M.TECH.
AUGMENTED REALITY AND VIRTUAL REALITY

CURRICULUM 2024-25

NATIONAL INSTITUTE OF TECHNICAL TEACHERS TRAINING AND RESEARCH CHENNAI
Deemed to be University under Distinct Category
A Centrally Funded Technical Institute
CSIR Road, Taramani, Chennai

NATIONAL INSTITUTE OF TECHNICAL TEACHERS TRAINING AND RESEARCH CHENNAI

Deemed to be University under Distinct Category – A Centrally Funded Technical Institute

M.TECH IN AUGMENTED AND VIRTUAL REALITY

REGULATIONS 2024

Augmented Reality (AR) and Virtual Reality (VR) are at the forefront of technological transformation, continually evolving and reshaping industries. This master's program in Augmented and Virtual Reality equips students with comprehensive knowledge of the latest advancements, emerging trends, and industry best practices. AR and VR are inherently interdisciplinary fields, integrating principles from computer science, design, cognitive psychology, engineering, and related domains. The synergy of expertise from various disciplines contributes to the creation of more holistic, effective, and ethically conscious augmented and virtual experiences. The program provides students with a holistic understanding of these technologies, preparing them to collaborate across disciplines and approach challenges with a multifaceted perspective.

Program Education Objectives (PEOs)

Graduates will demonstrate ability to:

- **PEO1:** Establish a strong base in fundamental sciences, mathematics, and engineering principles, fostering comprehensive knowledge and proficiency in Augmented and Virtual Reality.
- **PEO2:** Develop the ability to comprehend, interpret, and assess challenges in Artificial Intelligence enabling effective application to real-world problems.
- **PEO3:** Foster expertise in designing and implementing novel, secure solutions to solve real-world challenges in Engineering, Medical and Healthcare, Education, and Pedagogy.
- **PEO4:** Exhibit self-confidence, ethical integrity, and leadership skills while nurturing teamwork, collaboration, communication, and social awareness to bridge engineering with real-world applications.

Program Outcomes (POs)

Our graduates by the time of graduation will be able to

- **PO1:** Engage in research, problem-solving, and the development of innovative Augmented Reality (AR) and Virtual Reality (VR) solutions to address real-world challenges across diverse applications.

- **PO2:** Write and present well-structured technical reports, research papers, and documentation, effectively communicating theoretical concepts and practical applications of Augmented and Virtual Reality technologies.

- **PO3:** Demonstrate a degree of mastery over the area of Augmented and Virtual Reality, aligning with the specific requirements of the specialization and evolving industry standards.

- **PO4:** Design and develop AR/VR systems that address complex real-world challenges, prioritizing human-centred design and immersive user experiences to meet industry demands.

- **PO5:** Apply advanced computational techniques, tools, and frameworks to develop innovative AR and VR applications, ensuring ethical considerations, societal impact, and sustainability.

- **PO6:** Work effectively in multidisciplinary and collaborative environments, both independently and in teams, to develop AR/VR solutions that drive technological advancements in education, healthcare, manufacturing, and entertainment.

Programme Credit Requirement

		PG Certificate	PG Diploma	PG Degree
PCC (Theory)	Credit	6	12	12
	Course	2	4	4
PCC (Lab)	Credit	4	8	8
	Course	2	4	4
PEC / OEC	Credit	9	9	18
	Course	3	3	6
FC	Credit		3	3
	Course		1	1
MC	Credit	3	3	3
	Course	1	1	1
Audit Course	Credit	0	0	0
	Course	2	2	2
IIC	Credit	0	0	4
	Course	0	0	1
IP	Credit	0	0	4
	Course	0	0	1
PD	Credit	0	5	28
	Course	0	1	2

Minimum Credit Requirement to obtain
PG Certificate – 20 Credits; PG Diploma – 40 Credits; PG Degree – 80 Credits

PCC	Professional Core Courses
PEC	Professional Elective Courses
OEC	Open Elective
FC	Foundation Course
MC	Mandatory Course
AC	Audit Course
IIC	Industrial Integrated Courses
IP	Internship Programme
PD	Project Dissertation

Course Structure and Details

PROFESSIONAL CORE COURSES (Theory)			
S.No	**Course Code**	**Course Title**	**Credits**
1	AV24P11	Introduction to Augmented Reality and Virtual Reality	3
2	AV24P12	Computer Animation	3
3	AV24P13	Interaction and Experience Design for AR/VR	3
4	AV24P14	Human Computer Interaction in AR/VR	3
PROFESSIONAL CORE COURSES (Laboratory)			
1	AV24P21	Programming for AR and VR Lab	2
2	AV24P22	Content Creation for VR/AR Lab	2
3	AV24P23	AR/VR Application Development Lab	2
4	AV24P24	Data Visualisation Lab	2
FOUNDATION COURSE			
1	MA24M12	Mathematical Foundations for Engineers – Probability and Statistics	3
MANDATORY COURSE			
1	RM24K11	Research Methodology and IPR	3

PROFESSIONAL ELECTIVE COURSE – AUGMENTED EXPERIENCES			
S.No	**Course Code**	**Course Title**	**Credits**
1	AV24A11	Sensation and Perception	3
2	AV24A12	Image Synthesis	3
3	AV24A13	Psychophysics	3
4	AV24A14	Introduction to Haptics	3
PROFESSIONAL ELECTIVE COURSE – IMMERSIVE COMPUTING			
1	AV24B11	Immersive Sound & Audio Design	3
2	AV24B12	AR and VR applications in Industries	3
3	AV24B13	Augmented Reality	3
4	AV24B14	Mobile AR and VR	3

PROFESSIONAL ELECTIVE COURSE – WEB APPLICATION DEVELOPMENT			
1	AV24C11	Spatial Computing	3
2	AV24C12	Internet of Things	3
3	AV24C13	Web Technologies	3
4	AV24C14	Therapeutic Applications of AR and VR in Cognitive and Psychological Health	3
PROFESSIONAL ELECTIVE COURSE – GAME DESIGN & VIRTUAL PRODUCTION			
1	AV24D11	3D Game Modelling and Rendering	3
2	AV24D12	3D Shape Analysis	3
3	AV24D13	Neural Image Synthesis for AR/VR	3
4	AV24D14	VR Filming and Virtual Production	3
PROFESSIONAL ELECTIVE COURSE – NEXTGEN TECHNOLOGIES			
1	AV24E11	Operating Systems	3
2	AV24E12	Machine Learning	3
3	AV24E13	Cloud Computing Technologies	3
4	AV24E14	Data Visualization	3
PROFESSIONAL ELECTIVE COURSE – COMPUTER VISION & GENERATIVE AI			
1	AV24F11	Deep Learning	3
2	AV24F12	Image Processing	3
3	AV24F13	Computer Vision	3
4	AV24F14	Computer Graphics and 3D Modelling	3
5	AV24F15	Generative AI for 3D Modelling	3

INDUSTRY INTEGRATED COURSE			
1	AV24G11	Immersive User Experience (UX) Design for AR/VR	4
2	AV24G12	Interactive Narrative and Digital Storytelling in AR/VR	4
3	AV24G13	Enterprise Applications of AR/VR	4
INDUSTRIAL TRAINING			
1	AV24G21	Internship Programme	4

AUDIT COURSE			
1	AC24H11	English for Research Paper Writing	0
2	AC24H12	Indian Knowledge System	0
OPEN ELECTIVE			
1	OE24W11	Design Thinking for Educators	3
2	OE24W12	Blue Economy and Entrepreneurship	3
3	OE24W13	Swachhata Campus: Clean, Green and Sustainable Energy	3
4	OE24W14	Integration of AI in Educational Practices	3
5	OE24W15	Extended Reality Technologies	3
PROJECT DISSERTATION			
1	AV24T21	Project Phase I	12
2	AV24T22	Project Phase II	16

Theory: 1 Credit = 15 hours; Practical: 1 Credit = 30 hours; Experiential learning including relevant experience and proficiency/ professional levels acquired 1 Credit – 40 -45 hours.

The guidelines for attendance and assessment as stipulated in the PG regulations.

Detailed Syllabus

I. PROFESSIONAL CORE COURSES (Theory)

AV24P11	**INTRODUCTION TO AUGMENTED REALITY AND VIRTUAL REALITY**	**3 Credits**

Course Description:

This course introduces the fundamentals of Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), covering their hardware, software, and real-world applications. It explores human perception, optics, motion tracking, and interaction techniques essential for immersive experiences. Students will learn geometric modeling, visual transformations, and real-time AR/VR application development. The course also covers emerging frontiers like haptics, telepresence, and brain-machine interfaces, preparing students for advanced research and industry applications.

Course Content:

Unit I: Introduction to Extended Reality (XR)

Definition of XR (AR, VR, MR) - Modern experiences - Historical perspective – Hardware – Sensors – Displays – Software - Virtual World Generator - Game Engines.

Unit II: Geometry Of Visual World

Geometric Modelling - Transforming Rigid Bodies – Yaw – Pitch – Roll - Axis Angle Representation – Quaternions - 3D Rotation Inverses and Conversions - Homogeneous Transforms - Transforms to Displays, Look-at, and Eye Transform - Canonical View and Perspective Transform - Viewport Transforms.

Unit III: Light And Optics & Visual Perception

Interpretation of Light, Reflection, Optical Systems – Photoreceptors - Eye and Vision – Motion - Depth Perception - Frame Rates and Displays.

Unit IV: Tracking And Head Mounted Display

Orientation – Tilt – Drift – Yaw - Lighthouse Approach – Optics - Inertial Measurement Units - Orientation Tracking with IMUs - Panoramic Imaging - Cinematic VR and Audio.

Unit V: Frontiers

Touch – Haptics – Taste – Smell - Robotic Interfaces – Telepresence - Brain-Machine Interfaces.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Distinguish AR, VR, and MR technologies by analyzing key components such as hardware, sensors, displays, software, and virtual world generation.

CO2: Utilize geometric modeling techniques to manipulate 3D objects, spaces, and transformation methods to create accurate visual simulations.

CO3: Analyze the principles of light and optics to design and optimize immersive visual experiences.

CO4: Develop immersive VR and AR applications using tracking, HMDs, and IMUs.

CO5: Develop haptics and robotic interfaces to enhance future X-Reality experiences.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	1	1	1
CO2	2	2	2	2	2	1
CO3	2	2	2	3	2	1
CO4	2	2	2	2	2	1
CO5	2	2	2	1	2	2

References:

- Shirley, M., (2016), Fundamentals of Computer Graphics, 4th Edition, CRC Press.
- LaValle, (2016), Virtual Reality, Cambridge University Press.
- Schmalstieg D, and Hollerer T. (2016). Augmented Reality: Principles & Practice, Pearson Education India.
- Jerald,J., (2015), The VR Book: Human-Centered Design for Virtual Reality, Morgan & Claypool.
- Mather,G., (2009), Foundations of Sensation and Perception, 2nd Edition, Psychology Press.
- Shirley,P., Ashikhmin,M., Marschner,S. and Peters,A.K., Fundamentals of Computer Graphics, 3rd Edition, CRC Press.
- Bowman,D.A., Kruijff,E., LaViola,J.J. and Poupyrev,I., (2014), 3D User Interfaces: Theory and Practice, 2nd Edition, Addison Wesley Professional.

AV24P12	COMPUTER ANIMATION	3 Credits

Course Description:

This course introduces the principles and techniques of computer animation, focusing on various animation methods. Students will explore mathematical concepts related to animation, particle systems, rigid bodies, deformable models, and natural phenomena animation to create realistic motion. The course covers data-driven animation, virtual character movement, and crowd simulation, emphasizing realism and perception. Additionally, students will work with real-time animation systems, motion control, and interactive multi-sensory feedback for developing practical animation applications.

Course Content:

Unit I: Computer Animation

Core Mathematics and Methods for Computer Animation - Motion Simulation - Traditional Animation Techniques.

Unit II: Simulation Methods

Physics-based Simulation Methods for Modelling Shape and Motion - Particle Systems – Constraints - Rigid Bodies - Deformable Models.

Unit III: Animation Models

Collisions and Contact – Fluids - Fracture - Animating Natural Phenomena.

Unit IV: Animation Methods

Methods for Animating Virtual Characters and Crowds - Data-driven Animation Methods - Realism and Perception.

Unit V: Animation Systems

Animation Systems -Motion Control - Real-time and Interactive Methods - Multi-sensory Feedback.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Apply mathematical concepts required for animation and simulation.
CO2: Use the animation techniques for physics based real time systems.
CO3: Analyse three animation models based on animation techniques.
CO4: Apply data-driven animation methods to animate virtual characters and crowds while evaluating and enhancing realism and perception in animated environments.
CO5: Utilize animation systems with motion control, real-time and interactive methods, and multi-sensory feedback to enhance user experience in interactive environments.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	2	1
CO2	2	2	2	1	2	2
CO3	2	2	2	1	2	1
CO4	2	3	2	2	2	1
CO5	2	2	2	3	2	2

References:

- Hughes, J. F., Van Dam, A., Foley, J. D., McGuire, M., Feiner, S. K., & Sklar, D. F. (2014). Computer graphics: principles and practice. Pearson Education.
- Marschner, S., & Shirley, P. (2015). Fundamentals of computer graphics. CRC Press.

AV24P13	INTERACTION AND EXPERIENCE DESIGN FOR AR/VR	3 Credits

Course Description:

This course explores user-centered design principles for creating intuitive and engaging AR/VR experiences. Students will learn need-finding, ideation, storyboarding, and prototyping techniques to develop immersive applications. The course emphasizes collaborative design, usability evaluation, and user feedback collection to refine interactions and enhance the user experience. Through hands-on projects, students will apply design thinking methodologies to create and assess AR/VR prototypes using industry-standard tools.

Course Content:

Unit I: Introduction to the Design Thinking Process

Empathy - Human and Life-centered Approach - Problem Statement – Ideation – Prototyping – Testing - Design Critiques.

Unit II: Need Finding

Problem Context - User Personas - Observation of Context - Talking to Users – Constraints - Problem Statement.

Unit III: Ideation and Storyboarding

Mind maps - Thinking Visually - Collaborative Ideation Whiteboards - Digital Whiteboard Tools (Google Apps, Mural, Miro) - Synthesis of Ideas - Evaluating Ideas from the Perspective of the Medium - Use Cases - Summarizing the Idea into Key Use Cases.

Unit IV: Prototyping

Introduction to Prototypes - Low to High Fidelity - Importance of Prototyping - Making Prototypes Paper - Physical, Digital - Prototype Key Use Cases.

Unit V: Evaluation of Interaction, Experience and User Feedback

Usability – Usefulness - Guidelines for Interaction Development - Evaluating Usability against the Currently Known Guidelines - Taking User Feedback on the Prototype for Key Use Cases - The Think-Aloud Protocol.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1 Explain the Design Thinking process, incorporating empathy, a human- and life-centered approach, problem statement formulation, ideation, prototyping, testing, and design critiques to develop AR and VR solutions.

CO2 Frame effective problem statements based on user pain points and constraints within AR/VR environments.

CO3 Synthesize ideas into coherent storyboards and key use cases, tailored for AR/VR mediums.

