Integral University, Lucknow

Effective from Session: 2026-27							
Course Code	CS607	**Title of the Course**	System Simulation and Modeling	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	Define the basics of simulation modelling and replicating the practical situations in organizations Develop a simulation model using heuristic methods. Generate random numbers and random variates using different techniques. Analysis of Simulation models using input analyser, and output analyser Explain Verification and Validation of simulation model.						

Course Outcomes	
CO1	Describe the role of important elements of discrete event simulation and modeling paradigm.
CO2	Conceptualize real world situations related to systems development decisions, originating from source requirements and goals.
CO3	Interpret the model and apply the results to resolve critical issues in a real world environment.
CO4	Apply random number variates to develop simulation models
CO5	Analyze output data produced by a model and test validity of the model

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to Virtual Reality:**	Systems, Modelling, Simulation. Simulation as a tool, Advantages and Disadvantages of Simulation, Areas of Application, Classification of simulation models, continuous simulation, combined continuous-discrete simulation, Discrete-Event System Simulation, Monte Carlo Simulation. Steps of Simulation Study.	7	1
2	**Multiple Models of Input and Output Interface:**	Introduction to Modeling, Modeling Concepts and Definitions. Model of a System, Types of Models. Linear models, Nonlinear Functions Quadratic program model, Nonlinear modeling examples, Unconstrained and constrained growth models, Curve fitting, Stochastic models. Modeling complex systems. Accuracy and precision in modelling.	8	2
3	**Visual Computation in Virtual Reality:**	Basic Probability and statistics: Random Variables, Properties of Random Numbers, Generation of Pseudo- Random Numbers. Techniques for Generating Random Numbers. Tests for Random Numbers. Stochastic Processes. Means, Variances and Correlations. Probability Distribution. Confidence intervals and hypothesis test.	8	3
4	**Interactive Techniques in Virtual Reality:**	Types of Simulations with Respect to Output Analysis. Stochastic Nature of Output Data. Measures of Performance and Their Estimation. Output Analysis for Terminating Simulations, Output Analysis for Steady-State Simulations. Simulation Tools, Model Input. High-Level Computer- System Simulation, CPU Simulation, Memory Simulation.	9	4
5	**Application of Virtual Reality in Digital:**	Verification of Simulation Models, Calibration and Validation of Models. Increasing Model Validity and Credibility. Simulation Softwares: Simulation package vs programming languages, classification, features, General purpose simulation package, object-oriented simulation, application. Overview of commonly used simulation systems.	8	5

Reference Books:

1. Averill M. Law, W. David Kelton, "Simulation Modelling and Analysis" Third Edition, McGraw Hill.
2. Jerry Banks, John S. Carson, Barry L. Nelson, David M. Nicol, "Discrete- Event System Simulation", Third Edition, Prentice-Hall India
3. Geoffrey Gordon, "System Simulation", Second Edition, Prentice-Hall India.

PO-PS O / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	2	2	1	1		1						1		1	
CO 2	2	3	2	2	2	2	1		1			2			1
CO 3	1	2	1		2	1						1		1	
CO 4	2	2			2							1		1	
CO 5					1							1	2	2	3

3 Strong contribution, 2 Average contribution , 1 Low contribution

Integral University, Lucknow

Effective from Session: 2026-27							
Course Code	CS603	**Title of the Course**	Ad Hoc Sensor Networks	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To understand the basics of Ad-hoc & Sensor Networks. To learn various fundamental and emerging protocols of all layers. To study about the issues pertaining to major obstacles in establishment and efficient management of Ad-hoc and sensor networks. To understand the nature and applications of Ad-hoc and sensor networks						

Course Outcomes	
CO1	Identify different issues in wireless ad hoc and sensor networks
CO2	To analyze protocols developed for ad hoc and sensor networks..
CO3	To identify and address the security threats in ad hoc and sensor networks.
CO4	Establish a Sensor network environment for different types of applications.
CO5	To understand various security practices and protocols of Ad-hoc and Sensor Networks

