Faculty of Science and Technology

Savitribai Phule Pune University

Maharashtra, India

http://unipune.ac.in

Curriculum

for

Honours* in Virtual Reality and Augmented Reality

Board of Studies

(Computer Engineering)

(with effect from 2020-21)

Savitribai Phule Pune University

Honours* in Virtual Reality and Augmented Reality

With effect from 2020-21

Year & Semester	Course Code and Course Title		Teaching Scheme Hours / Week			Examination Scheme and Marks						Credit Scheme		
			Theory	Tutorial	Practical	Mid-Semester	End-Semester	Term work	Practical	Presentation	Total Marks	Theory / Tutorial	Practical	Total Credit
TE & V	310701	Virtual Reality	04	--	--	30	70	--	--	--	100	04	--	04
	310702	Virtual Reality Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
		Total	04	-	02	100		50	-	-	150	04	01	05
											Total Credits =			**05**
TE & VI	310703	Augmented Reality	04	--	--	30	70	--	--	--	100	04	--	04
		Total	04	-	-	100		-	-	-	100	04	-	04
											Total Credits =			04
BE & VII	410701	Virtual Reality in Game Development	04	--	--	30	70	--	--	--	100	04	--	04
	410702	Virtual Reality Game Development Laboratory	--	--	02	--	--	50	--	--	50	--	01	01
		Total	04	-	02	100		50	-	-	150	04	01	05
											Total Credits =			05
BE & VIII	410703	Application Development using Augmented Reality and Virtual Reality	04	-	--	30	70	--	--	--	100	04	--	04
	410704	Seminar	--	02	--	--	--	-	--	50	50	02	--	02
		Total	04	-	02	100		-		50	150	06	-	06
											Total Credits =			**06**

Total Credit for Semester V+ VI+ VII+ VIII = 20

*** <u>To be offered as Honours for Major Disciplines as–</u>**

1. Computer Engineering
2. Electronics and Telecommunication Engineering
3. Electronics Engineering
4. Information Technology

<u>For any other Major Disciplines which is not mentioned above, it may be offered as Minor Degree.</u>

Reference: https://www.aicte-india.org/sites/default/files/APH%202020_21.pdf / page 99-100

Savitribai Phule Pune University
Honours* in Virtual Reality and Augmented Reality
Third Year of Engineering (Semeser V)
310701: Virtual Reality

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	Mid_Semester(TH): 30 Marks End_Semester(TH): 70 Marks

Companion Course, if any: **Virtual Reality Lab**

Course Objectives: This course is designed to give historical and modern overviews and perspectives on virtual reality. It describes the fundamentals of sensation, perception, technical and engineering aspects of virtual reality systems.

Course Outcomes:
On completion of the course, learner will be able to–

CO1: Describe how VR systems work and list the applications of VR.
CO2: Understand the design and implementation of the hardware that enables VR systems tobe built.
CO3: Understand the system of human vision and its implication on perception and rendering.
CO4: Explain the concepts of motion and tracking in VR systems.
CO5: Describe the importance of interaction and audio in VR systems.

Course Contents

Unit I	Introduction to Virtual Reality	(08 Hours)
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- Visual, Aural & Haptic Displays, Applications of Virtual Reality.		
#Exemplar/ Case Studies	Study the use of Virtual Reality at NASA	
Unit II	**Representing the Virtual World**	**(08 Hours)**
Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR		
#Exemplar/ Case Studies	GHOST (General Haptics Open Software Toolkit) software development toolkit.	
Unit III	**The Geometry of Virtual Worlds &The Physiology of Human Vision**	**(08 Hours)**
Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.		
#Exemplar/ Case Studies	Sweeping coverage of eye movements	
Unit IV	**Visual Perception & Rendering**	**(08 Hours)**
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		
#Exemplar/ Case Studies	Automatic stitching of panoramas in Virtual Reality	
Unit V	**Motion & Tracking**	**(08 Hours)**

Motion in Real and Virtual Worlds- Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection Tracking- Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies		
#Exemplar/ Case Studies	A virtual Study Use Case- NICE, An Educational Experience	
Unit VI	**Interaction & Audio**	**(08 Hours)**
Interaction - Motor Programs and Remapping, Locomotion, Manipulation, Social Interaction. Audio -The Physics of Sound, The Physiology of Human Hearing, Auditory Perception, Auditory Rendering.		
#Exemplar/ Case Studies	Side effects of using VR systems/ VR sickness.	