CO4 Develop a life- and human-centered approach to problem-solving, focusing on the specific needs and behaviors of users in AR/VR contexts.

CO5 Evaluate interaction and experience designs in terms of usability and usefulness based on established guidelines.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	1	2
CO2	2	2	3	2	2	2
CO3	2	1	3	2	1	2
CO4	3	2	3	2	1	2
CO5	3	3	2	2	3	3

References:

- Jason Jerald, “The VR Book: Human-Centered Design for Virtual Reality,” Illustrated edition, Morgan and Claypool Publishers, 2015.
- Joseph LaViola, et al, 3D User Interfaces: Theory and Practice,” 2nd Ed, Addison-Wesley, 2017.
- Cornel Hillmann, “UX for XR: User Experience Design and Strategies for Immersive Technologies (Design Thinking),” 1st Ed, Apress, 2021.
- Don Norman, “The Design of Everyday Things,” 2nd Edition, Basic Books, 2013.

AV24P14	HUMAN COMPUTER INTERACTION IN AR/VR	3 Credits

Course Description

This course explores the fundamentals of human perception, sensation, and interaction in Augmented Reality (AR) and Virtual Reality (VR) environments. Students will learn how visual, aural, and haptic feedback influence user experiences, along with techniques for optimizing interaction design in immersive systems. The course covers geometric transformations, rendering techniques, motion tracking, and real-time system optimization to enhance usability. By engaging in practical applications and interactive simulations, students will apply Human Computer Interaction (HCI) principles to design and evaluate intuitive AR/VR experiences.

Course Content:

Unit I: Introduction to Virtual Reality and Interaction Design

Defining Virtual Reality - History of VR - Human Physiology and Perception - Key Elements of Virtual Reality Experience - Virtual Reality System - Interface to the Virtual World - Input & output for Visual, Aural & Haptic Displays - Applications of Virtual Reality.

Unit II: Representing the Virtual World

Visual Representation in VR - Aural Representation in VR - Haptic Representation in VR.

Unit III: Geometry of Virtual Worlds and the Physiology of Human Vision

Geometric Models - Changing Position and Orientation - Axis-Angle Representations of Rotation - Viewing Transformations - Chaining the Transformations - Human Eye - Eye Movements and Implications for VR.

Unit IV: Visual Perception and Rendering

Visual Perception - Perception of Depth - Perception of Motion - Perception of Color - Combining Sources of Information Visual Rendering - Ray Tracing and Shading Models – Rasterization - Correcting Optical Distortions - Improving Latency and Frame Rates.

Unit V: Motion and Tracking

Motion in Real and Virtual Worlds - Velocities and Accelerations - The Vestibular System - Physics in the Virtual World - Mismatched Motion and Motion Tracking - Tracking 2D & 3D Orientation - Tracking Position and Orientation - Tracking Attached Bodies.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1 Illustrate the working of VR systems and their applications in the real world.
CO2 Design immersive virtual environments by integrating visual, aural, and elements to enhance user interaction.
CO3 Develop visually accurate and immersive VR environments that support natural movement and orientation.
CO4 Illustrate the concepts of motion and tracking in VR systems.
CO5 Describe the importance of interaction and audio in VR systems.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	1	1	1
CO2	2	2	2	3	2	2
CO3	2	2	2	1	1	1
CO4	1	2	2	1	1	1
CO5	1	1	2	1	1	1

References:

- Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016.
- Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002.
- Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.
- Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005
- Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA, 2005.
- Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Meging Real and Virtual Worlds", 2005.
- Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Interscience, India, 2003.

II. PROFESSIONAL CORE COURSES (Laboratory)

AV24P21	PROGRAMMING FOR AR AND VR LAB	2 Credits

Course Objectives:

This course offers hands-on training in AR/VR development, using free and open-source software (FOSS) and industry-standard tools to create interactive applications. Students will build AR applications with gesture recognition, spatial audio, and physics-based interactions, and develop VR environments with gaze-based interactions, menus, and multi-user collaboration. The course emphasizes prototype development, user-centered design, and iterative feedback collection to enhance usability. By the end, students will gain practical experience in designing, developing, and deploying AR/VR applications across various platforms.

List Of Experiments:

1. Create a basic scene with 3D objects and compile and run the project on a VR headset.
2. Build a simple AR application where virtual objects interact with the real world.
3. Create or import 3D models using Blender using basic animations and add interactions
4. Create a VR menu interface for user interactions.
5. Integrate gesture recognition SDK and create an AR application where users can interact with virtual objects using gestures.
6. Implement 3D spatial audio using Unity or Unreal Engine's audio tools.
7. Create a collaborative multi-user VR environment.
8. Develop an AR application that spawns virtual objects when markers are detected.
9. Create a VR environment with interactive objects governed by physics (gravity, collisions).
10. Create a VR experience where users can interact with objects by looking at them.

Course Outcomes:

After the successful completion of this course, the students will be able to

CO1: Utilize AR/VR development tools such as Unity and Unreal Engine to create basic 3D scenes and deploy applications on VR headsets.
CO2: Design AR applications that blend digital and physical worlds through virtual objects and gesture recognition techniques.
CO3: Animate 3D objects and interact with them using tools like Blender to enhance user experiences in virtual reality.
CO4: Utilize interaction techniques such as hand or controller-based inputs, VR menus, gaze-based interactions, and multi-user experiences in VR environments.
CO5: Integrate spatial audio and physics-based interactions to create more immersive and realistic VR environments.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	1
CO2	2	2	2	2	2	2
CO3	2	3	2	1	1	3
CO4	2	2	2	1	1	1
CO5	2	2	2	2	2	2

References:

- Jason Jerald, "The VR Book: Human-Centered Design for Virtual Reality," Illustrated edition, Morgan and Claypool Publishers, 2015.
- Joseph LaViola, et al, 3D User Interfaces: Theory and Practice," 2nd Ed, Addison-Wesley, 2017.
- Cornel Hillmann, "UX for XR: User Experience Design and Strategies for Immersive Technologies (Design Thinking)," 1st Ed, Apress, 2021.
- Don Norman, "The Design of Everyday Things," 2nd Edition, Basic Books, 2013.

AV24P22	CONTENT CREATION FOR AR/VR LAB	2 Credits

Course Description

This course provides practical training in designing and deploying AR/VR applications, focusing on interactive environments and immersive user experiences. Students will learn to create and integrate 3D models, implement multimedia elements, and develop virtual tours with interactive hotspots. The course explores state-of-the-art AR/VR design problems and solutions, including marker-based AR, gaze interaction, and haptic feedback. By the end, students will have hands-on experience in developing and deploying AR/VR mini-projects using industry-standard tools.

List of Experiments

1. Create a simple 3D object (e.g., a chair, cube, or character) and export it for AR/VR applications. Implementation on Video/ Feature Viewing
2. Develop a simple virtual tour with interactive hotspots using a tool like Unity or Unreal Engine. Implementation on material animation
3. Create an AR app where users can place 3D objects in a real-world environment and interact with them (rotate, scale, etc.).
4. Build a basic VR scene where users can teleport between locations within a virtual space, using VR controllers for navigation
5. Use a marker (e.g., an image or QR code) to trigger 3D content in AR, which overlays on the real-world view when the marker is detected.
6. Create a VR environment where objects react to the user's gaze, enabling selection or activation without physical input devices.
7. Design a VR scenario with haptic feedback (e.g., vibration or resistance) to enhance realism when interacting with virtual objects.
8. Create an interactive AR module where users can explore 3D models. (Eg. AR for Educational content)

Course Outcome

Upon successful completion of this course, the students will be able to

CO1: Develop the game engines and their capabilities using Unity and Unreal Engine for content creation in 2D and 3D environments.

CO2: Implement multimedia elements to enhance content delivery through immersive storytelling techniques.

CO3: Develop interactive virtual tours that utilize material animations and virtual environments to create engaging, real-time user experiences.

CO4: Animate digital content, using animation techniques in game engines and content creation tools.

CO5: Design mini projects in AR and VR environments by integrating content from game engines to create immersive and innovative user experiences.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	1	2
CO2	2	2	2	2	2	1
CO3	2	2	2	2	2	1
CO4	2	3	2	2	2	2
CO5	3	3	3	3	2	2

References:

- Braun, A., & Rizzo, R. (2023). XR Development with Unity: Create VR, AR and MR experiences with Unity 2021.3 or later. Packt Publishing.
- Godoy Jr., C. H. (2021). Augmented Reality and Gamification: A framework for developing supplementary learning tool. arXiv.
- Linowes, J. (2021). Augmented Reality with Unity AR Foundation: A practical guide to cross-platform AR development with Unity 2020 and later versions (1st ed.). Packt Publishing.
- Pangilinan, E., Lukas, S., & Mohan, V. (2019). Creating Augmented and Virtual Realities: Theory and practice for next-generation spatial computing. O'Reilly/Shroff.
- Wijesooriya, I. (2023). Mastering Augmented Reality Development with Unity. BPB Publications.

AV24P23	AR/VR APPLICATION DEVELOPMENT LAB	2 Credits

Course Description:

This course provides practical training in designing and deploying AR/VR applications, focusing on interactive environments and immersive user experiences. Students will learn to create and integrate 3D models, implement multimedia elements, and develop virtual tours with interactive hotspots. The course explores state-of-the-art AR/VR design problems and solutions, including marker-based AR, gaze interaction, and haptic feedback. By the end, students will have hands-on experience in developing and deploying AR/VR mini-projects using industry-standard tools.

List Of Experiments:

1. Create simple 3D objects like cubes, spheres, and cones. Manipulate their position, rotation, and scale to form a basic scene in Blender.
2. Model a simple object (e.g., a cup or chair) by adding and manipulating vertices, edges, and faces in Edit Mode.
3. Import or create a texture and apply it to a 3D object. Adjust UV mapping for proper texture alignment.
4. Create material for a 3D object by combining multiple texture nodes (e.g., color, roughness, bump maps) to achieve a realistic look.
5. Arrange a simple 3D scene with appropriate camera placement and lighting that can be viewed in VR (e.g., a room or outdoor space).Set up a simple scene suitable for VR viewing.
6. Export a 3D model from Blender in a suitable format (e.g., FBX or OBJ) and import it into Unity or Unreal Engine for further development.
7. Implement simple interactions like object grabbing, teleportation, or button pressing in a VR environment using motion controllers. Build and deploy a VR application.
8. Create a VR project in Unity or Unreal Engine and deploy it to a VR headset (e.g., Oculus, HTC Vive).

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Use the Blender's interface and create 3D models using modeling techniques, including transformations and object manipulation.

CO2: Apply texture and shading techniques to enhance 3D models in Blender, by utilizing texturing tools to create realistic surfaces and materials.

CO3: Configure scenes in VR environments, by importing Blender models into Unity or Unreal Engine, and preparing VR-ready scenes.

CO4: Deploy interactive VR applications in Unity, Unreal Engine, incorporating immersive features and user interaction within a virtual environment.

CO5: Design AR applications in Unity or Unreal Engine, integrating real-world elements with digital overlays for interactive user experiences.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1	1	1
CO2	2	2	2	2	2	1
CO3	2	2	3	2	2	1
CO4	2	3	2	2	2	2
CO5	2	3	3	2	2	2

References:

- Blain, J. M. (2019). The complete guide to Blender graphics: computer modeling & animation. AK Peters/CRC Press.
- Hess, R. (2013). Blender Foundations: The Essential Guide to Learning Blender 2.5. Routledge.

AV24P24	DATA VISUALISATION LAB	2 Credits

Course Objectives:

This course provides hands-on experience in data visualization, enabling students to apply various techniques to analyze and interpret complex datasets. Students will learn to acquire, process, and visualize data from domains such as finance, healthcare, census, and geospatial analytics. The course covers statistical analysis, clustering, time-series visualization, streaming data representation, and text analytics to extract meaningful insights. By the end of the course, students will be able to evaluate and apply appropriate visualization methods to effectively communicate data-driven insights.

List Of Experiments:

1. Acquiring and plotting data.
2. Statistical Analysis – such as Multivariate Analysis, PCA, LDA, Correlation regression and analysis of variance.
3. Financial analysis using Clustering, Histogram and Heat Map.
4. Time-series analysis – stock market.
5. Visualization of various massive dataset - Finance - Healthcare - Census – Geospatial.
6. Visualization on Streaming dataset (Stock market dataset, weather forecasting).
7. Market-Basket Data analysis-visualization.
8. Text visualization using web analytics.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Plot data using various data collection methods and visualization tools for the enhancement of data interpretation, spatial understanding, and real-time decision-making.

CO2: Perform statistical analysis, including (i) Multivariate Analysis, (ii) Principal Component Analysis (PCA), (iii) Linear Discriminant Analysis (LDA), (iv) Correlation Regression, and (v) Analysis of Variance (ANOVA), to identify patterns and relationships within complex datasets.

CO3: Apply clustering techniques, histograms, and heatmaps for financial data analysis, enabling better decision-making through effective visualization and exploration of financial patterns.

CO4: Analyse Timeseries data on stock market data to predict trends and patterns using appropriate statistical and analytical methods.

CO5: Utilize visualization techniques for the massive datasets from multiple domains such as finance, healthcare, census, and geospatial data to uncover valuable insights.

CO6: Analyse streaming datasets from real-time sources, including stock market data and weather forecasting, to deliver actionable insights in real-time decision-making contexts.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1	1	1
CO2	2	2	2	2	2	1
CO3	2	2	3	2	2	1
CO4	2	3	2	2	2	2
CO5	2	3	3	2	2	2

References:

- Matthew Ward, Georges Grinstein and Daniel Keim, "Interactive Data Visualization Foundations, Techniques, Applications", 2010.
- Colin Ware, "Information Visualization Perception for Design", 2nd edition, Margon Kaufmann Publishers, 2004.

III. FOUNDATION COURSE

MA24M12	MATHEMATICAL FOUNDATIONS FOR ENGINEERS -PROBABILITY AND STATISTICS	3 Credits

Course Description:

This course provides a comprehensive foundation in probability, random variables, estimation theory, hypothesis testing, and experimental design for data-driven decision-making. Students will explore probability distributions, statistical inference techniques, and hypothesis testing methods applicable to real-world problems. The course also covers design of experiments, regression analysis, and time series models to analyse and interpret complex datasets. By the end of the course, students will be able to apply probability and statistical methods for data analysis, predictive modelling, and decision-making in engineering and scientific applications.

Course Content:

Unit I: Probability and Random Variables

Probability – Axioms of probability – Conditional probability – Baye's theorem - Random variables – Probability function – Moments – Moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a random variable.

Unit II: Estimation Theory

Principle of least squares – Regression – Multiple and partial correlations – Estimation of parameters – Maximum likelihood estimates – Method of moments.

Unit III: Testing Of Hypothesis

Sampling distributions – Small and large samples and problems – Tests based on Normal, t-distribution, Chi-square, Goodness of fit and F–distributions.

Unit IV: Design of Experiments

Analysis of variance – Completely randomized design – Randomized block design – Latin square design – 22 Factorial designs.

