RAJALAKSHMI
ENGINEERING COLLEGE
An AUTONOMOUS Institution
Affiliated to ANNA UNIVERSITY, Chennai

RAJALAKSHMI ENGINEERING COLLEGE

CURRICULUM AND SYLLABUS

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
REGULATIONS R2019

VISION

- To promote highly ethical and innovative computer professionals through excellence in teaching, training and research.

MISSION

- To produce globally competent professionals, motivated to learn the emerging technologies and to be innovative in solving real world problems.
- To promote research activities amongst the students and the members of faculty that could benefit the society.
- To impart moral and ethical values in their profession.

MINOR DEGREE IN VIRTUAL AND AUGMENTED REALITY

Graphics and visualization has become an integral form of experiencing the world and environment. Advancements in hardware and software architecture have given path to experiencing a whole new world through Virtual and Augmented Reality experiences.

This minor degree program provides an opportunity to learners interested in developing visual experiences through interactive graphics, immersive and non- immersive virtual environments and a whole new dimension of augmented reality. The courses in this minor degree program allows learners to master concepts, tools and techniques of various facets for developing interactive VR and AR applications through simulation and real-time interactive user experiences.

S. No.	Subject Code	Subject Name	L	T	P	C
1	MCS19041	Computer Graphics for Virtual Reality	3	0	2	4
2	MCS19042	Virtual Reality and Augmented Reality	3	0	2	4
3	MCS19043	Data Visualisation	3	0	2	4
4	MCS19001	Mathematical Modelling and Computer Aided Engineering	3	0	0	3
5	MCS19044	AI based Mobile Virtual Reality	3	0	2	4
		Total	**15**	**0**	**8**	**19**

SYLLABUS

Subject Code	Subject Name	L	T	P	C
MCS19041	Computer Graphics for Virtual Reality	3	0	2	4

Course Objectives:	
•	To introduce the use of the components of a graphics system and become familiar with building approach of graphics system components and algorithms related with them.
•	To learn the basic principles of 3-dimensional computer graphics.
•	Provide an understanding of mapping from a world coordinates to devicecoordinates, clipping, and projections.

UNIT – I	**Graphics system and models**	5
Applications of computer graphics, graphics system,physical and synthetic images, imaging systems, graphics architectures.		
UNIT – II	**Geometric objects and transformations**	10
Scalars, points and vectors, three-dimensionalprimitives, coordinate systems and frames, frames in OpenGL, matrix and vector classes,modelling a colored cube, affine transformations - translation, rotation and scaling,transformations in homogeneous coordinates, concatenation of transformations,transformation matrices in OpenGL, interfaces to 3D applications, quaternion. Vertices to fragments: basic implementation strategies, four major tasks, clipping – lineclipping, polygon clipping, clipping of other primitives, clipping in three dimensions,polygon rasterization, hidden-surface removal, anti-aliasing, display considerations.		
UNIT – III	**Lighting and shading**	10
Light and matter, light sources, the Phong reflection model,computation of vectors, polygonal shading, approximation of a sphere by recursivesubdivision, specifying lighting parameters, implementing a lighting model, shading ofthe sphere model, per-fragment lighting, global illumination.Hierarchical modelling: symbols and instances, hierarchical models, a robot arm, treesand traversal, use of tree data structures, other tree structures, scene graphs, openscene graph.		
UNIT – IV	**Discrete techniques**	10
Buffers - digital images - writing into buffers - mapping methods -texture mapping - texture mapping in OpenGL - texture generation - environment maps- reflection map - bump mapping - compositing techniques - sampling and aliasing.Advanced rendering: going beyond pipeline rendering - ray tracing - building a simperay tracer - the rendering equation - radiosity - Renderman - parallel rendering -volume rendering – ISO surfaces and marching cubes - mesh simplification – directvolume rendering - image-based rendering.		
UNIT - V	**Fractals**	10
Modelling - Sierpinski Gasket - coastline problem - fractal geometry – fractaldimension - recursively defined curves - Koch curves - c curves - dragons - space fillingcurves - turtle graphics - grammar based models - Graftals - volumetric examples - k-midpoint subdivision - fractal Brownian motion - fractal mountains - iteration in thecomplex plane - Mandelbrot set. Virtual reality modelling language: introduction, exploring and building a world,building object, lighting, sound and complex shapes, animation and user interaction,colors, normals and textures, nodes references. Special applications: stereo displayprogramming, multiport		

display systems, multi-screen display system, fly modenavigation, walk through navigation, virtual track ball navigation.		
TOTAL HOURS	:	45