Learning Resources

Text Books:

1. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
2. 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
3. Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.

Reference Books:

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

e-Books:

- http://lavalle.pl/vr/book.html

MOOC Courses:

- https://nptel.ac.in/courses/106/106/106106138/
- https://www.coursera.org/learn/introduction-virtual-reality

SavitribaiPhule Pune University
Honours* in Virtual Reality and Augmented Reality
Third Year of Engineering (Semester V)
310702:Virtual Reality Laboratory

Teaching Scheme:	Credit	Examination Scheme:
PR: 04 Hours/Week	01	TW: 50 Marks

Course Objectives: The objective of this course is to explore the concepts of Virtual reality and develop 3D virtual environment.

Course Outcomes:

On completion of the course, learner will be able to–

CO6: Create and deploy a VR application.
CO7: understand the physical principles of VR
CO8: Create a comfortable, high-performance VR application using Unity.
CO9: Identify, examine and develop software that reflects fundamental techniques for the design and deployment of VR experiences.

Guidelines for Instructor's Manual

The instructor‘s manual is to be developed as a reference and hands-on resource. It should include prologue (about University/program/ institute/ department/foreword/ preface), University syllabus, conduction & Assessment guidelines, topics under consideration, concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by student in the form of journal. Journal consists of Certificate, table of contents, and handwritten write-up of each assignment (Title, Date of Completion, Objectives, Problem Statement, Software & Hardware requirements, Assessment grade/marks and assessor's sign, Theory- Concept in brief, algorithm, flowchart, test cases, Test Data Set(if applicable), mathematical model (if applicable), conclusion/analysis. Program codes with sample output of all performed assignments are to be submitted as softcopy. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journal must be avoided. Use of DVD containing students programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints in the Laboratory.

Guidelines for Laboratory /TW Assessment

Continuous assessment of laboratory work should be based on overall performance of Laboratory assignments by a student. Each Laboratory assignment assessment will assign grade/marks based on parameters, such as timely completion, performance, innovation, efficient codes, punctuality and neatness.

Guidelines for Laboratory Conduction

The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic. The assignment framing policy need to address the average students and inclusive of an element to attract and promote the intelligent students. Use of open source software is encouraged. Based on the concepts learned. Instructor may also set one assignment or mini-project that is suitable to respective branch beyond the scope of syllabus.

Operating System recommended :- 64-bit Windows OS
Programming tools recommended: - Unity, C#, Blender, VRTK.
VR Devices: HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.

Suggested List of Laboratory Experiments/Assignments (Implementation of each problem statement is mandatory.)	
Sr. No.	**Group A**
1.	Installation of Unity and Visual Studio, setting up Unity for VR development, understanding documentation of the same.
2.	Demonstration of the working of HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.
3.	Develop a scene in Unity that includes: i. a cube, plane and sphere, apply transformations on the 3 game objects. ii. add a video and audio source.
4.	Develop a scene in Unity that includes a cube, plane and sphere. Create a new material and texture separately for three Game objects. Change the colour, material and texture of each Game object separately in the scene. Write a C# program in visual studio to change the colour and material/texture of the game objects dynamically on button click.
5.	Develop a scene in Unity that includes a sphere and plane . Apply Rigid body component, material and Box collider to the game Objects. Write a C# program to grab and throw the sphere using vr controller.
6.	Develop a simple UI(User interface) menu with images, canvas, sprites and button. Write a C# program to interact with UI menu through VR trigger button such that on each successful trigger interaction display a score on scene ..
7.	Create an immersive environment (living room/ battlefield/ tennis court) with only static game objects. 3D game objects can be created using Blender or use available 3D models.
8.	Include animation and interaction in the immersive environment created in Assignment 7.
	Mini-Projects/ Case Study
9.	Create a virtual environment for any use case. The application must include at least 4 scenes which can be changed dynamically, a good UI, animation and interaction with game objects. (e.g VR application to visit a zoo)

Savitribai Phule Pune University
Honours* in Virtual Reality and Augmented Reality
Third Year of Engineering (Semester VI)
310703: Augmented Reality

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	**04**	**Mid_Semester(TH): 30 Marks** **End_Semester(TH): 70 Marks**

Course Objectives: The objective of this course is to provide a foundation to the fast growing field of AR and make the students aware of the various AR devices.