Unit V: Time Series

Characteristics and representation – Moving averages – Exponential smoothing – Auto regressive processes.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Apply probability concepts, random variables, and probability distributions, including Binomial, Poisson, Geometric, Uniform, Exponential, Gamma, and Normal distributions, and moment generating functions and Bayes' theorem to solve real-world problems.

CO2: Apply estimation theory techniques, including the principle of least squares, regression, multiple and partial correlations, and parameter estimation methods for interpreting the data.

CO3: Use statistical tests in testing hypotheses on data.

CO4: List the guidelines for designing experiments and recognize the key historical figures in Design of Experiments.

CO5: Differentiate between various time series models and application of these models appropriately to engineering problems.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	1	1
CO2	3	1	3	2	3	1
CO3	1	1	2	3	3	1
CO4	3	3	2	3	1	1
CO5	1	2	3	1	2	3

References:

- Anderson, O.D, “Time Series Analysis: Theory and Practice”, North - Holland, Amsterdam, 1982.
- Devore, J. L., “Probability and Statistics for Engineering and Sciences”, 8th Edition, Cengage Learning, 2014.
- Gupta, S.C and Kapoor, V.K., “Fundamentals of Mathematical Statistics”, Sultan and Chand Company, New Delhi, 1999.
- Johnson, R.A., Miller, I and Freund J., “Miller and Freund’s Probability and Statistics for Engineers, Pearson Education, Asia, 8th Edition, 2015.
- Montgomery D.C and Johnson, L.A, “Forecasting and Time Series”, 6th Edition, McGraw Hill, 1990.

IV. **MANDATORY COURSE**

RM24K11	RESEARCH METHODOLOGY AND IPR	3 Credits

Course Description

This course equips students with the skills to identify research problems, analyze solutions, and effectively communicate findings through technical writing and presentations. Students will learn literature review techniques, ethical research practices, and methods for drafting research proposals and technical papers. The course also introduces Intellectual Property Rights (IPR), covering patents, copyrights, trade secrets, and licensing. By the end, students will be able to formulate patent drafts, understand the patent filing process, and explore the role of IPR in research and innovation.

Course Content:

Unit I: Research Problem Formulation

Meaning of research problem- Sources of research problem - Criteria characteristics of a good research problem - Errors in selecting a research problem - Scope and objectives of research problem. Approaches of investigation of solutions for research problems - Data collection - Analysis - Interpretation - Necessary instrumentations.

Unit II: Literature Review

Effective literature studies approach - analysis - plagiarism - and research ethics.

Unit III: Technical Writing/ Presentation

Effective technical writing - How to write reports and paper - Developing a research proposal - Format of research proposal - A presentation and assessment by a review committee.

Unit IV: Introduction to IPR

Nature of Intellectual Property: Patents, Designs, Trade and Copyright - Process of Patenting and Development: Technological Research, Innovation, Patenting, and Development - International Scenario: International cooperation on Intellectual Property - Procedure for grants of patents - Patenting under PCT.

Unit V: Intellectual Property Rights

Patent Rights: Scope of Patent Rights - Licensing and transfer of technology - Patent information and databases - Geographical Indications - New Developments in IPR: Administration of Patent System - IPR of Biological Systems - Computer Software - Traditional knowledge Case Studies - IPR.

Course outcomes

Upon successful completion of this course, the students will be able to

CO1: Identify research problems by evaluating sources, defining scope, setting objectives, and applying appropriate data collection and analysis methods.

CO2: Perform literature reviews by utilizing proper study approaches, ensuring ethical standards, and preventing plagiarism in research.

CO3: Compose technical reports, research papers, and proposals with a clear structure, and effectively present findings to a review committee.

CO4: Apply Intellectual Property Rights (IPR) principles, including patenting processes, licensing, and emerging trends in IPR across various domains such as technology and biological systems.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1		3	3	
CO2		2		3	3	
CO3		3	2			2
CO4	2		3			3

References:

- Asimov, “Introduction to Design”, Prentice Hall,1962.
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd,2007.
- Mayall, “Industrial Design”, McGraw Hill,1992.
- Niebel, “Product Design”, McGraw Hill,1974.
- Ranjit Kumar, 2nd Edition, “Research Methodology: A Step-by-Step Guide for beginners” 2010.

V. PROFESSIONAL ELECTIVE COURSE

CLUSTER A: AUGMENTED EXPERIENCES

AV24A11	SENSATION AND PERCEPTION	3 Credits

Course Description:

This course introduces the principles of sensation and perception, focusing on how perceptual information is processed and represented in the human brain. Students will explore various sensory systems, including vision, hearing, touch, taste, and smell, and their role in shaping everyday experiences. The course covers neurophysiological mechanisms, perception models, and experimental techniques used to study sensation and perception. By the end of the course, students will be able to analyze, evaluate, and apply perceptual principles in virtual environments, human-computer interaction, and immersive media.

Course Content:

Unit I: Introduction to Sensation and Perception

History and philosophy of perception - Methods & techniques: Signal Detection Theory - Physiology of perception and neuroimaging - Bottom-up vs. top-down processing.

Unit II: Multisensory Systems and Perception

Cutaneous senses and pain perception - Olfaction (smell) and gustation (taste) - Integration of senses: The role of flavor in perception

Unit III: Auditory System and Spatial Perception

Auditory pathways and fundamental auditory functions - Auditory localization and scene analysis - Speech perception and auditory processing.

Unit IV: Visual Perception and Experimental Design

Visual system pathways and functions - Object perception and visual attention mechanisms - Experimental methods for studying vision in virtual environments.

Unit V: Motion, Depth, and Perceptual Illusions

Motion detection and visual motion processing - Color vision and depth perception - Perceptual constancy, illusions, and camouflage in real and virtual spaces.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Analyze key techniques of human perception and interaction with virtual environments.

CO2: Explain the functions of human sensory systems and their role in enhancing multisensory experiences in virtual environments.

CO3: Design immersive soundscapes to improve speech recognition and auditory perception in virtual environments.

CO4: Apply principles of visual perception to design experiments that enhance object perception and attention in virtual spaces.

CO5: Investigate motion detection and color vision principles to create realistic visuals, incorporating depth perception, illusions, and camouflage.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	1	1
CO2	2	2	2	1	1	1
CO3	2	2	2	3	1	1
CO4	2	2	2	2	1	1
CO5	2	1	2	1	1	1

References:

- Goldstein, E. B. & Brockmole, James R. (2017). Sensation and Perception, 10th Edition. Cengage Learning.
- Wolfe, J. M., Kluender, K. R., Levi, D. M., et al. (2020). Sensation & Perception, 6th Edition. Oxford University Press.
- Martinez-Conde, S., Macknik, S. L., & Alonso, J. M. (2018). The Oxford Handbook of Perceptual Organization. Oxford University Press.

AV24A12	IMAGE SYNTHESIS	3 Credits

Course Description

This course introduces the fundamentals of realistic image synthesis, covering key rendering techniques used in animation and visual effects. Students will explore ray tracing, lighting models, reflection models, and advanced sampling techniques to enhance image realism. The course also covers Monte Carlo methods and radiosity techniques to achieve high-quality illumination and shading. By the end of the course, students will be able to develop applications that implement efficient rendering techniques for realistic image generation.

Course Content:

Unit I: Rendering Techniques

Goals of rendering - Ray tracing fundamentals: Basic algorithm and ray-surface intersection - Acceleration techniques in ray tracing.

Unit II: Lighting and Illumination

Light field and illumination models - Lights and their impact on rendering - Camera and film simulation in rendering - Sampling and reconstruction techniques - Anti-aliasing and statistical sampling.

Unit III: Reflection Models and Surface Properties

Bidirectional Reflectance Distribution Functions (BRDFs) - Specular and diffuse reflection models - Advanced reflection models: Glossy surfaces, textures, and exotic materials - The rendering equation and material properties - Mapping techniques for textures and lighting.

Unit IV: Monte Carlo Methods for Rendering

Probability and statistical sampling in rendering - Variance reduction techniques for image accuracy - Sampling paths for realistic lighting - Irradiance caching and photon mapping.

Unit V: Advanced Synthesis Techniques

Radiosity and form factor calculations - Solvers for global illumination - Meshing and hierarchical techniques in rendering - Application of radiosity for realistic scene synthesis.

Course Outcomes

Upon successful completion of this course, the students will be able to

CO1 Implement rendering techniques, including ray tracing and acceleration methods, to generate realistic images.

CO2 Apply concepts of lighting, illumination, and sampling techniques to enhance realism in synthesized images.

CO3 Analyse and apply reflection models and BRDFs to simulate realistic material properties in rendering.

CO4 Utilize Monte Carlo methods for efficient probability sampling and variance reduction in rendering.

CO5 Develop realistic image synthesis applications using radiosity and hierarchical meshing techniques.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	1	1	1
CO2	2	2	2	1	1	1
CO3	2	1	1	1	1	1
CO4	2	2	1	1	1	1
CO5	2	2	1	1	1	1

References:

- Akenine-Möller, T., Haines, E., & Hoffman, N. (2019). Real-time rendering. CRC Press.
- Hughes, J. F., Van Dam, A., Foley, J. D., McGuire, M., Feiner, S. K., & Sklar, D. F. (2014). Computer graphics: principles and practice. Pearson Education.

AV24A13	PSYCHOPHYSICS	3 Credits

Course Description:

This course explores the relationship between stimuli and sensation, focusing on how sensory systems process and interpret information. Students will learn psychophysical methods and models, including threshold measurement techniques, signal detection theory, and ratio scaling methods. The course also introduces statistical hypothesis testing techniques to evaluate perceptual data. By the end of the course, students will be able to apply psychophysical principles to measure sensory attributes and analyse perception through experimental and statistical methods.

Course Content:

Unit I: Introduction to Sensation and Perception

Physiological basis of vision, hearing, and touch - Sensory processing and perception mechanisms - Introduction to psychophysics.

Unit II: Psychophysical Laws and Threshold Measurement

Fundamentals of psychophysics and perception - Psychophysical laws: Weber's Law, Fechner's Law, and Steven's Power Law - Measurement of sensory thresholds: Absolute Sensitivity and Differential Sensitivity.

Unit III: Classical Psychophysical Methods

Method of Limits, Method of Constant Stimuli, and Method of Adjustment - Adaptive Staircase methods and its variants - Applications of psychophysical methods in perception studies.

Unit IV: Signal Detection and Sensory Measurement

Theory of Signal Detection (TSD) - Receiver Operating Characteristics (ROC) and response bias - Procedures and applications of TSD - Measurement of sensory attributes and discrimination scales.

Unit V: Ratio Scaling and Statistical Testing

Psychophysical Ratio Scaling methods: Ratio Production, Ratio Estimation, Magnitude Production, and Magnitude Estimation - Evaluation of ratio scaling methods - Statistical hypothesis testing: z-test, t-test, F-test, ANOVA.

Course Outcomes

Upon successful completion of this course, the students will be able to

CO1 Analyse the physiological foundations of sensation in the visual, auditory, and tactile systems.

CO2 Apply psychophysical laws to measure sensory thresholds and perception quantitatively.

CO3 Employ classical psychophysical methods to assess sensory perception and thresholds using experimental techniques.

CO4 Utilize signal detection theory to measure sensory attributes, response biases, and perceptual decision-making.

CO5 Implement psychophysical ratio scaling methods and statistical hypothesis testing to evaluate sensory data.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	1	1	1
CO2	2	2	2	1	1	1
CO3	2	2	2	1	1	1
CO4	2	2	1	1	1	1
CO5	2	2	1	1	1	1

References:

- G. A. Gescheider, “Psychophysics: The Fundamentals,” 3rd ed., Lawrence Erlbaum Associates, Publishers, 1997.
- E. B. Goldstein, “Sensation and Perception,” 7th Ed., Thomson Wadsworth, 2007.

AV24A14	INTRODUCTION TO HAPTICS	3 Credits

Course Description:

This course introduces the fundamentals of haptics, covering human touch perception, haptic rendering techniques, and applications across various domains. Students will explore kinesthetic and tactile sensations, psychophysical principles, and haptic perception models to understand the role of haptics in human-computer interaction. The course also delves into haptic rendering, telepresence systems, and emerging haptic technologies in AR/VR environments. By the end of the course, students will be able to analyze, implement, and evaluate haptic interactions for immersive applications.

Course Content:

Unit I: Human Haptics

Haptic sensations: Kinesthetic and tactile perception - Physiology of human touch - Overview of haptic interfaces - Applications of haptics in various domains.

Unit II: Haptic Perception

Kinesthetic and tactile interactions - Multisensory integration in haptic perception - Psychophysical principles for haptics: Perceptual thresholds and laws of perception - Classical and modern psychophysical methods.

Unit III: Haptic Rendering

Basic concepts and steps of haptic rendering - Rendering stability and realism - Kinesthetic rendering (3-DoF), Haptic volume rendering - Texture/tactile rendering and friction rendering - Measurement-based and data-driven haptic rendering techniques.

Unit IV: Haptics for Telepresence and Tele-Action (TPTA)

Overview of TPTA systems - Challenges in haptic transmission - Kinesthetic and tactile data compression - Haptic communication over shared networks.

Unit V: Emerging Areas in Haptics

Surface haptics: Electrostatic vs. ultrasonic approaches - Mid-air haptics and non-contact haptic feedback - Haptic interaction in virtual and augmented reality (VR/AR).

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Apply haptic sensations, including kinesthetics and tactile experiences, to evaluate the physiology and applications of human touch.
CO2: Utilize psychophysical principles to analyse perceptual thresholds and multisensory interactions in haptic perception.
CO3: Implement haptic rendering techniques for kinesthetics and tactile feedback to create realistic haptic experiences.
CO4: Examine the challenges and solutions for haptic transmission in telepresence systems, focusing on data compression and network constraints.
CO5: Investigate emerging haptic technologies and their applications in virtual and augmented reality environments.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	1	1	1
CO2	2	2	1	1	1	1
CO3	2	1	2	2	1	1
CO4	2	2	2	2	1	1
CO5	2	2	2	2	1	1

References:

- A. Bhardwaj and S. Chaudhuri, Kinesthetic Perception: A Machine Learning Approach, Springer Publishers, 2017.
- MC Lin and MA Otaduy (Eds), Haptic Rendering: Foundations, Algorithms, and Applications, AK Peters, Ltd; London: 2008.
- G. A. Gescheider, Psychophysics: The Fundamentals, 3rd ed., Lawrence Erlbaum Associates, Publishers, 1997.
- E. Steinbach, M. Strese, M. Eid, X. Liu, A. Bhardwaj, Q. Liu, M. Al-Jaa'afrah, T. Mahmoodi, R. Hassen, A. E. Saddik, and O. Holland, Haptic Codecs for the Tactile Internet [40pt], Proceedings of the IEEE, pp. 124, 2018.
- S. Choi and K. J. Kuchenbecker, Vibrotactile Display: Perception, Technology, and Applications, Proceedings of the IEEE, vol. 101, pp. 2093-2104, 2013.
- E. B. Goldstein, Sensation and Perception, 7th Ed., Thomson Wadsworth, Ch. 14, 2007.