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction of ad-hoc/sensor networks:**	Key definitions of ad-hoc/sensor networks, Advantages of ad-hoc/sensor networks, Unique constraints and characteristics of MANET, challenges & Performance parameters of Adhoc networks, Types & Applications of MANETs, Introduction of sensor network, sensor networks vs. ad-hoc networks, sensor network limitations, Design issues.	7	1
2	**Routing in Ad Hoc Networks:**	Introduction, Topology based routing protocol- Proactive routing- DSDV, WRP, TBRPF, OLSR, multipoint relay, STAR, Reactive routing- DSR, AODV, TORA, Hybrid routing approach- ZRP, FSR, LANMAR, CBRP, Position based routing- Location services- DREAM, quorum based location service, GLS, home zone, forwarding strategies-greedy packet forwarding, Restricted Directional flooding- DREAM, LAR, RDMAR, Hierarchical routing, Other position based routing protocols.	8	2
3	**Wireless sensor networks:**	Design Issues, Challenges of Wireless sensor network, Energy consumption, Clustering of sensors- regularly placed sensor, randomly distributed sensors, Heterogeneous WSNs. Mobile Sensors, attacks on sensor network routing- Spoofed, altered, or replayed routing information, selective forwarding, sinkhole attacks, the Sybil attack, Wormholes, HELLO flood attacks, Acknowledgement spoofing, application of sensor networks.	8	3
4	**Data retrieval in sensor networks:**	Introduction, Classification of WSNs- Architecture of sensor networks, network architecture, Routing Layer- Network structure based- flat routing- Directed diffusion, sequential assignment routing, MCFA, coherent and non-coherent processing, energy aware routing, Hierarchical routing- CBRP, LEACH, PEGASIS, MECN, TEEN, APTEEN, routing in fixed size clusters, sensor aggregates routing, Hierarchical power- Aware routing, flat versus Hierarchical.	9	4
5	**Security:**	Introduction, distributed system security, security in Ad- Hoc networks- requirements, security solutions constraints, challenges. Key Management- background, Diffie- Hellman key agreement, N- Party Diffie- Hellman Key agreement, The tree based generalized Diffie-Hellman protocol, Cooperation in MANETS, WSN security, Key distribution and management, Requirements for bootstrapping security in sensor networks, key distribution techniques in sensor networks- using a single network-wide key, using pair wise-shared keys, random key pre-distribution scheme, security protocols for sensor network, general consideration of using public key method, SPINS: SNEP AND µTELSA.	8	5

Reference Books:

1. AD HOC & SENSOR NETWORK "Theory and Application" by Carlos de MoraisCordeiro, World scientific press.

2."Wireless Ad Hoc and Sensor Networks" by HoudaLabiod, Willy Publication

PO-PS O / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	1		3	3	3	3		2	3	2	3	2		1	2
CO 2		2		2	1	3	3		1				3		
CO 3	3		3	1	2			1		2	3	1	2	3	3
CO 4		2	2	3		2	3		2	3	1	3	1	2	1
CO 5	2		1			3	1		2		2		3	3	2

3 Strong contribution, 2 Average contribution , 1 Low contribution

Integral University, Lucknow

Effective from Session: 2026-27							
Course Code	CS605	**Title of the Course**	Agile Software Engineering	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	This subject will introduce the principles and practices of Agile Project Management and DevOps. Over the recent years the agile movement has spread through the software development community and other organizations both large and small. The emphasis is on software development, but the principles can be applied to any type of project.						

