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|            | <b>Course Introduction</b><br>This course provides a comprehensive foundation in VR game development, covering HMD optics, tracking, rendering, modeling, interaction, and user evaluation techniques. Students learn to design, build, and assess immersive VR experiences using current advancements and industry best practices. | <b>01</b> |
| <b>01.</b> | <b>Head Mounted Display, Optics and Visual Foundations:</b>                                                                                                                                                                                                                                                                         |           |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |             |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
|     | <p><b>Learning Objective:</b><br/>To familiarize VR optical principles and analyze how HMD components—such as lenses, FOV, stereo rendering, and display technologies—shape image quality and user immersion.</p> <p><b>Contents:</b><br/>the visual principles behind VR headsets, including HMD optics, stereo rendering, field of view, and lens distortion correction. micro-display technologies, focus cues, the vergence–accommodation conflict, and emerging display systems such as varifocal and optical see-through AR displays</p> <p><b>Self-Learning Topics: Advances in varifocal and light-field displays used in next-generation headsets (Meta Quest Pro, Apple Vision Pro)</b></p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p><b>LO 1.1:</b> Apply VR principals to interpret how optical components such as lenses, field of view, and stereo rendering affect image formation in HMDs. (P.I–1.3.1)</p> <p><b>LO 1.2:</b> Apply design principals to analyze micro-display technologies and focus cue mechanisms used in VR/AR headsets. (P.I–1.4.1)</p> <p><b>LO 1.3:</b> Evaluate visual limitations and optical challenges—such as lens distortion or vergence–accommodation conflict—to identify key performance objectives for HMD design. (P.I–2.1.1)</p> <p><b>LO 1.4:</b> Identify critical optical and display-related parameters that influence VR/AR viewing performance, including focus cues, distortion behavior, and user visual field characteristics. (P.I–2.1.2)</p>                                               | <b>8-10</b> |
| 02. | <p><b>Tracking Technologies and Navigation Systems:</b></p> <p><b>Learning Objective:</b><br/>To study VR tracking methods by applying tracking parameters such as latency, drift, and precision to determine suitable navigation approaches for immersive gameplay.</p> <p><b>Contents:</b><br/>fundamentals of position and motion tracking in VR, comparing inside-out and outside-in approaches, optical and inertial trackers, and hybrid systems. depth sensing, camera-based tracking, SLAM, and review tracking specifications of modern commercial VR systems.</p> <p><b>Self-Learning Topics: Latest developments in inside-out SLAM tracking and depth-sensing technologies used in modern VR/AR systems</b></p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p><b>LO 2.1:</b> Apply Tracking Techniques to interpret how position and motion tracking technologies operate in VR systems, including optical, inertial, and hybrid trackers. (P.I–1.3.1)</p> <p><b>LO 2.2:</b> Apply position and motion tracking knowledge to analyze the performance behavior of inside-out tracking, SLAM algorithms, and depth sensing in VR navigation. (P.I–1.4.1)</p> <p><b>LO 2.3:</b> Identify key technical parameters—such as latency, drift, update rate, and precision—that impact the accuracy and reliability of VR tracking systems. (P.I–2.1.2)</p> <p><b>LO 2.4:</b> Analyze multiple VR tracking and navigation approaches to arrive at justified conclusions regarding their suitability for different gameplay environments. (P.I–2.4.4)</p> | <b>9-11</b> |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |      |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 03. | <p><b>Real-Time Rendering and Performance Pipelines:</b></p> <p><b>Learning Objective:</b></p> <p><i>To introduce rendering and optimization techniques to evaluate VR graphics pipelines and determine performance-critical strategies for real-time game experiences</i></p> <p><b>Contents:</b></p> <p>GPUs and rendering APIs support VR, along with key optimization methods such as foveated rendering and re projection. The module explores VR/AR/MR development pipelines in Unity and Unreal, distributed rendering architectures, multi-pipeline synchronization, and spatial audio integration.</p> <p><b>Self-Learning Topics:</b> <i>Exploring foveated rendering and eye-tracked rendering pipelines supported in modern VR engines (Unreal 5, Unity HDRP).</i></p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p><b>LO 3.1:</b> <i>Apply VR fundamentals to interpret how GPU architectures and rendering pipelines generate real-time VR graphics. (P.I–1.3.1)</i></p> <p><b>LO 3.2:</b> <i>Apply optimization methods to analyze rendering APIs and VR optimization techniques such as foveated rendering and re projection. (P.I–1.4.1)</i></p> <p><b>LO 3.3:</b> <i>Identify the functional components and computing resources required for XR development pipelines, including distributed rendering and multi-pipeline synchronization. (P.I–2.2.2)</i></p> <p><b>LO 3.4:</b> <i>Analyze different VR/AR/MR rendering workflows to arrive at conclusions about their suitability for performance-critical game scenarios. (P.I–2.4.4)</i></p>                 | 9-11 |
| 04. | <p><b>Modeling and World-Building for VR Games:</b></p> <p><b>Learning Objectives:</b></p> <p><i>To familiarize VR-specific modeling and world-building methods to create optimized assets and structured environments that support performance-efficient immersive gameplay.</i></p> <p><b>Contents:</b></p> <p>3D assets for VR, covering VR-specific modeling constraints, LOD strategies, and environment design workflows. Students explore lighting approaches, world-building techniques, and performance-aware asset creation to support immersive VR game spaces.</p> <p><b>Self-Learning Topics:</b> <i>AI-assisted 3D asset generation and procedural world-building tools (e.g., NVIDIA Omni verse, Unreal Procedural Modeling)</i></p> <p><b>Learning Outcomes:</b><br/>A learner will be able to</p> <p><b>LO 4.1:</b> <i>Apply VR fundamentals to interpret how VR modeling constraints such as scale, polygon limits, and scene complexity influence world-building. (P.I–1.3.1)</i></p> <p><b>LO 4.2:</b> <i>Apply VR gaming knowledge to analyze optimization techniques—such as LOD strategies and asset efficiency—used in VR game environments. (P.I–1.4.1)</i></p> <p><b>LO 4.3:</b> <i>Identify the functional elements and computing resources required for VR world-building, including asset workflows, lighting choices, and environment composition. (P.I–2.2.2)</i></p> <p><b>LO 4.4:</b> <i>Analyze different VR modeling and world-building approaches to conclude which methods best maintain performance while achieving immersive visual quality. (P.I–2.4.4)</i></p> | 9-11 |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |      |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
|     | <p><i>LO 4.5: Apply structured modeling and world-building processes to develop a VR game environment for a real use case, while identifying user and lifecycle impacts and communicating design outcomes collaboratively through clear oral and visual presentations. (P.I–2.3.1, 6.3.1, 6.3.2, 8.2.1, 8.3.1, 9.2.2, 9.3.2)</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |      |
| 05. | <p><b>Interaction and Gameplay Engineering in XR:</b></p> <p><b>Learning Objective/s:</b><br/> <i>To study XR interaction techniques—including locomotion, manipulation, and spatial UI—to select and refine gameplay interactions that maximize user comfort and engagement..</i></p> <p><b>Contents:</b><br/>           XR interaction concepts, motor programs, locomotion techniques, and manipulation methods used in VR games. spatial UI, holographic elements, mixed-reality interactions, social gameplay considerations, and narrative design to craft engaging XR experiences.</p> <p><b>Self-Learning Topics: Current XR interaction toolkits (Unity XR Interaction Toolkit, Open XR interaction profiles) and their evolving capabilities.</b></p> <p><b>Learning Outcomes :</b><br/> <i>A learner will be able to</i></p> <p><b>LO 5.1:</b> Apply XR interaction concepts to interpret how locomotion, manipulation, and interaction mechanisms function within XR gameplay environments. (P.I–1.3.1)</p> <p><b>LO 5.2:</b> Apply AR/VR interaction knowledge to analyze usability implications of XR interaction methods such as remapping, motor programs, and spatial UI. (P.I–1.4.1)</p> <p><b>LO 5.3:</b> Identify key interaction parameters—such as comfort, motion cues, and spatial constraints—that influence user performance in XR gameplay. (P.I–2.1.2)</p> <p><b>LO 5.4:</b> Analyze different XR interaction and locomotion approaches to arrive at justified conclusions about their suitability for specific gameplay scenarios. (P.I–2.4.4)</p> | 9-11 |
| 06. | <p><b>Human Computer Interaction and Evaluation of VR Experiences:</b></p> <p><b>Learning Objective/s:</b><br/> <i>To study structured VR evaluation and user-testing methods to analyze usability issues, validate prototype performance, and iteratively refine immersive experiences.</i></p> <p><b>Contents:</b><br/>           human factors, usability evaluation, comfort and presence metrics, and standard user-testing methods for VR. analyzing gameplay interactions, assessing accessibility and ethics, and applying iterative testing–feedback–refinement cycles to improve VR game experiences.</p> <p><b>Self-Learning Topics: Emerging VR HCI evaluation frameworks, including presence and comfort metrics used in industry-grade VR testing</b></p> <p><b>Learning Outcomes:</b><br/> <i>A learner will be able to</i></p> <p><b>LO 6.1:</b> Apply Human Computer Interaction fundamentals to interpret human–computer interaction factors such as comfort, presence, and usability when evaluating VR user experiences. (P.I–1.3.1)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 9-11 |