CLUSTER B: IMMERSIVE COMPUTING

AV24B11	IMMERSIVE SOUND AND AUDIO DESIGN	3 Credits

Course Description:

This course explores the history, principles, and techniques of immersive sound and audio design, focusing on spatial hearing, acoustics, and sound processing. Students will learn spatial listening techniques, binaural and ambisonics sound processing, and audio reproduction methods for virtual and real-world applications. The course provides hands-on experience in spatial sound capturing, rendering, and integration with haptics for immersive user experiences. By the end of the course, students will be able to design, implement, and evaluate immersive sound applications from both technical and creative perspectives.

Course Content:

Unit I: History of Immersive Sound

Evolution of immersive sound: Intersection of creative and technical needs - Spatial listening training and active verbalization - Listening field trips and soundscape analysis.

Unit II: Acoustics and Sound Transmission

Fundamentals of acoustics and sound propagation - Conceptualizing spatial sound fields - Object-oriented models for sound sources - Physical vs. virtual sound sources (Loudspeakers vs. Sounding Objects).

Unit III: Psychoacoustics and Room Acoustics

Spatial hearing: Binaural and psychoacoustic perception - Introduction to room acoustics and perceptual correlation - Correlation vs. decorrelation, direct vs. ambient sound - Head-tracked ambisonics mixing and retracted ambisonics.

Unit IV: Spatial Sound Processing and Reproduction

Capturing spatial sound using advanced microphone techniques - Techniques for spatial sound reproduction and playback - Processing of spatial sounds for immersive applications.

Unit V: Sound Immersion and User Experience

Designing user experiences through sound immersion - Integration of haptics with spatial sound for enhanced perception - Creative expression in immersive audio applications.

Course Outcomes

Upon successful completion of this course, the students will be able to

CO1 Describe the historical evolution and current practices of immersive sound, highlighting diverse approaches and conceptual models.

CO2 Investigate spatial listening techniques and psychoacoustics through analytical research and experimental projects.

CO3 Apply practical skills in capturing, processing, and reproducing immersive sounds while understanding the interplay between technology and perception.

CO4 Employ advanced techniques for spatial sound reproduction and processing to create immersive audio experiences.

CO5 Design and implement immersive sound applications or installations from both technical and artistic perspectives.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	1	1
CO2	2	2	2	1	1	1
CO3	2	2	2	1	2	1
CO4	2	2	2	1	2	1
CO5	2	2	2	1	2	1

References:

- Agnieszka Roginska, Paul Geluso, Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio by Routledge, 2017.
- Jean-Luc Sinclair, Principles of Game Audio and Sound Design: Sound Design and Audio, Implementation for Interactive and Immersive Media 1st Edition, Kindle Edition, 2020.

AV24B12	AR AND VR APPLICATIONS IN INDUSTRIES	3 Credits

Course Objectives:

This course explores the development and application of Augmented Reality (AR) and Virtual Reality (VR) in various industries, covering key components, interaction techniques, and design principles. Students will gain hands-on experience in using Unity and AR Foundation for building immersive applications with tracking, teleportation, gaze control, and object manipulation. The course also emphasizes usability, cognitive load management, and multi-user interactions while addressing legal, social, and human factors in AR/VR. By the end of the course, students will be able to design and implement AR/VR applications for diverse industry use cases such as gaming, healthcare, aerospace, and education.

Course Content:

Unit I: VR Application Components

Key components of a VR application: Environment, User, and Interaction - Software modules in VR applications - Sensory devices and coordination across senses.

Unit II: Device APIs and Integration

Overview of device APIs for AR/VR - Gaze control, tracking, and touch interactions - Pseudo-physics for VR applications - Measuring usability and immersion - Challenges in VR: Gulfs of execution and evaluation.

Unit III: Interaction and Navigation Techniques

Object manipulation and interaction in 3D spaces - Integration of traditional interfaces in VR applications - User locomotion techniques, wayfinding, and orientation in VR.

Unit IV: AR/VR Design Principles

Key design principles: Discoverability, affordances, perceptibility, constraints, and error tolerance - Recovering from tracking and sensing failures - Cognitive load in VR: Human perception and memory limitations - Multi-user VR and social interaction considerations.

Unit V: Industry Use Cases and Future Trends

AR/VR applications in Gaming, Entertainment, Architecture, Healthcare, Aerospace, and Education - Telerobotics and Telepresence - Human factors, legal, and social considerations in AR/VR - Future trends and advancements in AR/VR applications.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Evaluate the key features and user experiences of virtual reality (VR) and augmented reality (AR) environments.

CO2: Utilize device APIs and integration techniques for gaze, tracking, and touch to enhance usability and immersion in virtual reality environments.

CO3: Implement object manipulation, user locomotion, and wayfinding techniques to improve interaction and orientation in 3D virtual environments.

CO4: Apply design principles like affordances, error tolerance, and cognitive load management to create effective and user-friendly VR experiences.

CO5: Analyze use cases across sectors such as gaming, education, health, and aerospace to understand the legal, social, and human factors impacting AR/VR applications.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2	1	1
CO2	2	1	2	2	1	1
CO3	2	2	2	2	1	1
CO4	2	1	2	2	1	1
CO5	2	2	2	2	2	2

References:

- Aukstakalnis, S. (2016). Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR. Addison-Wesley Professional. ISBN: 9780134094328.
- Fowler, A. (2018). Beginning iOS AR Game Development: Developing Augmented Reality Apps with Unity and C#. Apress Publications. ISBN: 978-1484236178.
- Sherif, W. (2015). Learning C++ by Creating Games with UE4. Packt Publishing. ISBN: 978-1-78439-657-2.
- Glover, J., & Linowes, J. (2019). 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. ISBN: 978-1838648183.
- Linowes, J., & Babilinski, K. (2017). Augmented Reality for Developers: Build practical augmented reality applications with Unity, ARCore, ARKit, and Vuforia. Packt Publishing. ISBN: 978-1787286436.

AV24B13	AUGMENTED REALITY	3 Credits

Course Description:

This course provides an in-depth exploration of Augmented Reality (AR), covering its history, hardware, interaction techniques, and applications across various industries. Students will learn AR design principles, optical see-through displays, computer vision techniques, and interaction frameworks for AR systems. The course also covers mixed reality systems, human-robot interaction, and real-world AR applications in healthcare, sports, teleoperation, and creative design. By the end of the course, students will be able to develop and implement AR solutions using industry-standard technologies and design methodologies.

Course Content:

Unit I: Foundations of Augmented Reality

Introduction to Virtual Reality (VR) and Augmented Reality (AR) - History of AR and its evolution - AR use cases and designing for AR platforms - AR hardware and devices: Input and output systems - Optical see-through displays and eye tracking - Computer vision applications in AR.

Unit II: Interaction Design in Augmented Reality

AR interaction frameworks and embedded AR environments - Tangible interaction and auditory-induced presence in AR - Mixed interaction techniques for immersive AR experiences - Exertion-based interaction in AR systems.

Unit III: Mixed Reality Systems and Tracking

Mixed reality (MR) and outdoor MR systems - Multimodal excitatory interfaces and sensory integration - Tracking methods in mixed reality environments - Authoring tools and immersive MR - Collaborative AR and software engineering methods for AR.

Unit IV: Mixed Reality and Human-Robot Interaction (HRI)

Mixed reality applications in robotics - User-centered human-robot interaction (HRI) - Mental transformation and computational cognitive modeling in HRI - Evaluating usability in virtual environments - Security robots and AR-driven robotic interfaces.

Unit V: Applications of Augmented Reality

AR in healthcare and medical simulations - AR teleoperation interfaces for robotic systems - AR applications in psychological experimentation - AR in sports and performance analysis - AR prototypes for creative design and AR companion robots.

Course Outcomes

Upon successful completion of this course, the students will be able to

CO1: Design AR applications by utilizing the concepts of Virtual Reality (VR), Augmented Reality (AR), including their hardware, input/output systems, optical see-through displays, eye tracking, and computer vision.
CO2: Apply design principles and considerations specific to Augmented Reality platforms.
CO3: Develop interaction design principles in Augmented Reality to enhance user experience.
CO4: Apply software design and implementation skills for Augmented Reality systems.
CO5: Implement the integration of Augmented Reality technologies and principles into real-world applications.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	3	3	-
CO2	3	-	2	3	3	-
CO3	2	-	3	3	3	-
CO4	3	1	3	3	3	1
CO5	3	2	3	3	3	2

References:

- O'Connell, Kharis, “Designing for Mixed Reality”, O'Reilly Media, Inc, 2016.
- Dubois E, Gray P, Nigay L, “The engineering of mixed reality systems” Springer Science & Business Media, 2009.
- Wang, Xiangyu, “Mixed reality and human-robot interaction”. Vol. 47. Springer Science & Business Media, 2011.
- Benyon, D, “Designing Interactive Systems: A Comprehensive Guide to HCI, UX and Interaction Design”. Third Edition, Pearson Education Limited, 2013.

AV24B14	MOBILE AR AND VR	3 Credits

Course Description:

This course introduces mobile Augmented Reality (AR) and Virtual Reality (VR) technologies, focusing on application development, interaction design, and user experience optimization. Students will gain hands-on experience with Unity XR, headset and controller tracking, locomotion techniques, and user interaction models to create immersive mobile AR/VR applications. The course also covers best practices for optimizing user experience (UX), preventing motion sickness, and integrating real-world interaction elements into mobile VR environments. By the end of the course, students will be able to develop, optimize, and evaluate mobile AR/VR applications across various use cases and industry domains.

Course Content:

Unit I: Introduction to Mobile AR/VR

Fundamentals of Mobile AR and VR - Applications and use cases across industries - Differences between mobile AR, VR, and Mixed Reality (MR).

Unit II: Mobile VR Development with Unity

Unity XR framework for mobile VR development - Headset and controller tracking in mobile VR - Addressing tracking loss and optimizing tracking stability - Unity core APIs for XR functionality.

Unit III: Interaction and Locomotion in Mobile VR

Object interaction, scene exploration, and movement in VR - Teleportation, grabbing, and throwing interactions - Preventing motion sickness: Avoiding nausea and dizziness in VR environments.

Unit IV: VR UX Design with the Unity API

Text readability challenges in VR environments - Optimizing UI elements and attaching displays to controllers - Enhancing user interaction with canvas elements and constrained object tracking.

Unit V: Advanced UX Design for Mobile AR/VR

Object interactions and dynamic UX design in AR/VR - Creating user-friendly virtual controls that mimic real-world interactions - Triggering canvas events from ray casts and optimizing UX for mobile platforms.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Identify applications and use cases of mobile AR and VR technologies in various fields.
CO2: Implement Unity XR features, including headset and controller tracking, to develop immersive mobile VR experiences.
CO3: Design interactions and locomotion methods in VR, focusing on user comfort to prevent nausea and dizziness.
CO4: Apply Unity API techniques to optimize text readability and user interaction within VR environments.
CO5: Evaluate user experiences that include interactive elements, such as hitting objects and virtual controls that mimic real-world actions.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	1	1	1
CO2	2	2	2	2	2	1
CO3	2	2	2	2	2	1
CO4	2	2	2	2	2	1
CO5	3	2	2	2	2	2

References:

- Greengard, S. (2019). Virtual Reality. MIT Press.
- Nebling, M. Developing AR/VR/MR/XR Apps with WebXR, Unity & Unreal. University of Michigan, https://www.coursera.org/learn/develop-augmented-virtual-mixed-extended-reality-applications-webxr-unity-unreal.
- Patterson, P. Mobile VR App Development with Unity. Unity Technologies, https://www.coursera.org/learn/mobile-vr-app-development-unity.

CLUSTER C: WEB APPLICATION DEVELOPMENT

AV24C11	SPATIAL COMPUTING	3 Credits

Course Description

This course introduces the fundamental concepts of spatial computing, focusing on spatial audio capture, rendering processes, and their applications in AR/VR environments. Students will explore the evolution of audio technology from traditional systems to immersive spatial audio, covering topics such as auditory perception, ambisonics, binaural audio, and head-related transfer functions (HRTF). The course also emphasizes practical use cases of spatial audio in AR/VR applications, including gaming, event simulation, and immersive walkthroughs. By the end of the course, students will be able to analyse, design, and implement spatial computing solutions for immersive audio experiences.

Course Content:

Unit I: Importance of Audio in AR/VR

Introduction to spatial audio and its evolution - Traditional channel-based audio vs. immersive spatial audio - Role and significance of spatial audio in AR/VR experiences.

Unit II: Auditory Events and Spatial Perception

Audio as a physical phenomenon and its properties - Spatial hearing and perception cues - Time and level differences for audio localization - Auditory events and vector-based panning models (loudness, directionality, vector models).

Unit III: Ambisonics and Recording Techniques

Fundamentals of ambisonics: Recording techniques and storage formats - Basics of spherical harmonic analysis - Format conversion and ambisonics rendering engines - Practical applications of ambisonics in AR/VR environments.

Unit IV: Audio Rendering and Binaural Techniques

Introduction to binaural audio - Head-Related Transfer Function (HRTF): Basics, measurement, and applications - Integration of HRTF in audio rendering for immersive environments - Technologies for binaural audio reproduction.

Unit V: Use Cases of Spatial Audio in AR/VR

Immersive walkthroughs and 3D soundscapes - Spatial audio applications in gaming and interactive environments - Real-time event simulation using spatial audio - Future advancements and trends in spatial computing.

Course Outcome:

Upon successful completion of this course, the students will be able to
CO1: Explain the evolution of audio technology from traditional channel-based audio to immersive spatial audio and its significance in enhancing AR/VR experiences.
CO2: Analyse auditory events by examining the properties of hearing and spatial cues that contribute to audio perception, including loudness and directionality.
CO3: Apply knowledge of ambisonics, including recording techniques, spherical harmonic analysis, format conversion, and ambisonics rendering engines.
CO4: Apply the principles of binaural audio and HRTF to render immersive audio experiences effectively.
CO5: Evaluate various use cases for spatial audio in immersive AR/VR applications.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	1	1	1
CO2	2	2	1	2	1	1
CO3	1	2	1	1	1	1
CO4	1	2	1	1	1	1
CO5	2	2	2	2	2	2

References:

- Zotter, F., & Frank, M. (2019). Ambisonics: A Practical 3D Audio Theory for Recording, Studio Production, Sound Reinforcement, and Virtual Reality. Springer Nature.
- Rumsey, F. (2012). Spatial Audio. Routledge Publisher.

AV24C12	INTERNET OF THINGS	3 Credits

Course Description:

This course provides a foundational understanding of IoT concepts, architectures, protocols, and applications, covering domain-specific IoT implementations and Machine-to-Machine (M2M) communication. Students will explore IoT reference architectures, communication protocols, and cloud-based service development for IoT applications. The course also includes hands-on experience with Raspberry Pi, integrating sensors, managing data, and developing real-world IoT projects. By the end of this course, students will be able to design, develop, and deploy IoT solutions using cloud platforms and embedded systems.

Course Content:

Unit I: Introduction to IoT

Overview of the Internet of Things (IoT) - Domain-specific IoT applications - IoT and Machine-to-Machine (M2M) communication - Sensors and their role in IoT applications - IoT system management with NETCONF-YANG.