Course Outcomes:

On completion of the course, learner will be able to–

CO1: Describe how AR systems work and list the applications of AR.
CO2: Understand and analyse the hardware requirement of AR.
CO3: Use computer vision concepts for AR and describe AR techniques
CO4: Analyse and understand the working of various state of the art AR devices
CO5: Acquire knowledge of mixed reality

Course Contents

Unit I	Introduction to Augmented Reality (A.R)	(08 Hours)

What Is Augmented Reality - Defining augmented reality, history of augmented reality, The Relationship Between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum Between Real and Virtual Worlds, applications of augmented reality
Augmented Reality Concepts- How Does Augmented Reality Work? Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience.

#Exemplar/Case Studies	Timeline of evolution of AR from VR

Unit II	Augmented Reality Hardware	(08 Hours)

Augmented Reality Hardware – Displays – Audio Displays, Haptic Displays, Visual Displays, Other sensory displays, Visual Perception , Requirements and Characteristics, Spatial Display Model.
Processors – Role of Processors, Processor System Architecture, Processor Specifications.
Tracking & Sensors - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion.

#Exemplar/Case Studies	Study the design of an AR application with C# and Unity

Unit III	Computer Vision for Augmented Reality & A.R. Software	(08 Hours)

Computer Vision for Augmented Reality - Marker Tracking, Multiple-Camera Infrared Tracking, Natural Feature Tracking by Detection, Simultaneous Localization and Mapping, Outdoor Tracking
Augmented Reality Software - Introduction, Major Software Components for Augmented Reality Systems, Software used to Create Content for the Augmented Reality Application.

#Exemplar/Case Studies	Study all the available AR toolkits.

Unit IV	AR Techniques- Marker based & Markerless tracking	(08 Hours)

Marker-based approach- Introduction to marker-based tracking, types of markers, marker camera pose and identification, visual tracking, mathematical representation of matrix multiplication
Marker types- Template markers, 2D barcode markers, imperceptible markers.
Marker-less approach- Localization based augmentation, real world examples
Tracking methods- Visual tracking, feature based tracking, hybrid tracking, and initialisation and recovery.

#Exemplar/Case Studies	Study on enhancement and improving markers with Vuforia engine.

Unit V	AR Devices & Components	(08 Hours)

AR Components – Scene Generator, Tracking system, monitoring system, display, Game scene
AR Devices – Optical See- Through HMD, Virtual retinal systems, Monitor bases systems, Projection displays, Video see-through systems

#Exemplar/Case Studies	Case study on generating a scene using AR components

Unit VI	Beyond A. R. - Mixed Reality	(08 Hours)

Introduction to mixed reality, Applications of mixed reality, Input and Output in Mixed reality, Computer Vision and Mixed Reality, simultaneous localization and mapping (SLAM), variants of SLAM - dense tracking and mapping (DTAM), parallel tracking and mapping (PTAM) and semi-direct monocular visual odometry (SVO).

#Exemplar/Case Studies	Study of Microsoft Hololens.

Learning Resources

Text Books:

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

Reference Books:

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

e-Books: https://www.vttresearch.com/sites/default/files/pdf/science/2012/S3.pdf
https://docs.microsoft.com/en-us/windows/mixed-reality/
https://docs.microsoft.com/en-us/archive/msdn-magazine/2016/november/hololens-introduction-to-the-hololens

MOOC Courses: https://www.coursera.org/learn/ar
https://www.udemy.com/share/101XPi/

Savitribai Phule Pune University
Honours* in Virtual Reality and Augmented Reality
Final Year of Engineering (Semester VII)
410701: Virtual Reality for Game Development

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	Mid_Semester(TH): 30 Marks End_Semester(TH): 70 Marks

Prerequisite Courses, if any: Virtual Reality

Companion Course, if any: Virtual Reality for Game Development Laboratory

Course Objectives: This course will help students learn the basic principles of virtual reality applications and get them to know how games differ from desktop apps. It will help students build various types of VR experiences and use Unity to develop VR applications.