Course Outcomes	
CO1	Be able to compare and contrast the differences between Agile and other project management methodologies
CO2	Be able to interpret and apply various principles, phases and activities of the Scrum methodology
CO3	Be able to understand Agile Testing principles for real life situations and learn the basics of SAFe for scaled agile
CO4	Be able to identify and use various tools for Agile development and CI/CD
CO5	Be able to understand and implement DevOps principles for CI/CD

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Agile:**	Why Agile? Understanding Success, Beyond Deadlines, The Importance of Organizational Success, Enter Agility, How to Be Agile? Agile Methods Don't Make Your Own Method, The Road to Mastery, Find a Mentor.	7	1
2	**Understanding XP:**	Understanding XP: The XP Lifecycle, The XP Team, XP Concepts, Adopting XP: Is XP Right for Us? Go! Assess Your Agility.	8	2
3	**Practicing XP:**	Practicing XP: Thinking: Pair Programming, Energized Work, Informative Workspace, Root-Cause Analysis, Retrospectives, Collaborating: Trust, Sit Together, Real Customer Involvement, Ubiquitous Language, Stand Up Meetings, Coding Standards, Iteration Demo, Reporting, Releasing: "DoneDone", No Bugs, Version Control, Ten- Minute Build, Continuous Integration, Collective Code Ownership, Documentation, Planning: Vision, Release Planning, The Planning Game, Risk Management, Iteration Planning, Slack, Stories, Estimating, Developing: Incremental Requirements, Customer Tests, Test-Driven Development, Refactoring, Simple Design, Incremental Design and Architecture, Spike Solutions, Performance Optimization, Exploratory Testing.	8	3
4	**Mastering Agility:**	Mastering Agility: Values and Principles: Commonalities, About Values, Principles, and Practices, Further Reading, Improve the Process: Understand Your Project, Tune and Adapt, Break the Rules, Rely on People: Build Effective Relationships, Let the Right People Do the Right Things, Build the Process for the People, Eliminate Waste: Work in Small, Reversible Steps, Fail Fast, Maximize Work Not Done, Pursue Throughput.	9	4
5	**Deliver Value:**	Deliver Value: Exploit Your Agility, Only Releasable Code Has Value, Deliver Business Results, Deliver Frequently, Seek Technical Excellence: Software Doesn't Exist, Design Is for Understanding, Design Tradeoffs, Quality with a Name, Great Design, Universal Design Principles, Principles in Practice, Pursue Mastery.	8	5

Reference Books:

1. The Art of Agile Development (Pragmatic guide to agile software development), James shore, Chromatic, O'Reilly Media, Shroff Publishers & Distributors, 2007.
2. Agile Software Development, Principles, Patterns, and Practices, Robert C. Martin, Prentice Hall; 1st edition, 2002
3. Agile and Iterative Development A Manger's Guide", Craig Larman Pearson Education, First Edition, India, 2004.

PO-PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1
CO 2	2	2	1	1	1	1	1	1	1	1	1	2	1	1	1
CO 3	3	1	1	1	1	1	2	2	2	1	1	3	2	3	2
CO 4	2	2	1	2	2	2	2	2	2	1	1	2	3	2	2
CO 5	2	2	2	1	1	1	1	1	1	1	2	1	2	2	3

3 Strong contribution, 2 Average contribution , 1 Low contribution

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**CS-626**	**Title of the Course**	**Internet of Things**	**L**	**T**	**P**	**C**
Year	**II**	**Semester**	**III**	**3**	**1**	**0**	**4**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	• To understand the fundamentals of Internet of Things. • To build a small low-cost embedded system using Arduino / Raspberry Pi or equivalent boards. • To apply the concept of Internet of Things in the real-world scenario • Develop web services to access/control IoT devices.						

Course Outcomes	
CO1	As per the new technology, a student should perform data transfer operations using IOT that help the students to guide in a formal way to communicate over new IOT devices within a short span of time.
CO2	For a given situation, a student should be able to deal with different structural aspects of designing and he/she can know the use of key technologies that would be used by the students to promote the development of a coherent learning program.
CO3	With the enhancement in technology, IOT deals with the challenges and unique product codes for a particular product so a student should be able to tackle the unique codes and he/she should develop different approaches that can continue the legacy of an organization.
CO4	During clustering phenomena, a student should be prepared to deal with principles and policies governed according to the company rules so as to provide better identity management using different models like isolated and federated user identity models.
CO5	A student should know the basic idea of security requirements and vulnerabilities in IOT. He/she should be good enough to deal with the establishment of identity for smart applications to be used in IOT