Unit II: IoT Architecture Generations and Protocols

IETF architecture for IoT - IoT reference architecture - First-generation IoT: Description and characteristics - Advanced-generation IoT: Description and characteristics - Integrated IoT sensors: Features and applications.

Unit III: IoT Protocols and Technology

Supervisory Control and Data Acquisition (SCADA) and RFID protocols - BACNet Protocol and Zigbee architecture - 6LoWPAN and CoAP - Wireless sensor network architecture and components - Energy storage, power management, RF, and sensing modules.

Unit IV: Cloud Architecture for IoT

Cloud computing models: IaaS, PaaS, SaaS - Development environments for IoT services - Industry platforms: Amazon Web Services (AWS), Microsoft Azure, Google Cloud - Cloud integration for IoT solutions.

Unit V: IoT Projects with Raspberry Pi

IoT application development using Raspberry Pi - Creating sensor-based IoT projects - Interfacing sensors with Raspberry Pi - Data storage, processing, and real-time data visualization - Exporting sensor data for cloud applications.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Describe the Internet of Things (IoT), including domain-specific applications, the role of M2M communication, and IoT system management techniques.

CO2: Explain the evolution of IoT architecture and analyze various communication protocols used in IoT solutions.

CO3: Evaluate different IoT protocols and technologies to determine their suitability for specific IoT applications.

CO4: Identify cloud computing services and platforms for building scalable and efficient IoT applications.

CO5: Design and implement IoT projects using Raspberry Pi, focusing on sensor integration, data representation, and cloud-based data export.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	1	1	1
CO2	1	2	1	1	1	1
CO3	2	2	1	2	1	1
CO4	1	2	1	1	1	1
CO5	2	2	1	2	1	1

References:

- Arshdeep Bahga, Vijay Madisetti, Internet of Things: A hands-on approach, Universities Press, 2015.
- Dieter Uckelmann, Mark Harrison, Florian Michahelles (Eds), Architecting the Internet of Things, Springer, 2011.
- Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015.
- Ovidiu Vermesan Peter Friess, 'Internet of Things – From Research and Innovation to Market Deployment', River Publishers, 2014.
- N. Ida, Sensors, Actuators and Their Interfaces: A Multidisciplinary Introduction, 2nd EditionScitech Publishers, 2014.
- Reese, G. (2009). Cloud Application Architectures: Building Applications and Infrastructure in the Cloud. Sebastopol, CA: O'Reilly Media, Inc. (2009).

AV24C13	WEB TECHNOLOGIES	3 Credits

Course description:

This course provides a comprehensive understanding of modern web technologies, covering front-end and back-end development, client-server communication, and web application frameworks. Students will learn HTML5, CSS3, JavaScript, PHP, XML, and AngularJS, along with server-side programming using Java Servlets and JSP. The course also introduces web frameworks like Firebase, Node.js, Django, and React, enabling students to build dynamic, interactive, and scalable web applications. By the end of the course, students will be able to develop full-stack web applications using modern web technologies and frameworks.

Course Content:

Unit I: Website Basics, HTML5, CSS3, and Web 2.0

Web Essentials: Clients, servers, and communication protocols - HTTP request and response messages - HTML5: Tables, lists, images, control elements, drag and drop, audio, and video - CSS3: Styling, rule cascading, inheritance, transformations, transitions, and animations - Introduction to the Bootstrap framework.

Unit II: Client-Side Programming

JavaScript: DOM model, exception handling, validation, built-in objects - Event handling and dynamic HTML (DHTML) - Introduction to JSON: Syntax, functions, and file handling

Unit III: Server-Side Programming

Java Servlets: Architecture, lifecycle, form GET and POST methods, session handling - Understanding cookies and their role in web applications - Database connectivity: Introduction to JDBC.

Unit IV: PHP and XML for Web Development

PHP: Variables, program control structures, built-in functions, and form validation - XML: Basics, Document Type Definition (DTD), XML Schema, XML Parsers, and validation - XSL for XML data representation.

Unit V: AngularJS and Web Application Frameworks

Introduction to AngularJS: MVC architecture, expressions, data binding, directives, controllers, filters, forms, routers, modules, and services - Overview of modern web application frameworks and tools: Firebase, Docker, Node.js, React, Django - UI/UX considerations in web development.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Construct a basic website using HTML5 and CSS3 for structured and visually appealing web content.

CO2: Build dynamic web pages with JavaScript, incorporating event handling, validation, and JSON data manipulation.

CO3: Develop server-side programs using Java Servlets and JSP for secure, data-driven web applications.

CO4: Create interactive web applications using PHP and represent structured data using XML.

CO5: Implement web applications using AngularJS and modern frameworks like Node.js, Firebase, and Django.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	1	1	3
CO2	2	2	3	1	2	1
CO3	2	2	2	2	2	1
CO4	2	2	3	1	2	1
CO5	2	2	2	2	1	2

References:

- Deitel and Deitel and Nieto, Internet and World Wide Web – How to Program, Prentice Hall, 5th Edition, 2011.
- Jeffrey C and Jackson, Web Technologies A Computer Science Perspective, Pearson Education, 2011.
- Angular 6 for Enterprise-Ready Web Applications, Doguhan Uluca, 1st edition, Packt Publishing.
- Stephen Wynkoop and John Burke Running a Perfect Websitell, QUE, 2nd Edition,1999.
- Chris Bates, Web Programming – Building Intranet Applications, 3rd Edition, WileyPublications, 2009.
- Gopalan N.P. and Akilandeswari J., Web Technologyl, Prentice Hall of India, 2011.
- UttamK.Roy, Web Technologiesl, Oxford University Press, 2011.
- Angular: Up and Running: Learning Angular, Step by Step, Shyam Seshadri, 1st edition, O'Reilly.

AV24C14	THERAPEUTIC APPLICATIONS OF AR AND VR IN COGNITIVE AND PSYCHOLOGICAL HEALTH	3 Credits

Course Description:

This course explores the role of Augmented Reality (AR) and Virtual Reality (VR) in psychological therapy and cognitive rehabilitation. Students will examine the neurophysiological impact of immersive environments, the integration of EEG sensors and biofeedback, and the application of AR/VR in mental health interventions. The course covers cognitive-behavioral therapy (CBT), VR exposure therapy, and adaptive feedback systems to create personalized therapeutic experiences. By the end of this course, students will be able to analyze, design, and evaluate AR/VR-based therapeutic solutions for mental health conditions, including anxiety, PTSD, and cognitive training.

Course Content:

Unit I: Introduction to AR/VR in Therapy

Overview of AR/VR applications in mental health and therapy - Evolution of AR/VR technology in psychological treatments - Personalized therapeutic environments - AR/VR applications for depression, trauma, and stress-related disorders - Case studies: Anxiety, PTSD, and phobia treatments using AR/VR.

Unit II: Neurophysiological Impact of AR/VR

Brain-Computer Interfaces (BCI) and EEG sensors in therapy - Cognitive load and emotional states in immersive environments - Effects of sensory stimulation on neural pathways - AR/VR-induced neuroplasticity for cognitive enhancement - Emotional regulation and stress reduction through VR therapy.

Unit III: Cognitive Processes and Behavioral Changes

Cognitive Behavioral Therapy (CBT) using VR - VR exposure therapy for psychological rehabilitation - Role of AR/VR in cognitive load management and attention training - Psychological and emotional responses to virtual stimuli.

Unit IV: Feedback Mechanisms and Adaptive Systems

Integration of biofeedback in AR/VR therapy - Real-time physiological monitoring in immersive environments - Adaptive feedback loops using heart rate, brain activity, and behavioral data - Designing personalized and data-driven therapeutic experiences.

Unit V: Ethics, Challenges, and Future Directions

Ethical considerations in AR/VR-based psychological treatments - Implementation challenges in VR/AR therapy - Technological advancements in AR/VR therapy - Future trends in digital mental health interventions.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Explain the impact of AR and VR on psychological therapy, cognitive functions, and emotional well-being.

CO2: Evaluate the effectiveness of EEG and biofeedback integration in VR/AR therapeutic applications.

CO3: Design AR/VR-based therapeutic environments using adaptive feedback systems.

CO4: Assess ethical concerns and implementation challenges in AR/VR-based psychological therapies.

CO5: Investigate future possibilities and advancements in AR/VR applications for cognitive and psychological health.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	2	1	1
CO2	3	2	2	2	2	1
CO3	2	3	2	2	2	2
CO4	2	3	2	1	2	2
CO5	3	2	3	1	2	1

References:

- Wiederhold, B. K., & Wiederhold, M. D. (2005). Virtual reality therapy for anxiety disorders: Advances in evaluation and treatment. American Psychological Association. https://doi.org/10.1037/10858-000.
- Riva G. Virtual Reality in Clinical Psychology. Comprehensive Clinical Psychology. 2022:91–105. doi: 10.1016/B978-0-12-818697-8.00006-6. Epub 2022 Apr 12. PMCID: PMC7500920.
- Schultheis, M. T., & Rizzo, A. A. (2001). The application of virtual reality technology in rehabilitation. Rehabilitation Psychology, 46(3), 296–311. https://doi.org/10.1037/0090-5550.46.3.296.

CLUSTER D: GAME MODELLING & VIRTUAL PRODUCTION

AV24D11	3D GAME MODELLING AND RENDERING	3 Credits

Course Description:

This course provides a comprehensive understanding of 3D game modeling, rendering techniques, and game design principles, emphasizing the use of OpenGL, DirectX, and other industry-standard frameworks. Students will learn mathematical concepts for 2D and 3D transformations, character modeling techniques, shading models, and level design principles. The course also explores game engines, AI-driven mechanics, collision detection, and interactive game development for multiple platforms. By the end of this course, students will be able to develop engaging and interactive 2D and 3D games using advanced graphics and rendering techniques

Course Content:

Unit I: Mathematics for 3D Modeling and Rendering

Vector tools and polar coordinates for game environments - Representation of geometric objects: Intersection of lines, planes, and polygons - Clipping algorithms for real-time graphics - 2D and 3D affine transformations - 3D viewing and rendering pipeline - Camera movements and perspective transformation - Introduction to OpenGL programming.

Unit II: Character Modeling and Shading

Solid modeling concepts: Polyhedra, extruded shapes, tessellation - Mesh approximation of smooth objects - Bezier curves, B-splines, and NURBS for character animation - Hierarchical modeling for animation - Shading models: Flat shading, smooth shading, reflections - Antialiasing and dithering techniques - Applying real-world lighting and reflections using OpenGL

Unit III: Game Design Principles and AI

Storytelling and narration in game design - Game balancing and core mechanics - Principles of level design and genres of games - Collision detection and game physics - Game AI concepts: Pathfinding, renderers, software vs. hardware rendering - Controller-based animation and spatial sorting for real-time interaction.

Unit IV: Gaming Platforms and Development Frameworks

Overview of gaming platforms: OpenGL, DirectX, Java, Python, XNA with Visual Studio - Mobile game development: Android and iOS - Game engines: Unity, Adventure Game Studio, DXStudio - Comparison of real-time rendering techniques across platforms.

Unit V: Game Development and Implementation

Developing 2D and 3D interactive games using OpenGL and DirectX - Isometric and tile-based games - Implementing puzzle games and physics-driven mechanics - Optimization techniques for real-time rendering.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Apply mathematical concepts and techniques in 2D and 3D graphics modeling and rendering using OpenGL.

CO2: Build character models using various solid modeling techniques and shading models, incorporating color, reflections, and antialiasing methods in OpenGL.

CO3: Analyze core game design principles, including storytelling, game mechanics, and collision detection, to develop engaging and balanced gameplay experiences.

CO4: Compare various gaming platforms and frameworks, such as OpenGL and Unity, to understand their applications in game development across different devices.

CO5: Develop interactive 2D and 3D games using OpenGL and DirectX, focusing on gameplay mechanics, user interactions, and puzzle design.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	2	1	1
CO2	2	2	1	2	1	1
CO3	2	2	2	2	1	1
CO4	1	2	1	1	1	1
CO5	2	2	1	2	2	1

References:

- David H. Eberly, “3D Game Engine Design, Second Edition: A Practical Approach to Real Time Computer Graphics” Morgan Kaufmann, 2nd Edition, 2006.
- Donald Hearn, M. Pauline Baker, “Computer Graphics with OpenGL”, 3rd Edition, Pearson Education, 2012.
- Ernest Adams and Andrew Rollings, “Fundamentals of Game Design”, Prentice Hall 1st edition, 2006.
- F.S. Hill Jr., Stephen Kelly, “Computer Graphics Using OpenGL”, 3rd Edition, Persons Education/PHI Learing, 2007.
- Jonathan S. Harbour, “Beginning Game Programming”, Course Technology PTR, 3rd edition, 2009.
- Jung Hyun Han, “3D Graphics for Game Programming”, Chapman and Hall/CRC, 1st edition, 2011.
- Mike Mc Shaffrfy, “Game Coding Complete”, Third Edition, Charles River Media, 2009.
- Roger E. Pedersen, “Game Design Foundations”, Edition 2, Jones & Bartlett Learning, 2009.
- Scott Rogers, “Level Up!: The Guide to Great Video Game Design”, Wiley, 1st edition, 2010.

AV24D12	3D SHAPE ANALYSIS	3 Credits

Course Description:

This course explores the fundamental principles of 3D shape analysis, covering differential geometry, 3D acquisition techniques, shape descriptors, and local feature detection for real-world applications. Students will learn how to analyze and manipulate 3D models, employ various shape-preserving transformations, and use deep learning-based shape descriptors for recognition tasks. The course also delves into feature extraction, key point detection, and semantic applications in fields such as computer vision, medical imaging, and augmented reality. By the end of the course, students will be able to apply 3D shape analysis techniques to face recognition, object recognition, and scene understanding.

Course Content:

Unit I: Foundations of 3D Shape Analysis

Elements of differential geometry - Parametric curves and continuous surfaces - Manifolds, metrics, and geodesics - Shape transformations and deformations (bending, stretching) - Shape-preserving transformations in 3D models.

Unit II: 3D Acquisition and Preprocessing

3D acquisition techniques: Contact-based and non-contact-based - Time-of-flight, triangulation, stereo vision, structured light - Preprocessing 3D models: Surface smoothing and fairing - Spherical parameterization of 3D surfaces.

Unit III: 3D Shape Descriptors

Distribution-based descriptors: Point sampling, geometric features - Signature construction and comparison for 3D models - View-based 3D shape descriptors - Spherical function-based descriptors - Deep learning-based 3D descriptors.

Unit IV: Local Shape Descriptors and Feature Extraction

Challenges in 3D keypoint detection - Fixed-scale vs. adaptive-scale keypoint detection - Local feature description techniques - Feature aggregation using Bag-of-Feature techniques.