Course Outcomes:
Upon completion of the course, the students will be able:

•	To list the basic concepts used in computer graphics.
•	To implement various algorithms to scan, convert the basic geometrical primitives, transformations, Area filling, clipping.
•	To define the fundamentals of animation, virtual reality and its related technologies.
•	To design an application with the principles of virtual reality.
•	To design Fractals

Lab Experiemnts:

1. Geometric Objects
2. implementing a lighting model
3. Hierarchical modeling
4. texture mapping in OpenGL
5. VR Modelling

Text Book(s) / Reference Book(s)

1. Rajesh K. Maurya, Computer Graphics with Virtual Reality System, John Wiley &Sons, 2018.
2. Edward Angel, “Interactive Computer Graphics: A Top-Down Approach UsingOpenGL”, Addison-Wesley, 2005.
3. Foley James D, Van Dam, Feiner and Hughes, “Computer Graphics: Principles andPractice”, Pearson Education, 2013.
4. Donald Hearn and Pauline Baker, “Computer Graphics C Version”, PearsonEducation, 2015.
5. William R. Sherman, Alan B. Craig Dr, Understanding Virtual Reality: Interface, Application, and Design (The Morgan Kaufmann Series in Computer Graphics), 2018

Subject Code	Subject Name	L	T	P	C
MCS19042	Virtual Reality and Augmented Reality	3	0	2	4

Course Objectives:	
•	To make students know the basic concept and framework of virtual reality.
•	To teach students the principles and multidisciplinary features of virtual reality.
•	To teach students the technology for multimodal user interaction and perception in VR, in particular the visual, audial and haptic interface and behaviour.
•	To teach students the technology for managing large scale VR environment in real time
•	To provide students with an introduction to the VR system framework and development tools.

UNIT – I	Introduction to VR &AR	9
Categorizing the realities – Virtual Reality, Augmented Reality & Mixed Reality, Introduction, features and application areas of Virtual Reality, Augmented Reality & Mixed Reality. All you need to know about VR – Integration of VR techniques, Contents objects and scale, GazeBased Control, Handy Interactables, IDE setup with package files, concepts and features of VR, VR project example All you need to know about AR - Working with AR techniques, compatibility with the environment, system architecture, AR terminology, application areas of AR, Integration of AR toolkits with existing IDE's, connectivity of smart devices with AR. **Case Study:** Case study of a single application using both VR and AR technologies		
UNIT – II	**VR App Development with Unity**	9
VR SDK's – VR SDK'S and Frameworks – OpenVR SDK, StreamVR SDK, VRTK, Oculus SDK, Google VR SDK. VR Concept Integration- Motion Tracking, Controllers, Camera , Hardware and Software requirements Setting up Unity with VR-Framework/SDK Integration with Unity, Debugging VR projects, Unity XR API's, Mobile VR Controller Tracking, Object Manipulation, Text optimizing and UI for VR , Case Studies: Creating 3D objects using Blender.		
UNIT – III	**AR App Development with Unity**	9
AR Foundation – Detection of surfaces, identifying feature points, track virtual objects in real world, face and object tracking. AR Algorithms – Briefing on SLAM Algorithm (Simultaneous Localization and Mapping), understanding uncertain spatial relationship, Anatomy of SLAM, Loop detection and Loop closing Unity AR concepts- Pose tracking, Environmental detection, Raycasting and physics for AR, Light estimation, Occlusion, working with ARCore and ARKit Working with AR Tools– ARCore, ARToolkit, ARCore - Features of ARCore, integration with Unity/Unreal/iOS/Android Studio, augmented reality applications with ARCore. ARToolkit – Features of ARToolkit, setting up the environment for application development. Vuforia- Features of Vuforia, setting up the environment for application development. **Case Study:** Use of OpenCV for AR App Development		
UNIT – IV	**Programming Languages for AR & VR applications**	9
C# with Unity – OOL concepts, classes in C#, setting up visual studio or code editor for C#, 3D models compatibility with C#, C# for AR and VR C++ with Unreal Engine – Building and compiling C++ programs with unreal engine, variables and memory, looping and if else structures with unreal engine, functions and macros, adding actors to the scene, dynamic memory allocations, spell book. #Exemplar/Case Studies Create a C# script		