Course Outcomes:

On completion of the course, learner will be able to–

- CO6: Learn about the technology and psychology of VR and differentiate between VR and AR systems.
- CO7: Understand the concepts of content creation, interaction and iterative design.
- CO8: Create 3D scenes with Unity and experiment with various user interface (UI) techniques that are used in VR applications
- CO9: Create a 2D game in Unity.
- CO10: Understand the effect of VR systems on the health of individuals.

Course Contents

Unit I	Virtual Reality in a Nutshell	(0 Hours)

What is virtual reality?, Types of head-mounted displays, The difference between virtual reality and augmented reality, Applications versus games, How virtual reality really works, Types of VR experiences, Technical skills that are important to VR

#Exemplar/Case Studies	Study about VR device interaction and working with OS(Windows/Linux) and IDE's (Unity/Unreal)

Unit II	Content Creation & Interaction	(08 Hours)

High-Level Concepts of Content Creation, Environmental Design, Affecting Behavior, Transitioning to VR Content Creation, Content Creation: Design Guidelines

Human-Centered Interaction, VR Interaction Concepts, Input Devices, Interaction Patterns and Techniques, Interaction: Design Guidelines

#Exemplar/Case Studies	Case study of a developed VR game in Unity with the above mentioned features

Unit III	Iterative Design	(08 Hours)

Philosophy of Iterative Design, The Define Stage, The Make Stage, The Learn Stage, Iterative Design: Design Guidelines

#Exemplar/Case Studies	Study of Iterative design of any VR game.

Unit IV	Game Development in Unity - Part I	(08 Hours)

Overview, Building Your Project and Character, Getting Animated, The Town View, Working with Unity's UI System, NPCs and Interactions, The World Map, Encountering Enemies and Running Away

#Exemplar/Case Studies	Animation in Unreal Engine vs Unity Engine	
Unit V	**Game Development in Unity - Part II**	**(08 Hours)**
Getting Ready to Fight, The Battle Begins, Shopping for Items, Sound and Music, Putting a Bow on It, Deployment and Beyond		
#Exemplar/Case Studies	Case study on considering windows mixed reality for game development in Unity	
Unit VI	**Adverse Health Effects**	**(08 Hours)**
Motion Sickness, Eye Strain, Seizures, and Aftereffects, Hardware Challenges, Latency, Measuring Sickness, Summary of Factors That Contribute to Adverse Effects, Examples of Reducing Adverse Effects, Adverse Health Effects: Design Guidelines		
#Exemplar/Case Studies	Effect of any VR game on health.(Beat Saber/Rick and Morty: Virtual Rick-Ality/ Cloudlands VR Minigolf)	

Learning Resources

Text Books:

3. Jason Jerald- The VR Book: Human- Centered Design for Virtual Reality, Association for Computing Machinery and Morgan & Claypool Publishers (Aug. 5 2016), ISBN- B01JV1LAZW
4. Mastering Unity 2D Game Development - Second Edition,AshleyGodbold, Simon Jackson, Packt Publishing, October 2016, ISBN: 9781786463456
5. Jonathan Linowes – Unity Virtual Reality Projects: Explore the world of virtual reality by building immersive and fun VR projects using Unity 3D Paperback‖, 1st Edition, Packt Publications, 2015, ISBN 978-1783988556

Reference Books:

1. Tony Parisi – Learning Virtual Reality, O'Reilly Media, Inc., 2015, ISBN- 9781491922835
2. Virtual Reality with VRTK4, Create Immersive VR Experiences Leveraging Unity3D and Virtual Reality Toolkit, Authors: Baruah, Rakesh, ISBN 978-1-4842-5488-2

e-Books: https://vrgamedevelopment.pro/free-ebook-ar-game-development/

MOOC Courses: https://learn.unity.com/course/teaching-game-design-and-development
https://www.coursera.org/specializations/unity-xr
https://www.coursera.org/learn/making-virtual-reality-game