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|              | <p><b>LO 6.2:</b> Apply VR experiences knowledge to explain how user-testing methods like Think-Aloud and behavioral observation support VR experience evaluation. (P.I-1.4.1)</p> <p><b>LO 6.3:</b> Analyze VR user-testing data using appropriate evaluation tools to interpret interaction quality, usability issues, and user-experience patterns. (P.I-2.4.2)</p> <p><b>LO 6.4:</b> Identify performance limitations and usability problems in VR experiences by examining user feedback and testing outcomes from key use cases. (P.I-2.4.3)</p> <p><b>LO 6.5:</b> Apply structured user-testing methods to evaluate a VR experience for a real-world Societal scenario, while collaborating effectively as a team and communicating findings through clear oral and visual presentations. (P.I-2.3.1, 6.3.1, 6.3.2, 8.2.1, 8.3.1, 9.2.2, 9.3.2)</p> |           |
|              | <p><b>Course Conclusion</b></p> <p>By the end of this course, students will be able to analyse, design, and evaluate VR game systems through a complete development pipeline—from visual foundations and tracking to world-building, interaction, and user testing. They will be equipped to create immersive VR experiences that effectively integrate technical performance, gameplay design, and user-centered evaluation</p>                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>01</b> |
| <b>Total</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>60</b> |