which plays a video when an image is scanned using AR App (use ARCore& Unity)		
UNIT - V	**VR & AR Devices**	9
VR Devices – Structure and working of HTC Vive, Google Cardboard, Samsung gear VR, Oculus Quest, Samsung Odyssey+, Oculus Rift. AR Components – Scene Generator, Tracking system, monitoring system, display, Game scene AR Devices – Optical See-Through HMD, Virtual retinal systems, Monitor based systems, Projection displays, Video see-through systems. Advantages and Disadvantages of AR and VR technologies. **Case Studies**: Google Daydream **Use Cases of AR VR:** Trending Application Areas - Gaming and Entertainment, Architecture and Construction, Science and Engineering, Health and Medicine, Aerospace and Defence, Education, Telerobotics and Telepresence. Case Study: What is Google Maps AR Navigation and how it is used?		
TOTAL HOURS	:	45

Course Outcomes: Upon completion of the course, the students will be able to:	
•	Compare and Contrast VR and AR experiences
•	Demonstrate and develop VR apps in Unity
•	Demonstrate and develop AR apps in Unity
•	Acquire knowledge in VR and AR technologies in terms of used devices, building of the virtual environment and modalities of interaction and modeling.
•	Acquire knowledge about the application of VR and AR technologies in medicine, education, cultural heritage and games.

Lab Experiments:
1. Develop a VR Ball Game. The scene should contain a play area surrounded by four walls and a ball that acts as a player. The objective of the game is to keep the ball rolling without colliding with the walls. If it collides with either of the walls, the wall color should change and a text should display on the screen indicating the collision.
2. Develop a VR Golf Game. The scene should contain a play area (golf course), which consists of a series of cups/holes each having different scores. Display the score card.
3. Develop a VR game in Unity such that on each gun trigger click, destroy the cubes placed on the plane and gain a score point. Make a score UI and display it on the screen.
4. Develop a VR Basketball Game. The scene should contain a basketball court. The developed game should be a single player game. The objective of the game is to let the player put the ball in the basket maximum number of times. Display the score card.
5. Develop an AR bowling game with one image target. The image target should include 3d models as per requirement. Write a c# program to develop score point system for bowling game. Build an APK. (Note: Vuforia plugin should be installed in unity)
6. Develop a VR environment for flying helicopter/moving car simulation.
Programming tools recommended: - Unity, C#, Blender, VRTK. VR Devices or emulators: HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.
Total Hours: 30

Text Book(s) / Reference Book(s)

1. Steve Aukstakalnis- Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR, Addison-Wesley Professional, 2016.
2. Allan Fowler- Beginning iOS AR Game Development Developing Augmented Reality Apps with Unity and C#, 1st Edition, Apress Publications, 2018.
3. William Sherif- Learning C++ by Creating Games with UE4|, Packt Publishing, 2015.

Reference Books:

1. Jesse Glover, Jonathan Linowes – Complete Virtual Reality and Augmented Reality Development with Unity: Leverage the power of Unity and become a pro at creating mixed reality applications. Packt publishing, 2019.
2. Jonathan Linowes, KrystianBabilinski – Augmented Reality for Developers: Build practical augmented reality applications with Unity, ARCore, ARKit, and Vuforia. Packt publishing, 2017.

MOOC Reference:

1. https://www.coursera.org/learn/augmented-reality
2. https://www.coursera.org/specializations/unity-xr

Subject Code	Subject Name	L	T	P	C
MCS19043	Data Visualization	3	0	2	4

Course Objectives:	
•	To learn about different Visualization Techniques
•	To study the Interaction techniques in information visualization fields
•	To understand various abstraction mechanisms
•	To create interactive visual interfaces

UNIT – I	Data Visualization	9
Information visualization –Data Wrangling – Plotting and Visualization- Data Aggregation and Group operations – Time Series – Financial and Economic Applications		
UNIT – II	**Computer Visualization**	9
Non-Computer Visualization – Computer Visualization: Exploring Complex Information Spaces –Fisheye Views – Applications – Comprehensible Fisheye views – Fisheye views for 3D data – Non Linear Magnification – Comparing Visualization of Information Spaces – Abstraction in computer Graphics – Abstraction in user interfaces		
UNIT – III	**Multidimensional Visualization**	9
1D, 2D, 3D – Multiple Dimensions – Trees – Web Works – Data Mapping: Document Visualization – Workspaces		
UNIT – IV	**Textual Methods of Abstraction**	9
From Graphics to Pure Text – Figure Captions in Visual Interfaces – Interactive 3D illustrations with images and text – Related work –Consistency of rendered – images and their textual labels – Architecture – Zoom techniques for illustration purpose – Interactive handling of images and text		
UNIT - V	**Abstraction In Time And Interactive Systems**	9
Animating non Photo realistic Computer Graphics – Interaction Facilities and High Level Support for Animation Design – Zoom Navigation in User Interfaces – Interactive MedicalIllustrations – Rendering Gestural Expressions – Animating design for Simulation – Tactile Maps for Blind People – Synthetic holography – Abstraction Versus Realism– Integrating Spatial and Non Spatial Data		
	TOTAL HOURS :	45