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction**	Introduction Characteristics Physical design Protocols Logical design Enabling technologies IoT Levels Domain Specific IoTsIoT vs M2M.	8	1
2	**IoT systems management**	IoT systems management IoT Design Methodology Specifications Integration and Application Development.	8	2
3	**BUILDING IOT WITH RASPBERRY**	BUILDING IOT WITH RASPBERRY PI Physical device Raspberry Pi Interfaces Programming APIs / Packages Web services	8	3
4	**BUILDING IOT WITH GALILEO/ARDUINO**	BUILDING IOT WITH GALILEO/ARDUINO Intel Galileo Gen2 with Arduino Interfaces Arduino IDE Programming APIs and Hacks	8	4
5	**CASE STUDIES**	CASE STUDIES and ADVANCED TOPICS Various Real time applications of IoT Connecting IoT to cloud Cloud Storage for Iot Data Analytics for IoT Software & Management Tools for IoT	8	5

Reference Books:

1. Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014.
2. ArshdeepBahga, Vijay Madisetti, “Internet of Things: A hands on approach”, Universities Press, 2015.

e-Learning Source:

https://nptel.ac.in/courses/106105166

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO5	PSO6	PSO7
CO1	**1**	**2**	**2**	**3**	**1**	**2**	**1**	**3**	**1**	**2**	**1**	**2**	**1**	**2**	**2**			
CO2	**3**	**2**	**1**	**1**	**1**	**2**		**2**	**2**	**2**	**3**	**1**	**3**	**2**	**2**			
CO3	**2**	**2**	**2**	**2**	**1**	**1**		**2**		**1**	**1**	**2**		**1**				
CO4	**3**	**2**	**1**	**2**		**1**	**1**	**3**		**2**	**3**	**3**		**3**	**1**			
CO5	**1**	**2**	**2**	**3**	**1**	**2**	**1**	**3**	**1**	**2**	**1**	**2**	**1**	**2**	**2**			

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27							
Course Code	CS631	**Title of the Course**	Integration Project Lab	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**0**	**0**	**8**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The aim of the Joint Interdisciplinary Project is to prepare students to contribute to solving impactful technological challenges. The projects not only demand good engineering working knowledge but also experience with interdisciplinary and systems theory, and both knowledge and mindsets of innovation and entrepreneurial behavior. Teams of interdisciplinary student teams guided by a coach and offered academic and industry expertise, are invited to realize an innovative problem solution to a complex problem and contribute to the sustainable development goals.						

Course Outcomes	
CO1	Cognitive abilities attributable to interdisciplinary learning • Demonstrate the ability to engage in perspective-taking; • Develop structural knowledge pertaining to the problem; • Integrate knowledge and modes of thinking drawn from two or more disciplines; • Produce an interdisciplinary understanding of complex problems or intellectual questions.
CO2	Scientific and intellectual development • Capable to analyse scientific and societal consequences (economic, social, cultural, environmental) of the innovation;
CO3	Research and design capabilities • Demonstrate engineering skills: technical skills, interpreting results, creativity, usability for company/institute; • Demonstrate that they are capable to independently apply relevant theory and/or knowledge to research and/or design;
CO4	Collaboration and communication in an interdisciplinary team • Demonstrate behavioural competences and skills: taking initiative, responsibility, showing communication skills, independency, collaboration and the ability to respect different disciplines and adapt to different cultures); • Show ability to write a technical report: structured/consistent, language proficient, with correct use of literature/references, use of figures/tables/equations, and has a concise format (30 pages); • Present work performed in a structured way through an oral presentation to their peers and customers.
CO5	Self-adjustment and reflection capabilities • Plan and control the project efficiently considering resources and methodology; • Being able to reflect on personal functioning in an evaluation report: reflect on personal objectives, indicate personal strengths/weaknesses. Indicate future personal improvement, drawing conclusions for future career.
CO6	Cognitive abilities attributable to interdisciplinary learning; • The ability to integrate (scientific and practical technological) knowledge from different disciplines to solve complex problems Scientific and intellectual development • The capacity to evaluate the ethical, scientific and societal consequences of the proposed innovation Research and design capabilities • The ability to create reasonable and relevant research or design, according to the academic standards of the involved disciplines Collaboration and communication in an interdisciplinary team • Demonstrate behavioural competences and skills relevant for teamwork and effective communication with different stakeholders. Self-adjustment and reflection capabilities • To carry out regular reflections on professional and personal development and being able to improve upon those reflections • Understand contemporary and societal issues in their work.