Performance Indicators:

| <u>P.I. No.</u> | <u>P.I. Statement</u>                                                                                                       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------|
| 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                          |
| 2.2.2           | Identify functionalities and computing resources.                                                                           |
| 2.3.1           | Able to apply computer engineering principles to formulate modules of a system with required applicability and performance. |
| 2.4.3           | Identify the limitations of the solution and sources/causes.                                                                |
| 2.4.2           | Analyse and interpret the results using contemporary tools.                                                                 |
| 2.4.4           | Arrive at conclusions with respect to the objectives.                                                                       |
| 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            |
| 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 core VR display concepts to interpret optical behaviour, assess visual limitations, and identify key parameters that influence HMD image quality. (LO 1.1, LO 1.2, LO 1.3, LO 1.4)

2. Apply VR tracking concepts to understand system behaviour, identify essential performance parameters, and determine suitable tracking methods for VR navigation. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4)*
3. Analyse VR rendering workflows to interpret graphics behaviour, identify pipeline requirements, and evaluate rendering approaches for performance-critical game scenarios. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4)*
4. Apply modelling principles and optimization techniques to construct and evaluate VR game environments, integrating world-building processes for real use cases while collaboratively communicating outcomes and considering user and lifecycle impacts. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5)*
5. Analyse XR interaction principles to interpret gameplay mechanics, identify key user factors, and evaluate suitable interaction and locomotion methods for immersive experiences. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4)*
6. Apply user-testing and evaluation methods to assess VR experiences in real-world societal scenarios, interpreting testing outcomes, identifying usability issues, and collaboratively communicating findings through professional oral and visual presentations. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5)*

#### CO-PO Mapping Table with Correlation Level

| CO ID          | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| HMCAV804.1     | 3   | 3   | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAV804.2     | 3   | 3   | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAV804.3     | 3   | 3   | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAV804.4     | 3   | 3   | --  | --  | --  | 3   | --  | 3   | 3   | --   | --   |
| HMCAV804.5     | 3   | 3   | --  | --  | --  | --  | --  | --  | --  | --   | --   |
| HMCAV804.6     | 3   | 3   | --  | --  | --  | 3   | --  | 3   | 3   | --   | --   |
| <b>Average</b> | 3   | 3   | --  | --  | --  | 3   | --  | 3   | 3   | --   | --   |

#### Text Books :

1. Dieter Schmalstieg , Tobias Hollerer, Augmented Reality: Principles and Practice (Usability), 1st Edition, Addison-Wesley Professional
2. Sherman, William R. and Alan B. Craig. Understanding Virtual Reality – Interface, Application, and Design, Morgan Kaufmann, Morgan Kaufmann Publishers.

**Reference Books :**

1. Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. Springer
2. Furht, B., & Kaplantzis, S. (Eds.). (2019). Handbook of augmented reality. Springer
3. Kam, H. J., Mirza, F., & Li, J. (Eds.). (2020). Extended reality in education: Synthesis and perspectives. Springer.

**Other resources:**

1. NOC: Virtual Reality Engineering, <https://archive.nptel.ac.in/courses/121/106/121106013/>
2. Virtual Reality, <https://archive.nptel.ac.in/courses/106/106/106106138/>

**IN-SEMESTER ASSESSMENT (50 MARKS)****1. Continuous Assessment - Theory-(20 Marks)**

*Suggested breakup of distribution*

Assignment on live problem :10 marks

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

Regularity and active participation: 05 Marks

**1. 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.