Course Outcomes: Upon completion of the course, the students will be able:	
•	To design processes to develop visualization methods and visualization systems, and methods for their evaluation.
•	To complete preparation and processing of data, visual mapping and the visualization.
•	To analyze large-scale abstract data.
•	To understand the textual methods of Abstraction
•	To design interactive systems

Lab Experiments:
• Numpy and Pandas based experiments for data visualization
• 3D visualization

• Multi dimensional visualization
• Animation and Manipulation with Zoom, Navigation etc
Software Requirements: Python, Unity, Blender, Vuforia

Text Book(s) / Reference Book(s)

1. Colin Ware "Information Visualization Perception for Design",3rd edition, Morgan Kaufman 2012.
2. Claus Wilke, Fundamentals of Data Visualization, O'Reilly Media, 2019
3. Kieran Healy, Data Visualization, Princeton University Press, 2018.
4. Stuart.K.Card, Jock.D.Mackinlay and Ben Shneiderman, "Readings in Information Visualization Using Vision to think", Morgan Kaufmann Publishers, 1999. (UNIT 3)
5.ThomasStrothotte, "Computer Visualization–Graphics Abstraction and Interactivity", Springer Verlag Berlin Heiderberg 1998. (UNIT 2,4,5)

Subject Code	Subject Name	L	T	P	C
MCS19001	**Mathematical Modelling and Computer Aided Engineering**	**3**	**0**	**0**	**3**

Course Objectives:	
•	Students should be able to formulate, analyze and apply mathematical models.
•	Students should be able to understand the necessary mathematical abstraction to solve problems.

UNIT – I	**INTRODUCTION**		12
Problems in engineering-structural - fluid flow and heat transfer withtheir relevance in product development - examples - need for computer aidedengineering.Partial differential equations: elliptic, parabolic and hyperbolic - physical significance -solution techniques.Numerical methods to solve PDEs: central differences, Crank-Nicolson and ADI methods- examples - stability and error of numerical schemes.			
UNIT – II	**Variational calculus**		8
Introduction, solutions selected differential equations byVariational methods, Rayleigh - Ritz method - introduction to finite element method.			
UNIT – III	**Finite element method**		8
Concepts, nodes, elements, connectivity, coordinate systems,shape functions, stiffness matrix, global stiffness matrix, Iso-parametric elements solutionmethods – examples- use of software.			
UNIT – IV	**Fluid flow**		7
Introduction to computational fluid dynamics (finite difference, finiteelement techniques) - formulation of fluid flow problems (simple cases only) - Navier-Stokes equation - solution techniques - examples, solution of fluid flow problems usingsoftware.			
UNIT - V	**Heat transfer**		10
Derivation of energy equation in general form - solutions using numericalmethods (finite difference and finite element techniques), solutions using FEA and CFDtechniques for conductive and convective heat transfer problems.Introduction to multi-physics problems: electrophoresis, electro-osmosis, lab-on – chipused in biotechnology use of software.			
	TOTAL HOURS	:	45

Course Outcomes: Upon completion of the course, the students will be able:	
•	To describe the basics of partial differential equations and numerical methods.
•	To understand the variational calculus
•	To understand the methods of finite element methods.
•	To understand the methods fluid flow techniques.
•	To understand the methods of Heat transfer

Text Book(s) / Reference Book(s)

1. Reddy J N, “An Introduction to the Finite Element Method”, Tata McGraw Hill, 2010.
2. Singiresu S Rao, “The Finite Element Method in Engineering”, ButterworthHeinemann, 6th Edition, 2018.
3. Curtis F Gerald Patrick O Wheatley, “Applied Numerical Analysis”, Pearson, 7th Edition, 2005.
4. Muralidhar K and Sundararajan T, “Computational Fluid Flow and Heat Transfer”,Narosa Publications, 2003.
5. Vladimir Mityushev, WojciechNawalaniec, Natalia Rylko, Introduction to Mathematical Modeling and Computer Simulations, CRC Press, 2018

Subject Code	Subject Name	L	T	P	C
MCS19044	AI based Mobile Virtual Reality	3	0	2	4

Course Objectives:	
•	To provide students hands-on exposure to mobile virtual reality in Moduley.
•	To give students experience with basic AI algorithms in virtual reality.
•	To provide students with fundamentals of game designs in virtual reality.