Project :
The course is not divided into Units. The course comprises interdisciplinary work, scientific reasons and ethical mindset, innovation process, presentation and communication.

PO-PS O / **CO**	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO 1	2	2	3	1	1	1	2	2	2	1	2	1	2	3	3
CO 2	1	1	2	3	3	2	1	2	3	1	1	1	1	1	1
CO 3	3	3	2	1	2	3	2	3	3	2	2	1	3	3	3
CO 4	1	1	1	1	2	2	3	3	3	1	3	1	1	1	1
CO 5	3	1	1	2	2	3	2	2	3	2	1	1	1	1	1
CO 6	1	1	1	3	3	3	3	3	2	2	1	1	1	1	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	CS-609	**Title of the Course**	Big Data	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	1. To study the basic technologies that form the foundations of Big Data. 2.To study the programming aspects of cloud computing with a view to rapid prototyping of complex applications. 3.To understand the specialized aspects of big data including big data application, and big data analytics. 4.To study different types Case studies on the current research and applications of the Hadoop and big data in industry.						

Course Outcomes	
CO1	Students must be able to understand the building blocks of Big Data.
CO2	Students must be able to articulate the programming aspects of cloud computing(map Reduce etc.)
CO3	Student must be able to understand the specialized aspects of big data with the help of different big data applications
CO4	Students must be able to represent the analytical aspects of Big Data.
CO5	Students must know the recent research trends related to Hadoop File System, MapReduce and Google File System etc.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Data structures in Java**	Data structures in Java: Linked List, Stacks, Queues, Sets, Maps; Generics: Generic classes and Type parameters, Implementing Generic Types, Generic Methods, Wrapper Classes, Concept of Serialization	8	1
2	**Working with Big Data**	Google File System, Hadoop Distributed File System (HDFS) – Building blocks of Hadoop (Namenode, Datanode, Secondary Namenode, JobTracker, TaskTracker), Introducing and Configuring Hadoop cluster (Local,Pseudo-distributed mode, Fully Distributed mode), Configuring XML files	8	2
3	**Writing MapReduce Programs**	Understanding Hadoop API for MapReduce Framework, Basic programs of Hadoop MapReduce: Driver code, Mapper code, Reducer code, RecordReader, Combiner, Partitioner	8	3
4	**Hadoop I/O**	The Writable Interface, WritableComparable and comparators, Writable Classes: Writablewrappers for Java primitives, Text, BytesWritable, NullWritable, ObjectWritable and GenericWritable, Writable collections, Implementing a Custom Writable: Implementing a RawComparator for speed, Custom comparators	8	4
5	**Pig and hive**	Pig Architecture, Evaluating Local and Distributed Modes of Running Pig Scripts, Checking out the Pig Script Interfaces. Hadoop Data with Hive: Saying Hello to Hive, Seeing How the Hive is Put Together, Getting Started with Apache Hive, Examining the Hive Clients, Working with Hive Data Types, Creating and Managing Databases and Tables, Seeing How the Hive Data Manipulation Language Works, Querying and Analyzing Data.	8	5

Reference Books:

1. Big Java 4th Edition, Cay Horstmann, Wiley John Wiley & Sons, INC
2. Hadoop: The Definitive Guide by Tom White, 3rd Edition, O'Reilly, Hadoop in Action by Chuck Lam, MANNING Publ.
3. Hadoop: The Definitive Guide by Tom White, 3rd Edition, O'Reilly Hadoop for Dummies by Dirk deRoos, Paul C.Zikopoulos, Roman B.Melnyk,Bruce Brown, Rafael Coss

e-Learning Source:

https://nptel.ac.in/courses/106104189

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	–	–	–	–	–	–	–	–	2	2
CO2	2	2	1	1	1	–	–	–	–	–	–	–	–	2	2
CO3	2	2	1	2	1	–	–	–	–	–	–	–	–	2	2
CO4	2	2	1	2	1	–	–	–	–	–	–	–	–	2	2
CO5	2	2	2	3	2	–	–	–	–	–	–	–	–	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27							
Course Code	CS632	**Title of the Course**	Machine Perception	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	CS-272 Python Programming Lab, CS-544 Machine Learning Techniques	**Co-requisite**	None				
Course Objectives	This course provides an overview of machine perception techniques in robotics						

Course Outcomes	
CO1	explain the role of Machine Perception (MP) in Robotics, and describe possible applications
CO2	explain the measurement principles of the relevant sensors, explain the principles of well-established methods for low- to high-level sensor processing
CO3	Analyze an MP problem, consider available sensor and computational resources, and select the appropriate MP methods to apply
CO4	write Python code in relevant frameworks to visualize data and implement MP methods, perform MP experiments, evaluate the results, and draw sound conclusions

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction**	Machine perception in robotics, Course organization, Overview sensors (camera, radar, LiDAR, tactile), 3D Machine vision: Perspective camera model, Extrinsic and intrinsic camera transformations, Image matching, Stereo vision	8	1
2	**Sensors**	Radar, Lidar and Tactile sensing	8	2
3	**Object Detection and Classification**	Detection vs. Classification, Object proposals, Handcrafted features (e.g. HOG) & classification (e.g. linear SVM), End-to-end learning: Neural Networks, Performance metrics: confusion matrices, precision vs. recall, ROC curves	8	3
4	**State estimation**	Bayesian Filtering, Kalman Filtering, Particle Filtering, Object Tracking, Data Association, Track Management	8	4
5	**Self-Localization & Sensor Fusion**	Absolute vs. relative localization, Ego-motion compensation (e.g. odometry, ICP algorithm), Extrinsic sensor calibration, Environment representations (grids, voxels)	8	5

Reference Books:

1. C.M. Krishna & Shin, "Real Time Systems", Mc Graw Hill1985.
2. Jane W.S. LIU, "Real Time Systems", Pearson Education".
3. Levi & Agarwal, "Real Time System", McGraw Hill.
4. Mall Rajib, "Real Time Systems", Pearson

PO-PSO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	2	1	1	1	2	1	1	1	1	2	2	2	2	3	1
CO 2	2	2	2	1	2	1	2	1	1	2	2	2	2	2	1
CO 3	3	3	2	1	1	1	1	1	1	2	3	3	3	3	1
CO 4	3	3	3	1	1	1	1	1	2	2	3	2	3	3	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27							
Course Code	CS634	**Title of the Course**	Deep Learning	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	To understand the basic ideas and principles of Neural Networks To understand the basic concepts of Big Data and Statistical Data Analysis To familiarize the student with The Image Processing facilities like Tensorflow and Keras To appreciate the use of Deep Learning Applications To understand and implement Deep Learning Architectures						

Course Outcomes	
CO1	Understand basics of deep learning
CO2	Implement various deep learning models
CO3	Realign high dimensional data using reduction techniques
CO4	Analyze optimization and generalization in deep learning
CO5	Explore the deep learning applications