Savitribai Phule Pune University
Honours* in Virtual Reality and Augmented Reality
Fourth Year of Engineering (Semester VII)
410702: Virtual Reality in Game Development Laboratory

Teaching Scheme:	Credit	Examination Scheme:
PR: 02 Hours/Week	01	TW: 50 Marks

Prerequisite Courses, if any: Virtual Reality

Companion Course, if any: Virtual Reality in Game Development

Course Objectives: The objective of this course is to explore the concepts of Virtual reality and develop games using Unity.

Course Outcomes:

On completion of the course, learner will be able to–

CO1: Create 3D scenes with Unity and experiment with various user interface (UI) techniques that are used in VR applications

CO2: Create a 2D game in Unity.

CO3: Choose, develop, explain and defend the use of particular designs for VR experiences.

Guidelines for Instructor's Manual

The instructor‘s manual is to be developed as a reference and hands-on resource. It should include prologue (about University/program/ institute/ department/foreword/ preface), University syllabus, conduction & Assessment guidelines, topics under consideration, concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by student in the form of journal. Journal consists of Certificate, table of contents, and handwritten write-up of each assignment (Title, Date of Completion, Objectives, Problem Statement, Software & Hardware requirements, Assessment grade/marks and assessor's sign, Theory- Concept in brief, algorithm, flowchart, test cases, Test Data Set(if applicable), mathematical model (if applicable), conclusion/analysis. Program codes with sample output of all performed assignments are to be submitted as softcopy. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journal must be avoided. Use of DVD containing students programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints in the Laboratory.

Guidelines for Laboratory /TW Assessment

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The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic. The assignment framing policy need to address the average students and inclusive of an element to attract and promote the intelligent students. Use of open source software is encouraged. Based on the concepts learned. Instructor may also set one assignment or mini-project that is suitable to respective branch beyond the scope of syllabus.

Operating System recommended :- 64-bit Windows OS

Programming tools recommended: - Unity, C#, Blender, VRTK.

VR Devices: HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.

Suggested List of Laboratory Experiments/Assignments (Implementation of each problem statement is mandatory.)	
Sr. No.	**Group A**
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.
	Mini-Projects/ Case Study
7.	Create a multiplayer VR game (battlefield game). The game should keep track of score, no. of chances/lives, levels(created using different scenes), involve interaction, animation and immersive environment.

Savitribai Phule Pune University
Honours* in Virtual Reality and Augmented Reality
Fourth Year of Engineering (Semester VIII)
410703: Application Development Using Augmented Reality and Virtual Reality

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 Hours/Week	04	Mid_Semester(TH): 30 Marks End_Semester(TH): 70 Marks

Prerequisite Courses, if any: Virtual Reality, Augmented Reality.

Course Objectives: The objective of this course is to explain how Unity supports the many components of a VR app, including tracking, teleporting, interacting with virtual objects. At the same time to see how Unity's AR Foundation supports building AR apps.

Course Outcomes:

On completion of the course, learner will be able to–

CO11: Compare and Contrast VR and AR experiences
CO12: Demonstrate and develop VR apps in Unity
CO13: Demonstrate and develop AR apps in Unity
CO14: Acquire knowledge in VR and AR technologies in terms of used devices, building of the virtual environment and modalities of interaction and modelling.
CO15: Acquire knowledge about the application of VR and AR technologies in medicine, education, cultural heritage and games.

Course Contents

Unit I	Introduction to AR & VR	(08 Hours)

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, Gaze-Based 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 (Unity-Vuforia, Visual Studio, Netbeans, intellij IDEA, Android, iOS), connectivity of smart devices with AR.

#Exemplar/Case Studies	Case study of a single application using both VR and AR technologies

Unit II	VR App Development with Unity	(08 Hours)

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

#Exemplar/Case Studies	Creating 3D objects using Blender.

Unit III	AR App Development with Unity	(08 Hours)

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, ARToolkitx 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.