Unit V: Applications of 3D Shape Analysis

3D semantic applications - 3D face recognition techniques - Object recognition in 3D scenes - Real-world applications in AR/VR and medical imaging.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Apply differential geometry principles, including parametric curves and shape transformations, for analyzing 3D shape structures.
CO2: Analyze various 3D acquisition techniques and preprocessing methods to refine and enhance 3D models.
CO3: Employ distribution-based, geometric, and deep learning-based 3D shape descriptors to compare and classify 3D shapes.
CO4: Utilize local shape descriptors and feature extraction techniques for 3D object recognition and scene understanding.
CO5: Implement 3D shape analysis techniques in practical applications, including face recognition, object recognition, and semantic analysis in AR/VR.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	2	1	1
CO2	2	2	2	2	1	1
CO3	2	2	1	2	1	1
CO4	2	2	1	2	1	1
CO5	2	2	2	2	2	1

References:

- Ward, M., Grinstein, G., & Keim, D. (2010). Interactive Data Visualization: Foundations, Techniques, Applications.
- Ware, C. (2021). Information Visualization: Perception for Design (4th ed.). Morgan Kaufmann Publishers.
- Spence, R. (2007). Information Visualization – Design for Interaction (2nd ed.). Pearson Education.
- Telea, A. C. (2008). Data Visualization: Principles and Practice. A. K. Peters Ltd.

AV24D13	NEURAL IMAGE SYNTHESIS FOR AR/VR	3 Credits

Course Description:

This course explores deep generative methods for image synthesis, focusing on modern neural and differentiable rendering techniques for Augmented Reality (AR) and Virtual Reality (VR) applications. Students will learn about Generative Adversarial Networks (GANs), Variational Autoencoders (VAEs), Neural Radiance Fields (NeRF), and differentiable rendering, along with their use in creating realistic and immersive visual environments. The course also covers neural antialiasing, deep foveated rendering, and inverse rendering techniques to enhance realism in AR/VR applications. By the end of the course, students will be able to develop high-quality synthesized images for immersive and interactive AR/VR experiences.

Course Content:

Unit I: Introduction to Image Synthesis

Classical image synthesis techniques - Global illumination with path tracing - Image-based rendering and its applications.

Unit II: Generative Models for Image Synthesis

Neural and differentiable rendering approaches - Generative models: GANs and VAEs - Neural scene representation and rendering - Neural Radiance Fields (NeRF) and differentiable rendering.

Unit III: Image Synthesis for AR/VR

Techniques for generating immersive AR/VR images - Spherical (360°) panoramas and environment mapping - High-fidelity image synthesis in mixed reality.

Unit IV: Neural Antialiasing and Rendering Optimization

Neural antialiasing techniques for enhanced image clarity - Vergence-Accommodation Conflict and its impact on AR/VR - Deep foveated rendering for computational efficiency.

Unit V: Advanced Rendering Techniques

Inverse rendering and its applications in AR/VR - Neural rendering of point clouds for 3D scene synthesis - Future trends in AI-driven rendering for immersive media.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Utilize classical image synthesis techniques, neural rendering, and differentiable approaches for enhanced realism in AR/VR environments.
CO2: Analyze generative models such as GANs and VAEs for image synthesis, focusing on neural scene representation, rendering, and neural radiance fields.
CO3: Apply image synthesis techniques to create immersive virtual and augmented reality environments that enhance visual experience in AR/VR systems.
CO4: Implement neural antialiasing methods and address visual challenges such as the Vergence-Accommodation Conflict to improve clarity and performance in immersive experiences.
CO5: Employ advanced rendering techniques, including inverse rendering and neural rendering of point clouds, to generate high-quality images for complex AR/VR applications.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	2	1	1
CO2	2	2	2	2	1	1
CO3	2	2	1	2	1	1
CO4	2	2	2	2	1	1
CO5	2	2	2	2	1	1

References:

- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.
- Tewari, A., Elgharib, M., Bernard, F., Seidel, H. P., Pons-Moll, G., & Theobalt, C. (2020). Neural Rendering: Taxonomy, Applications, and Future Directions. arXiv preprint arXiv:2004.03805.
- Karras, T., Laine, S., & Aila, T. (2019). A Style-Based Generator Architecture for Generative Adversarial Networks. IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR).
- Mildenhall, B., Srinivasan, P. P., Tancik, M., Barron, J. T., Ramamoorthi, R., & Ng, R. (2021). NeRF: Representing Scenes as Neural Radiance Fields for View Synthesis. Communications of the ACM.
- Tulsiani, S., Efros, A. A., Malik, J., & Gupta, A. (2018). Learning Shape Abstractions by Assembling Volumetric Primitives. IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR).

AV24D14	VR FILMING AND VIRTUAL PRODUCTION	3 Credits

Course Description:

This course introduces students to the fundamentals of VR filming and virtual production, covering techniques for capturing, editing, and distributing immersive video content. Students will learn how to set up VR cameras, shoot 180° and 360° videos, edit VR footage, and integrate virtual production tools for realistic environments. The course also explores motion capture, real-time rendering, and post-production workflows for VR storytelling. By the end of the course, students will be able to produce high-quality VR films and prepare content for various platforms like Oculus and YouTube VR.

Course Content:

Unit I: Introduction to VR Filming

Overview of VR filming and production techniques - Types of VR cameras and their applications (180°, 360°) - Basic principles of VR storytelling and scene composition.

Unit II: Camera Setup and Capture Techniques

Setting up VR cameras for monoscopic and stereoscopic capture - Camera placement, movement, and spatial considerations in VR - Techniques for capturing spatial audio.

Unit III: Editing in VR

Introduction to 180° and 360° monoscopic editing - VR editing software (e.g., Adobe Premiere, Final Cut Pro) - Basic color correction and spatial audio editing for immersive experiences.

Unit IV: Virtual Production Techniques

Overview of virtual production tools (e.g., Unreal Engine, Unity) - Motion capture and real-time rendering for VR filmmaking - Integration of green screen and virtual backgrounds.

Unit V: Post-Production and Distribution

Advanced post-production techniques (e.g., stitching, compositing) - Preparing VR content for platforms like Oculus, YouTube VR, and social media - Challenges and future trends in VR filmmaking and content distribution.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Explain VR filming principles and the unique challenges of VR storytelling.

CO2: Set up and configure VR camera systems for immersive video production.

CO3: Edit and enhance VR video using industry-standard editing software.

CO4: Utilize virtual production tools to create realistic and interactive VR environments.

CO5: Prepare and optimize VR content for various platforms and distribution channels.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	1	1
CO2	3	2	3	1	2	1
CO3	2	3	2	2	1	2
CO4	2	2	2	3	1	2
CO5	3	2	3	2	2	1

References:

- Millerson, G., & Owens, J. (2008). Video Production Handbook. Germany: Focal Press.
- Glover, J., & Linowes, J. (2019). 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 Ltd.
- Tricart, C. (2017). Virtual Reality Filmmaking: Techniques & Best Practices for VR Filmmakers (1st ed.). Routledge. https://doi.org/10.4324/9781315280417.
- Bucher, J. (2017). Storytelling for Virtual Reality: Methods and Principles for Crafting Immersive Narratives (1st ed.). Routledge. https://doi.org/10.4324/9781315210308.

CLUSTER E: NEXTGEN TECHNOLOGIES

AV24E11	OPERATING SYSTEMS	3 Credits

Course Objectives:

This course provides a comprehensive introduction to the core concepts of operating systems, including process management, memory management, storage systems, and virtualization. Students will explore CPU scheduling, process synchronization, deadlock handling, file system functionalities, and input/output (I/O) system management. Additionally, the course covers virtual memory management, mass storage techniques, virtualization, and mobile operating systems such as iOS and Android. By the end of the course, students will be equipped with the analytical and practical skills needed to evaluate and implement key operating system components in real-world applications.

Course Content:

Unit I: Introduction to Operating Systems

Overview of operating systems and their evolution - Operating system structures and services - User operating system interface and system calls - System programs and OS design methodologies - Structuring methods for operating systems.

Unit II: Process Management and Scheduling

Process concepts, scheduling, and operations - Inter-process communication and synchronization - CPU scheduling: Scheduling criteria and algorithms - Threads, multithreading models, and threading issues - Process synchronization: Critical-section problem, semaphores, and monitors - Deadlocks: Prevention, avoidance, detection, and recovery).

Unit III: Memory Management and Virtual Memory

Main memory management and allocation strategies - Paging and segmentation techniques - Virtual memory and demand paging - Page replacement algorithms and thrashing prevention - Copy-on-write and frame allocation.

Unit IV: Storage Management and File Systems

Mass storage systems: Disk structure and scheduling - File system interface: Concepts, access methods, and directory structures - File system implementation: Allocation methods, free space management - I/O systems: I/O hardware, kernel subsystems, and application I/O interfaces.

Unit V: Virtualization and Mobile Operating Systems

Virtual machines: History, benefits, and features - Types of virtual machines and their implementations - Virtualization techniques and OS components - Mobile operating systems: iOS and Android architecture - Security, challenges, and future trends in mobile OS.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Analyze and compare different scheduling algorithms and process synchronization techniques.

CO2: Implement and evaluate deadlock prevention, avoidance, and recovery algorithms.

CO3: Compare and contrast memory management strategies, including paging, segmentation, and virtual memory.

CO4: Evaluate the functionalities of file systems, I/O subsystems, and virtualization.

CO5: Compare the architecture, features, and functionalities of iOS and Android operating systems.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	1	2
CO2	2	2	3	2	2	2
CO3	2	1	3	2	1	2
CO4	3	2	3	2	1	2
CO5	2	1	2	2	1	2

References:

- Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, “Operating System Concepts”, 10th Edition, John Wiley and Sons Inc., 2018.
- Andrew S Tanenbaum, "Modern Operating Systems", Pearson, 5th Edition,2022
- New Delhi.
- Ramaz Elmasri, A. Gil Carrick, David Levine, “Operating Systems – A
- Spiral Approach”, Tata McGraw Hill Edition, 2010.
- William Stallings, "Operating Systems: Internals and Design Principles", 7th Edition, Prentice Hall, 2018.

AV24E12	MACHINE LEARNING	3 Credits

Course Description:

This course provides a comprehensive introduction to machine learning, covering supervised, unsupervised, and deep learning techniques. Students will explore linear and logistic regression, decision trees, clustering, feature selection, and neural networks, along with optimization techniques such as gradient descent. The course also delves into generative models, statistical learning theory, and deep learning architectures including CNNs and RNNs. By the end of this course, students will be able to apply machine learning algorithms to real-world problems, optimize models, and enhance predictive accuracy.

Course Content:

Unit I: Supervised Learning

Introduction to machine learning and different types of learning - Linear regression and logistic regression - Gradient descent: Stochastic gradient descent (SGD) and sub-gradients - Support Vector Machines (SVM): Hard SVM, Soft SVM, optimality conditions, kernel trick - Implementing Soft SVM with kernels.

Unit II: Decision Trees and Backpropagation

Decision tree algorithms and random forests - Neural networks: Feedforward neural networks, expressive power of neural networks - Stochastic gradient descent (SGD) and backpropagation - Model selection and validation: k-fold cross-validation, training-validation-testing split - Regularization and loss minimization).

Unit III: Unsupervised Learning

k-Nearest Neighbour (k-NN) and the curse of dimensionality - Clustering techniques: Linkage-based clustering, k-means, spectral clustering - Dimensionality reduction: Principal Component Analysis (PCA), random projections, compressed sensing.

Unit IV: Generative Models

Maximum likelihood estimator, Naive Bayes, and Linear Discriminant Analysis - Expectation-Maximization (EM) algorithm and Bayesian learning - Feature selection, transformation, and feature learning.

Unit V: Computational Learning Theory and Deep Learning

Statistical learning framework: PAC learning, Agnostic PAC learning, Bias-complexity tradeoff - No free lunch theorem, VC dimension, and structural risk minimization - Boosting techniques: AdaBoost - Foundations of deep learning: Deep Neural Networks (DNN), Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN), and Autoencoders.

Course Outcomes:

After the successful completion of this course, the students will be able to

CO1: Apply supervised learning techniques such as regression, gradient descent, and SVM to real-world problems.

CO2: Build decision trees, random forests, and neural networks using stochastic gradient descent and backpropagation.

CO3: Implement unsupervised learning methods for clustering and dimensionality reduction.

CO4: Utilize generative models for probabilistic inference and perform feature selection and transformation.

CO5: Analyse computational learning theories and implement deep learning architectures such as DNNs, CNNs, and RNNs.

Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	2	1	1
CO2	2	2	2	1	1	1
CO3	2	2	2	2	2	1
CO4	2	2	1	1	2	1
CO5	2	2	2	1	1	1

References:

- Shalev-Shwartz,S, Ben-David,S., (2014), Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press.
- Mitchell Tom (1997). Machine Learning, Tata McGraw-Hill.
- Marco Gori, Machine Learning: A Constraint-Based Approach, Morgan Kaufmann. 2017.
- Ethem Alpaydin, Machine Learning: The New AI, MIT Press-2016.

AV24E13	CLOUD COMPUTING TECHNOLOGIES	3 Credits

Course Description:

This course provides a comprehensive introduction to cloud computing, covering virtualization, cloud architecture, cloud platforms, and programming models. Students will learn about various virtualization techniques, cloud deployment models, and cloud services such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). The course includes hands-on exposure to Amazon Web Services (AWS), Windows Azure, Hadoop, and Aneka for cloud application development. By the end of the course, students will be able to design, deploy, and manage cloud-based solutions for various real-world applications.

Course Content:

Unit I: Virtualization and Virtualization Infrastructure

Introduction to virtualization and virtual machines: Process vs. System Virtual Machines - Virtualization techniques: Emulation, Interpretation, Binary Translation - Virtualization architectures: Hardware Maximization, Storage Virtualization, Network Virtualization - Virtualization management, resource allocation, and automation in data centers.

Unit II: Cloud Platform Architecture

Fundamentals of cloud computing: Definition, characteristics, and benefits - Cloud deployment models: Public, Private, Hybrid, and Community clouds - Cloud computing service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), - Software as a Service (SaaS) - Architectural design challenges in cloud computing.

Unit III: AWS Cloud Platform – IaaS

Overview of AWS infrastructure, APIs, and management console - Storage management in AWS: Elastic Compute Cloud (EC2), AWS Lambda, AWS S3 - AWS Developer Tools: CodeCommit, CodeBuild, CodeDeploy, CodePipeline - AWS Management Tools: CloudWatch, Auto Scaling, Control Tower, CloudTrail.

Unit IV: PaaS Cloud Platform – Windows Azure

Introduction to Windows Azure and its architecture - Azure services: Compute, Storage, Networking, and Security - Service management API and developer portal - Azure storage services: REST API, Blob storage, and file systems.

Unit V: Programming Models for Cloud Computing

Introduction to Hadoop framework and its architecture - MapReduce programming model: Input splitting, Map and Reduce functions, output configuration - Hadoop file system design and cluster setup - Aneka Cloud Application Platform: Thread Programming, Task Programming, and MapReduce.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Explain virtualization concepts, including virtual machines and their implementation techniques such as emulation, interpretation, and binary translation.

CO2: Analyze cloud computing architecture, deployment models, and design challenges related to Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).

CO3: Demonstrate proficiency in AWS cloud infrastructure, utilizing various AWS management and developer tools for implementing cloud-based services.