UNIT – I	INTRODUCTION TO MODULEY	10
Introduction to Moduley, Moduley Editor, Moving a Cube, Lights, Particle Systems, Applying Physics, and Moduley Asset Store, C# Coding Introduction, Variables, Methods, If Blocks, Loops, Hello Mammoth, User Interaction in Moduley, Inputs Introduction Preview, Key Presses, Moving a Player, Jumping, Moving Forward, Cycling Cameras, Prefabs Introduction, What are Prefabs?, Instantiating Objects, Random Angles, Destroying Objects, Explosion Effects, Adding Explosion Effects.		
UNIT – II	**GAME DEVELOPMENT**	10
Developing a Pathfinding Game, How to Set Up a Project, Node, String Map, A* Algorithm Setup, A* Algorithm Loop, Auxiliary Methods, Finishing the Algorithm, Importing 2D Assets, Building a Level, From Console to Visual, Adding Tanks, Identifying Nodes, Moving the Tank, Visually Moving Tank, Smooth Movement, Smooth Rotation, Ordering Tank to Move, Speeding up Player, Spawning Logic, Crate Visuals, Adding Crates to Valid Positions, Collecting Crates, Score Counting, Game Interface, Starting the Game, Game Over Screen, Scoring, Sounds.		
UNIT – III	**VIRTUAL REALITY IN MODULEY**	9
VR Introduction - Moduley, Activating VR, Building a Castle, Camera Changing Position, Lowering Castle Doors, Triggering Events Interface, Blender, Download and Install Blender, Introduction & Customizing Settings, Controlling Blender Camera, Emulate Numpad Camera, Manipulating Objects, Common Tools, Mirroring 1 Side of Object. Case Study: Flappy bird Moduley game, First person shooter game, Kart Moduley game		
UNIT – IV	**MACHINE LEARNING AND MODULEY**	8
Introduction to Moduley-ML, Why Machine Learning, different kinds of learnings, Neural Networks (NNs), Training a NN, Optimizer, Convolutional layers, Transfer learning, Imitation learning in Moduley, Training the kart in kart game via IL, Testing the drive.		
UNIT - V	**REINFORCEMENT LEARNING AND MODULEY**	8
Introduction to Reinforcement Learning in Moduley-ML, Reinforcement Learning, Initial state, training a policy, The PPO algorithm, Evolutional Strategies, Reward, training a kart in the kart game with RL, Tensor board analysis, Testing results.		
	TOTAL HOURS :	45

Lab Experiments:
1. Use the A* algorithm to make a 2D game in Unity
2. AI in human-computer interactions in mobile virtual reality systems
3. Build 3D games in Unity
4. Immersive analytics and visualization using AI in mobile VR

5. Machine intelligence, AI, and haptic technology in mobile VR

Course Outcomes: Upon completion of the course, the students will be able to:	
•	Code in Moduley for game development
•	Use AI algorithms (A*, IL, and RL) in Moduley-ML
•	Demonstrate visual realism by using VR tools/software.
•	Apply machine learning techniques in training and testing
•	Apply reinforcement learning techniques in training and testing

Text Book(s) / Reference Book(s)

1. Linowes, J., & Schoen, M, Cardboard VR Projects for Android. Packt Publishing Ltd, 2016.
2. Lanham, M., Hands-On Deep Learning for Games: Leverage the power of neural networks and reinforcement learning to build intelligent games. Packt Publishing Ltd, 2019.
3. Aversa, D., Kyaw, A. S., & Peters, C.,Moduley Artificial Intelligence Programming: Add powerful, believable, and fun AI entities in your game with the power of Moduley, Packt Publishing Ltd, 2018.
4. Tony Parisi, Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web, and Mobile, O'Reilly Media, 2016
5. Jesse Glover (Author), Jonathan Linowes, Complete Virtual Reality and Augmented Reality Development with Unity, Packt, 2019.