#Exemplar/Case Studies	Use of OpenCV for AR App Development

Unit IV	**Programming Languages for AR & VR applications**	**(08 Hours)**

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	**Working with VR & AR Devices**	**(08 Hours)**

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.

#Exemplar/Case Studies	Google Daydream

Unit VI	**Use Cases for AR and VR in single application**	**(08 Hours)**

Trending Application Areas - Gaming and Entertainment, Architecture and Construction, Science and Engineering, Health and Medicine, Aerospace and Defence, Education, Telerobotics and Telepresence **Human Factors, Legal and Social Considerations -** Human Factors Considerations, Legal and Social Considerations, The Future.

#Exemplar/Case Studies	What is Google Maps AR navigation and how it is used?

Learning Resources

Text Books:

6. Steve Aukstakalnis- Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR, Addison-Wesley Professional, September 2016, ISBN: 9780134094328
7. Allan Fowler- Beginning iOS AR Game Development Developing Augmented Reality Apps with Unity and C#, 1st Edition, Apress Publications, 2018, ISBN 978-1484236178
8. William Sherif- Learning C++ by Creating Games with UE4 ||, Packt Publishing, 2015, ISBN 978-1-78439-657-2

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, 17th April 2019. ISBN -13 : 978-1838648183
2. Jonathan Linowes, Krystian Babilinski – Augmented Reality for Developers: Build practical augmented reality applications with Unity, ARCore, ARKit, and Vuforia. Packt publishing, 9th October 2017. ISBN-13: 978-1787286436

MOOC Courses: https://www.coursera.org/learn/augmented-reality
https://www.coursera.org/specializations/unity-xr

Savitribai Phule Pune University
Honours* in Virtual Reality and Augmented Reality
Fourth Year of Engineering (Semester VIII)
410704: Seminar

Teaching Scheme	Credit Scheme	Examination Scheme and Marks
Practical: 02 Hours/Week	**02**	**Presentation: 50 Marks**

Course Objectives:

- To train the student to independently search, identify and study important topics in computer science.
- To develop skills among students to study and keep themselves up to date of the technological developments taking place in computer science
- To expose students to the world of research, technology and innovation.

Course Outcomes:

On completion of the course, student will be able to

- To train the student to independently search, identify and study important topics in computer science.
- To develop skills among students to study and keep themselves up to date of the technological developments taking place in computer science.
- To expose students to the world of research, technology and innovation

Guidelines for Seminar:

- The department will assign an internal guide under which students shall carry out Hons. seminar work
- In order to select a topic for Hons. Seminar, the student shall refer to various resources like books, magazines, scientific papers, journals, the Internet and experts from industries and research institutes
- The topic selected for Hons. Seminar by the students will be scrutinized and if found suitable, shall be approved by the internal guide
- Student should also explore the tools and technologies available for implementation of selected topic. Student should implement/ simulate the seminar work partially/ fully for enhancing the practical skill set on topic.
- Student shall submit the progress of his/her Hons. Seminar work to the internal guide.
- The student shall prepare a REPORT on the work done on Hons. Seminar and submit it at the time of presentation.

Evaluation of IT Seminar Work

- During the seminar work, its progress will be monitored, by the internal guide.
- At the end of seminar work, copy of Hons. Seminar Report should be prepared and submitted to department.
- End Examination shall be based on the Report, technical content and Presentation.
- **Guidelines for Assessment**: Panel of staff members along with a guide would be assessing the seminar work based on these parameters-Topic, Contents and Presentation, implementation, regularity, Punctuality and Timely Completion, Question and Answers, Report, Paper presentation/Publication, Attendance and Active Participation.

References:

1. Rebecca Stott, Cordelia Bryan, Tory Young, “Speaking Your Mind: Oral Presentation and Seminar Skills (Speak-Write Series)”, Longman, ISBN-13: 978-0582382435
2. Johnson-Sheehan, Richard, “Technical Communication”, Longman. ISBN 0-321-11764-6
3. Vikas Shirodka, “Fundamental skills for building Professionals”, SPD, ISBN 978-93-5213- 146-5