CO4: Develop cloud applications using Windows Azure services, leveraging storage services and API-based cloud management.

CO5: Implement cloud computing solutions using the Hadoop and Aneka frameworks for large-scale data processing and analytics.

Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	1	1
CO2	2	2	2	1	1	2
CO3	2	1	1	1	1	1
CO4	2	2	2	1	1	2
CO5	2	2	2	1	1	2

References:

- Bernard Golden, Amazon Web Service for Dummies, John Wiley & Sons, 2013.
- Raoul Alongi, AWS: The Most Complete Guide to Amazon Web Service from Beginner to Advanced Level, Amazon Asia- Pacific Holdings Private Limited, 2019.
- Sriram Krishnan, Programming: Windows Azure, O'Reilly,2010.
- Rajkumar Buyya, Christian Vacchiola, S.Thamarai Selvi, Mastering Cloud Computing , MCGraw Hill Education (India) Pvt. Ltd., 2013.
- Danielle Ruest, Nelson Ruest, "Virtualization: A Beginner‟s Guide‖, McGraw-Hill Osborne Media, 2009.
- Jim Smith, Ravi Nair, "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005.
- John W.Rittinghouse and James F.Ransome, "Cloud Computing: Implementation, Management, and Security", CRC Press, 2010.
- Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach", McGraw-Hill Osborne Media, 2009.

AV24E14	DATA VISUALIZATION	3 Credits

Course Description:
This course provides a comprehensive introduction to data visualization, covering fundamental principles, perception theories, visualization techniques, and interaction models. Students will learn about various data representation techniques, including spatial, geospatial, multivariate, hierarchical, and textual visualizations. The course also explores interaction techniques, system design challenges, and emerging research directions in large-scale data visualization. By the end of the course, students will be able to design, develop, and critique effective visual representations of complex data sets.

Course Content:

Unit I: Introduction and Data Foundation

Basics of data visualization and its relationship with other fields - The visualization process and pseudo-code conventions - The scatter plot and data representation principles - Types of data, structure within and between records - Data preprocessing techniques and real-world data sets.

Unit II: Foundations for Visualization

Visualization pipeline and stages - Semiology of graphical symbols and eight visual variables - Historical perspectives and taxonomies of visualization techniques - Experimental semiotics and perception-based visualization models - Gibson's Affordance Theory and perceptual processing.

Unit III: Visualization Techniques

Spatial Data: 1D, 2D, and 3D data visualization - Geospatial Data: Point, line, and area-based visualization methods - Multivariate Data: Techniques for visualizing complex datasets - Hierarchical Data: Tree-based structures and network visualization - Hybrid Techniques: Combining multiple visualization methods.

Unit IV: Interaction Concepts and Techniques

Text and Document Visualization: Single document vs. document collection visualizations - Interaction Concepts: Operators, operands, and interaction spaces - Interaction Techniques: Screen space, object space, attribute space, and data structure space - Animation and Transformation: Enhancing visualization interactivity and user experience.

Unit V: Research Directions in Visualization

Design principles for effective visualizations - Challenges in designing large-scale visualizations - Issues related to data representation, cognition, and perception - System design, hardware limitations, and visualization applications - Emerging trends and future research directions in visualization.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Explain the visualization process, its relationship with other fields, and data preprocessing techniques for effective representation.

CO2: Apply perception-based theories, including Gibson's Affordance Theory, to optimize visualization effectiveness.

CO3: Utilize spatial, geospatial, multivariate, and hierarchical visualization techniques to analyze and represent complex datasets.

CO4: Develop interactive visualizations incorporating user-centered interaction models and techniques.

CO5: Evaluate visualization challenges related to large-scale data, cognition, and system design, exploring new research directions.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	1	1
CO2	2	1	1	1	1	1
CO3	2	2	1	2	1	1
CO4	2	2	1	2	1	1
CO5	2	2	2	1	1	2

References:

1. Matthew Ward, Georges Grinstein and Daniel Keim, "Interactive Data Visualization Foundations, Techniques, Applications", 2010.
2. Colin Ware, "Information Visualization Perception for Design", 4th edition, Morgan Kaufmann Publishers, 2021.
3. Robert Spence "Information visualization – Design for interaction", Pearson Education, 2nd Edition, 2007.
4. Alexandru C. Telea, "Data Visualization: Principles and Practice," A. K. Peters Ltd, 2008.

CLUSTER F: COMPUTER VISION & GENERATIVE AI

AV24F11	DEEP LEARNING	3 Credits

Course Objectives:

This course provides a comprehensive introduction to deep learning, covering neural networks, convolutional architectures, natural language processing (NLP), reinforcement learning, and unsupervised learning techniques. Students will learn how to develop and train deep neural networks, implement advanced models like CNNs, RNNs, and Autoencoders, and explore applications in image processing and NLP. The course also covers generative adversarial networks (GANs) and deep reinforcement learning techniques. By the end of the course, students will be able to design, optimize, and apply deep learning models for real-world applications.

Course Content:

Unit I: Deep Learning Concepts

Fundamentals of deep learning and probabilistic modeling - Perceptron learning algorithms and early neural networks - Differences between machine learning and deep learning - Introduction to scalars, vectors, matrices, and tensors - Manipulating various data types (vector, time series, image, video).

Unit II: Neural Networks and Optimization

Neural network architecture and building blocks - Activation functions, loss functions, and optimizers - Feature engineering and data preprocessing techniques - Overfitting, underfitting, and regularization methods - Hyperparameter tuning and model validation.

Unit III: Convolutional Neural Networks (CNNs) for Image Processing

Convolutional layers, pooling layers, and feature extraction - Backpropagation through convolutional layers - CNN architectures: LeNet, AlexNet, VGG16, ResNet - Transfer learning techniques with pre-trained models - Object detection and segmentation: R-CNN, Fast R-CNN, Faster R-CNN, Mask R-CNN, YOLO.

Unit IV: Natural Language Processing (NLP) Using RNNs

Introduction to NLP and its toolkits - Language modeling and vector space representation - Word embedding techniques: Word2Vec, GloVe - Recurrent Neural Networks (RNNs): Bidirectional RNNs (BRNN), LSTMs, GRUs - Sequence-to-sequence models (Seq2Seq) and backpropagation through time.

Unit V: Deep Reinforcement Learning and Unsupervised Learning

Reinforcement learning concepts: Q-learning, Deep Q-Network (DQN), Policy Gradient Methods - Actor-critic algorithm and reward-based learning - Introduction to Autoencoders and their applications - Variational Autoencoders (VAE), Generative Adversarial Networks (GANs) - Denoising and sparse autoencoders for feature extraction.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Explain deep learning fundamentals, including neural networks, probabilistic modelling, and tensor operations for diverse data types.

CO2: Develop and optimize deep neural networks with feature engineering, activation functions, and hyperparameter tuning techniques.

CO3: Design and implement Convolutional Neural Networks (CNNs) for image classification and object detection using advanced architectures like ResNet and YOLO.

CO4: Apply Natural Language Processing (NLP) with recurrent neural networks (RNNs), LSTMs, GRUs, and Word Embeddings for text-based applications.

CO5: Implement deep reinforcement learning techniques and unsupervised learning models like Autoencoders and GANs for real-world problem-solving.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	2	1	1
CO2	2	2	2	2	1	1
CO3	2	2	2	1	2	1
CO4	2	1	2	1	1	1
CO5	2	2	3	2	2	1

References:

- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.
- Aggarwal, C. C. (2018). Neural Networks and Deep Learning: A Textbook. Springer.
- Lapan, M. (2018). Deep Reinforcement Learning Hands-On. Packt Publishing.
- Géron, A. (2019). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow (2nd ed.). O'Reilly Media.
- Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.
- Chollet, F. (2018). Deep Learning with Python. Manning Publications.
- Koller, D., & Friedman, N. (2009). Probabilistic Graphical Models: Principles and Techniques. MIT Press.
- Rao, D., & McMahan, B. (2019). Natural Language Processing with PyTorch. O'Reilly Media.
- Rosebrock, A. (2019). Deep Learning for Computer Vision with Python. PyImageSearch.
- Foster, D. (2019). Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play. O'Reilly Media.

AV24F12	IMAGE PROCESSING	3 Credits

Course Description:

This course provides a comprehensive introduction to digital image processing, covering image acquisition, enhancement, filtering, segmentation, and feature extraction techniques. Students will explore pixel relationships, color models, and noise removal methods, along with spatial and frequency domain filtering using Fourier and Discrete Cosine Transforms (DCT). The course also includes segmentation techniques like thresholding, edge detection, and morphological operations. Finally, real-world applications of image processing in AR/VR, including face recognition, automated inspection, and medical imaging, will be explored.

Course Content:

Unit I: Image Acquisition and Fundamentals

Elements of visual perception - Light and electromagnetic spectrum - Imaging modalities and digital image models - Image file formats, sampling, and quantization - Pixel relationships: adjacency, connectivity (4, 8, and m connectivity), region, boundary detection - Color models and conversions.

Unit II: Image Enhancement

Intensity transformation functions - Image negatives, contrast stretching, log transformation, gamma correction - Histogram equalization and color histogram processing - Noise models: Gaussian, uniform, salt and pepper noise removal.

Unit III: Spatial and Frequency Domain Filtering

Spatial filtering: Smoothing filters - Mean, median, min, max, and midpoint filtering - Sharpening filters: Laplacian filter, unsharp masking - Frequency domain filtering: Fourier Transform, Discrete Cosine Transform (DCT) - Low-pass and high-pass filters - Principal Component Analysis (PCA).

Unit IV: Image Segmentation and Feature Extraction

Segmentation techniques: Thresholding: Local and global - Edge-based segmentation: Prewitt, Sobel, Canny, and Roberts operators - Region-based segmentation: Region growing, region splitting, and merging - Gray-scale morphological operations - Feature extraction: Boundary feature descriptors - Region feature descriptors - Topological and texture feature descriptors.

Unit V: Real-World Applications in AR/VR

PCA-based face recognition for VR avatar customization - Automated industrial inspection using VR for missing component detection - Non-destructive testing for industrial applications - Medical imaging applications: Detection of cysts/tumors in US/CT images - VR-based medical training applications.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Demonstrate human visual perception principles, image acquisition, and pixel relationships in grayscale and color images.

CO2: Enhance images by applying contrast adjustments, histogram equalization, and noise removal techniques.

CO3: Implement spatial and frequency domain filtering using Fourier and DCT transforms for image enhancement.

CO4: Extract regions of interest using thresholding, edge detection, and region-based segmentation techniques.

CO5: Apply image processing techniques to real-world AR/VR applications, including face recognition, industrial inspections, and medical imaging.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	-	-	-	1
CO2	1	2	1	-	1	1
CO3	2	2	1	-	1	1
CO4	1	2	1	-	-	-
CO5	3	2	2	2	2	2

References:

- Rafael.C.Gonzalez, Richard.E. Woods and Steven L. Eddins, "Digital Image Processing using Matlab", 4th Edition, Gatesmark Publishing, 2018, ISBN 10: 1-292-22304-9.
- William K. Pratt, "Introduction to Digital Image Processing", CRC Press, 2013.
- Oge Marques, "Practical Image and Video Processing using MATLAB", Wiley-IEEE Press, 2011, ISBN: 978-0-470-04815-3.
- Al.Bovik, "The Essential Guide to Image Processing", Academic Press, 2009.

AV24F13	COMPUTER VISION	3 Credits

Course Description:

This course provides an in-depth introduction to computer vision, covering its fundamental concepts, mathematical foundations, and practical applications. Students will explore image formation, geometric transformations, feature detection, stereo vision, segmentation techniques, and object recognition. The course also introduces machine learning and deep learning-based methods for advanced computer vision tasks, including CNNs, YOLO, and Mask-RCNN. By the end of the course, students will be able to develop and implement real-world computer vision applications using various feature extraction, image transformation, and object recognition techniques.

Course Content:

Unit I: Image Formation and Transformations

History and evolution of computer vision - Applications of computer vision in robotics, healthcare, and surveillance - Geometric image formation: Pinholes, lenses, perspective, orthographic projections - 2D and 3D transformations: Image scaling, rotation, and translation - Camera parameters: Intrinsic and extrinsic calibration - Photometric image formation: Light reflection models, color constancy - The Three R's of Computer Vision: Recognition, Reconstruction, Reorganization.

Unit II: Feature Detection and Matching

Feature detectors and descriptors - Interest points and Harris corner detection - Scale Invariant Feature Transform (SIFT) and Histogram of Oriented Gradients (HOG) - Blob detection and Laplacian of Gaussian (LOG) - Feature matching techniques: Euclidean distance metric - Brute Force Matching - FLANN-based Matching (Fast Library for Approximate Nearest Neighbors) - Real-time matching in robotic navigation and visual servoing.

Unit III: Geometric Vision and 3D Scene Reconstruction

Stereo vision and depth estimation - Epipolar geometry and homography - Camera calibration and warping - Optical flow estimation - Structure from motion (SfM) - Simultaneous Localization and Mapping (SLAM).

Unit IV: Segmentation and Object Recognition

Threshold-based segmentation - Edge-based segmentation (Prewitt, Sobel, Canny, Roberts operators) - Region-based segmentation (Graph cut, Level-set, K-means clustering) - Active Contour Model for segmentation - Instance segmentation and semantic segmentation.

Unit V: Machine Learning and Deep Learning for Object Detection

Traditional classifiers: Supervised vs. Unsupervised Learning - K-nearest neighbor (KNN) - Support Vector Machines (SVM) - Principal Component Analysis (PCA) - Deep learning-based models for object detection: Convolutional Neural Networks (CNN) - Region-based CNN (R-CNN), Faster R-CNN - Single Shot Detector (SSD), You Only Look Once (YOLO).

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Illustrate image formation concepts using geometric and photometric transformations and the relationship between world and image coordinates.

CO2: Implement feature detection and matching techniques such as SIFT, Harris corner detection, and real-time feature matching for robotic navigation.

CO3: Apply geometric vision techniques including stereo vision, structure from motion, and optical flow analysis for 3D scene reconstruction.

CO4: Develop segmentation algorithms, including thresholding, edge-based, and region-based segmentation, for scene understanding and object recognition.

CO5: Design and implement deep learning-based models such as CNN, YOLO, and Mask-RCNN for advanced object detection and recognition.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	1	1
CO2	2	2	1	1	1	1
CO3	2	2	1	1	1	1
CO4	2	2	2	1	1	1
CO5	2	2	2	2	1	1

References:

- R. HARTLEY, A. ZISSERMAN (2004), Multiple View Geometry in Computer Vision, Cambridge University Press, 2nd Edition.
- R. SZELISKI, (2010), Computer Vision: Algorithms and Applications, Springer-Verlag London. Research literature.

AV24F14	COMPUTER GRAPHICS AND 3D MODELING	3 Credits

Course Description:

This course introduces computer graphics techniques with a focus on 2D and 3D modelling, image synthesis, and rendering. It covers graphical primitives, transformations, object representation, hidden surface elimination, and shading models. The course also explores photo-realistic rendering techniques and animation development using OpenGL. By the end of the course, students will gain the ability to develop interactive graphics applications and basic animation videos using GPU functionalities.

Course Content:

Unit I: Introduction to Graphical Primitives

Overview of computer graphics - Graphical representation techniques: Picture preparation, presentation, and interaction - Scan conversion techniques: Line drawing algorithms (DDA, Bresenham's), circle and ellipse generation - Area filling algorithms: Boundary fill, flood fill, and scan-line fill - Clipping algorithms: Cohen-Sutherland, Liang-Barsky, Sutherland-Hodgman polygon clipping - Anti-aliasing techniques.

Unit II: Transformations and Viewing

2D and 3D transformations: Translation, scaling, rotation, shearing - Matrix representations and homogeneous coordinates - Viewing pipeline and coordinate transformation - Window-to-viewport transformations - Clipping operations and viewport clipping - 3D viewing techniques and projections.

Unit III: Graphical Object Representation

Curves and surfaces: Conic sections, parametric and non-parametric forms - Bezier curves: Bernstein polynomials, cubic splines, B-splines - Quadratic surfaces, Bezier surfaces, and NURBS modeling - 3D object representation and modeling techniques.

Unit IV: Graphics Rendering

Hidden surface elimination techniques: - Depth comparison, Z-buffer algorithm - Back-face detection, Binary Space Partitioning (BSP) - Scan-line algorithm and wireframe models - Shading and lighting models: - Phong shading, Gouraud shading - Color models and lighting techniques - Photo-realistic rendering and fractal geometry.

Unit V: Animation and OpenGL Programming

Introduction to OpenGL primitives - OpenGL functions and rendering pipeline - Drawing 2D and 3D objects using OpenGL - Event handling and real-time view manipulation - GPU functionalities for animation and real-time graphics.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Demonstrate graphical primitives and techniques to represent, prepare, and interact with 2D geometric objects for graphical presentations.

CO2: Implement 2D and 3D transformations using matrix representations and homogeneous coordinates and apply viewing techniques for rendering 3D scenes.

CO3: Construct curves and surfaces using parametric and non-parametric representations, B-splines, NURBS, and quadratic surfaces for 3D modeling.

CO4: Apply hidden surface elimination techniques, shading, and lighting models to create realistic 3D renderings with photo-realistic effects.

CO5: Develop 2D and 3D graphical objects and animations using OpenGL primitives and analyze GPU functionalities for real-time rendering and animation.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	1	1
CO2	2	2	2	1	1	2
CO3	2	2	1	2	1	1
CO4	2	2	1	2	1	1
CO5	2	2	1	2	1	1

References:

- J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, Computer Graphics; Principles and practice, Addison Wesley, 2nd Edition in C, 1997.
- D. F. Rogers and J. A. Adams, Mathematical elements for Computer Graphics, McGraw-Hill, 2nd Edition, 1990.

AV24F15	GENERATIVE AI FOR 3D MODELING	3 Credits

Course Description:

This course introduces Generative AI tools for 3D modelling and explores the latest advancements in Artificial Intelligence, including Generative AI, prompt engineering, and ChatGPT. Students will gain an in-depth understanding of various generative models such as VAEs, GANs, transformers, and autoencoders and their applications in 3D content generation. The course will also focus on ethical considerations, model evaluation, and security/privacy concerns in AI-driven 3D modelling. By the end of the course, students will be able to apply AI-based generative techniques to automate and enhance 3D modelling processes.

Course Content:

Unit I: Python for Data Science

Python Basics and Programming Fundamentals - Data Structures and Numpy Arrays - Statistics Fundamentals for AI Applications - Data Wrangling Techniques - Data Visualization and Interpretation.

Unit II: Introduction to Generative AI Models

Fundamentals of Generative AI - Explainable AI (XAI) in 3D Modeling - Prompt Engineering for Generative AI - Fine-Tuning ChatGPT for Custom Applications.

Unit III: Ethical Considerations in Generative AI

Ethical Concerns in Generative AI and ChatGPT - Bias, Fairness, and Explainability in AI Models - Security and Privacy Considerations in AI-driven 3D Modeling - The Future of Generative AI and its Implications.

Unit IV: Generative Models and Transformer Architectures

Introduction to Generative Models for 3D Content Creation - Large Language Models (LLMs) and AI-driven 3D Asset Generation - Attention Mechanisms and Transformer Models -

Role of Transformers in Modern AI Applications.

Unit V: Advanced Generative AI Techniques

Types of Generative AI Models: VAEs, GANs, Diffusion Models - Popular Generative AI Models: GPT, BERT, Stable Diffusion, DALL-E - Benchmarking and Evaluating Generative AI Models - Advanced Prompt Engineering and Model Fine-Tuning.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Apply Python programming fundamentals, data wrangling, and data visualization to AI-based modeling tasks.

CO2: Understand various generative AI models, including VAEs, GANs, transformers, and diffusion models, and their role in 3D content creation.

CO3: Analyze the significance of transformers and attention mechanisms in AI-driven generative applications.

CO4: Evaluate design principles of advanced generative models such as GPT, BERT, and their counterparts.

CO5: Examine the influence of model architecture on language processing capabilities and AI-driven generative tasks.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	1	1
CO2	2	2	2	1	1	2
CO3	2	2	1	2	1	1
CO4	2	2	1	2	1	1
CO5	2	2	1	2	1	1

References:

- Omar Sanseviero, Pedro Cuenca, Apolinario Passos, Jonathan Whitaker, Hands-On Generative AI with Transformers and Diffusion Models, November 2024, Publisher(s): O'Reilly Media, Inc., ISBN: 9781098149246.
- Radford, A., Narasimhan, K., Salimans, T., Sutskever, I., Improving Language Understanding by Generative Pre-Training (GPT), 2018, Publisher(s): OpenAI Research.
- Goodfellow, I., Bengio, Y., Courville, A., Deep Learning, 2016, Publisher(s): MIT Press.

VI. INDUSTRY INTEGRATED COURSE

AV24G11	IMMERSIVE USER EXPERIENCE (UX) DESIGN FOR AR/VR	4 Credits

Course Description:

This course explores the principles and methodologies of UX design for Augmented Reality (AR) and Virtual Reality (VR), focusing on creating seamless and user-friendly immersive experiences. Students will learn design strategies, user needs hierarchy, prototyping techniques, and usability testing methods tailored for AR/VR environments. The course also covers ethical considerations, privacy concerns, and technical constraints in immersive UX design. By the end of the course, students will be able to design, evaluate, and optimize immersive UX experiences using industry best practices and emerging trends.

Course Content:

Unit I: Introduction to User Experiences for Immersive Technologies

The role of UX in AR/VR applications - Principles of immersive user experience design - Interaction models and spatial considerations.

Unit II: Ethical Considerations and Strategies in UX Design

Design challenges and constraints in immersive environments - Privacy, security, and ethical concerns in AR/VR - Developing a structured UX design process and ideation techniques.

Unit III: UX Hierarchy of Needs

User Needs Hierarchy and its application in AR/VR - Visual hierarchies in UX design - Balancing technical constraints with user-centered design - Case Studies: Google Maps AR navigation.

Unit IV: Rapid Prototyping and User Testing

Prototyping methods for immersive applications - Usability testing and iteration cycles - Case studies on AR/VR usability improvements - Case Studies: Ethical challenges of AR/VR design.

Unit V: Functionality in Immersive Designs & UX Storytelling

Optimizing interactions for AR/VR functionality - Design documentation, assets, and specifications - Storytelling in UX design and collaboration in virtual spaces - Case Studies: UX in Metaverse Banking AR/VR concepts.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Analyze the role of UX in AR and VR and apply user experience principles to design and enhance immersive applications.

CO2: Integrate ethical, security, and privacy principles to establish responsible and user-centric immersive UX experiences.

CO3: Develop user-centric AR/VR designs using rapid prototyping, usability testing, and iteration techniques.

CO4: Evaluate immersive UX solutions by applying visual hierarchy, interaction design, and storytelling methods.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	2	1
CO2	1	2	3	2	1	1
CO3	3	2	2	1	1	2
CO4	2	1	3	1	2	2

References:

- Krug, S. (2014). Don’t Make Me Think, Revisited: A Common Sense Approach to Web Usability. New Riders.
- Bowman, D. A., Kruijff, E., LaViola, J. J., & Poupyrev, I. (2004). 3D User Interfaces: Theory and Practice. Addison-Wesley.
- Jerald, J. (2015). The VR Book: Human-Centered Design for Virtual Reality. ACM Books.
- Norman, D. (2013). The Design of Everyday Things. Basic Books.

AV24G12	INTERACTIVE NARRATIVE AND DIGITAL STORYTELLING IN AR/VR	4 Credits

Course Description:

This course explores the principles of interactive storytelling and narrative design in AR/VR, focusing on how immersive environments transform traditional storytelling techniques. Students will examine character development, interactive story structures, and the role of user agency in shaping narratives within AR/VR experiences. The course introduces various tools and techniques for crafting compelling digital stories, addressing both challenges and opportunities in immersive storytelling. By the end of the course, students will be equipped to analyze, design, and implement engaging AR/VR narratives using emerging technologies.

Course Content:

Unit I: Evolution of Storytelling in Traditional Media

Foundations of storytelling: oral, written, and digital narratives - Transition from linear to interactive storytelling - Key storytelling structures in traditional media.

Unit II: Role of Characters in AR/VR Storytelling

Character-driven narratives and user engagement - Agency and interactivity in immersive storytelling - Emotion and immersion in AR/VR narratives.

Unit III: Tools and Techniques for AR/VR Storytelling

Overview of industry-standard tools for AR/VR storytelling - Scripting and interactive storytelling techniques - Integration of AI and real-time user adaptation.

Unit IV: Challenges and Opportunities in AR/VR Storytelling

Narrative coherence in interactive media - Ethical considerations and user experience - Opportunities for interactive education, training, and entertainment.

Unit V: Future Trends and Case Studies in AR/VR Storytelling

Emerging trends in immersive narratives - Real-world applications and case studies of successful AR/VR storytelling - Experimental storytelling and future possibilities.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Analyze the evolution of storytelling techniques and their transformation in AR/VR environments.

CO2: Design interactive narratives by developing characters, structuring user-driven storylines, and implementing engagement strategies.

CO3: Utilize industry-standard tools and techniques to create immersive AR/VR storytelling experiences.

CO4: Evaluate the challenges and opportunities in AR/VR storytelling and explore emerging trends for future applications.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	2	3
CO2	1	2	1	2	3	1
CO3	1	3	2	1	1	2
CO4	2	1	3	1	1	2

References:

- Murray, J. (1997). Hamlet on the Holodeck: The Future of Narrative in Cyberspace. Free Press.
- Ryan, M.-L. (2004). Narrative Across Media: The Languages of Storytelling. University of Nebraska Press.
- Aarseth, E. (1997). Cybertext: Perspectives on Ergodic Literature. Johns Hopkins University Press.
- Glassner, A. (2004). Interactive Storytelling: Techniques for 21st Century Fiction. AK Peters.
- Koenitz, H., Ferri, G., Haahr, M., Sezen, D., & Sezen, T. (2015). Interactive Digital Narrative: History, Theory, and Practice. Routledge.

AV24G13	ENTERPRISE APPLICATIONS OF AR/VR	4 Credits

Course Description:

This industry-supported course provides a comprehensive understanding of how Augmented Reality (AR) and Virtual Reality (VR) technologies are transforming various industries. Developed in collaboration with leading AR/VR companies, the course emphasizes practical applications, real-world case studies, and hands-on projects aligned with current industry standards. Students will gain exposure to industry-grade tools, hardware, and development environments through workshops and mentorship from industry professionals.

Course Content:

Unit I: Evolution and Market Trends in AR/VR Technologies

AR, VR, XR Evolution, Hardware and Software Ecosystem (HP Reverb, Insta360, HoloLens, etc.), Overview of AR/VR Development Tools and Industry Platforms Integration with Emerging Technologies, Role of AI, IoT, and 5G in AR/VR evolution, Global Market Overview, Industry Adoption Across Sectors, Success Stories in Enterprise AR/VR Applications.

Unit II: AR/VR in Enterprise Sectors

Manufacturing and Industrial Training: Virtual prototyping, assembly line simulation, Healthcare: Surgical simulation, case studies from healthcare technology companies-Retail and Marketing: Product visualization, featuring industry demonstrations-Education and Training: Virtual classrooms-Defense and Aerospace: Simulation-based training and maintenance support systems.

Unit III: Designing Enterprise AR/VR Applications

UX and UI Design Principles for AR/VR in enterprise environments-Interaction Techniques: Gesture, Voice, Eye Tracking (industry-supported workshops)-Case Studies: Successful Enterprise Implementations from Partner Companies-Ethical Considerations, Data Security, and User Privacy.

Unit IV: Development and Deployment

Industry Tools and Frameworks: Unity, Unreal Engine, Vuforia, ARKit/ARCore-Hands-on Development with Industry-Provided Hardware and Software-Testing, Debugging, and Performance Optimization with expert mentorship-Deployment Strategies, Maintenance, and Industry Standards-Site visit to a partnering enterprise to observe AR/VR implementation.

Unit V: Future Trends and Innovations

AI and Machine Learning Integration with AR/VR-5G and Cloud-Based AR/VR Applications for Enterprises-Wearable Technologies, IoT Integration, and Enterprise Use Cases-Emerging Trends: Haptics, Brain-Computer Interfaces, Spatial Computing.

Course Outcomes:

Upon successful completion of this course, the students will be able to

CO1: Explore the fundamentals of AR/VR and their role in enterprise applications.

CO2: Analyze the technical foundations of AR/VR and their integration with emerging technologies.

CO3: Apply UX design principles to develop effective AR/VR experiences for enterprise users.

CO4: Design AR/VR solutions for training, collaboration, and customer engagement in enterprise environments.

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	2	1
CO2	1	2	3	2	1	2
CO3	3	3	2	1	1	2
CO4	2	1	3	1	2	3

References:

- Aukstakalnis, S. (2016). Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR. Addison-Wesley.
- Jerald, J. (2015). The VR Book: Human-Centered Design for Virtual Reality. ACM Books.
- Milgram, P., & Kishino, F. (1994). A Taxonomy of Mixed Reality Visual Displays. IEICE Transactions on Information and Systems.
- Craig, A. B. (2018). Understanding Augmented Reality: Concepts and Applications. Morgan Kaufmann.
- Sherman, W. R., & Craig, A. B. (2018). Understanding Virtual Reality: Interface, Application, and Design. Morgan Kaufmann.
- Schmalstieg, D., & Hollerer, T. (2016). Augmented reality: principles and practice. Addison-Wesley Professional.

VII. INDUSTRIAL TRAINING: (4 credits)

i. Internship Programme

Refer to PG Regulations 2024.

VIII. AUDIT COURSE: (0 credit)

Refer to Swayam – MOOC Syllabus.

IX. OPEN ELECTIVE: (3 credits)

Refer SWAYAM – MOOC Syllabus.

X. Project DISSERTATION:

i. Project Phase I (12 credits)

ii. Project Phase II (16 credits)

Refer to PG Regulations 2024.

***