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction:**	Introduction to machine learning- Linear models (SVMs and Perceptrons, logistic regression)- Intro to Neural Nets: What a shallow network computes- Training a network: loss functions, back propagation, and stochastic gradient descent- Neural networks as universal function approximates	7	1
2	**Deep Networks:**	History of Deep Learning- A Probabilistic Theory of Deep Learning- Backpropagation and regularization, batch normalization- VC Dimension and Neural Nets-Deep Vs Shallow Networks Convolutional Networks- Generative Adversarial Networks (GAN), Semi-supervised Learning	8	2
3	**Dimensionality Reduction:**	Linear (PCA, LDA) and manifolds, metric learning - Auto encoders and dimensionality reduction in networks - Introduction to Convnet - Architectures – AlexNet, VGG, Inception, ResNet - Training a Convnet: weights initialization, batch normalization, hyper parameter optimization	8	3
4	**Optimization and Generalization:**	Optimization in deep learning– non-convex optimization for deep networks- Stochastic Optimization Generalization in neural networks- Spatial Transformer Networks- Recurrent networks, LSTM - Recurrent Neural Network Language Models- Word-Level RNNs & Deep Reinforcement Learning - Computational & Artificial Neuroscience	9	4
5	**Case Study and Applications:**	Imagenet- Detection-Audio WaveNet-Natural Language Processing Word2Vec - Joint Detection Bioinformatics- Face Recognition- Scene Understanding- Gathering Image Captions	8	5

Reference Books:

1. CosmaRohillaShalizi, Advanced Data Analysis from an Elementary Point of View, 2015.
2. Deng & Yu, Deep Learning: Methods and Applications, Now Publishers, 2013.
3. Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, MIT Press, 2016.
4. Ian Goodfellow, YoshuaBengio, Aaron Courville, Deep Learning, MIT Press, 2016.

PO-PS O / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	2	2	1	1		1	2	2	2	2	1	1	1	1	
CO 2	2	3	2	2	2	2	1	1	1	2	2	2	1		1
CO 3	1	2	1		2	1	2	2	1	1	2	1	2	1	
CO 4	2	2			2		2	1	2	1	1	1	1	1	
CO 5					1		2		1	2	1	1	2	2	3

3 Strong contribution, 2 Average contribution , 1 Low contribution

Integral University, Lucknow

Effective from Session: 2026-27							
Course Code	CS564	**Title of the Course**	Field and Service Robot	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	Learn the skills for controlling the interaction between robots and poorly structured environments, through force control, visual control, manipulation and cooperation. The tools for modeling, planning and control of self-driving mobile robots (with wheels, drones, legged, underwater).						

Course Outcomes	
CO1	Knowledge and Understanding: The course path aims to provide students with the essential methodological tools for modelling, planning and control of autonomous mobile robot systems. The fundamental problems concerning robots with locomotion mechanisms in open spaces, structured and not, are dealt with. The analytical methods acquired by the students are then used to understand the peculiarities in the design of planning techniques and control laws for such robots.
CO2	Applying knowledge and understanding: The student must demonstrate that (s)he is able to apply the methodologies acquired to model, plan and control autonomous-drive robots with different locomotion mechanisms, such as land rovers, drones (in particular quadcopters), underwater robots, quadrupedal and bipedal robots

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction**	Field and Service Robots, Wheeled Robots, Odometric localization	8	1
2	**Aerial Robotics**	Aerial robotics, drone kinematics, dynamics of a quadcopter, hierarchical control and geometrical control, passive control with external disturbance estimator	10	1
3	**Underwater robotics**	Underwater robotics, kinematics and dynamics, mixed controller	10	2
4	**Legged Robots**	Legged robots, kinematics of the floating base, dynamics and centroidal dynamics, stability and criteria, whole-body control, planner, momentum-based estimator.	12	2

Reference Books:

1. B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, Robotics – Modeling, Planning and Control, Springer, London, 2009, ISBN 978-1-84628-641-4
2. A. Ollero, B. Siciliano (Eds.), Aerial Robotic Manipulation, Springer, Berlin, 2019, ISBN 978-3-030-12945-3
3. G. Antonelli, Underwater Robots, 3rd Ed., Springer, Berlin, ISBN 978-3-319-02877-4

PO-PSO / CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO 1	3	2	2	2	1	-	-	-	-	-	-	3	2	2	-
CO 2	3	3	3	2	2	-	-	-	2	-	-	3	3	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2026-27							
Course Code	**CS699**	**Title of the Course**	**Dissertation**	**L**	**T**	**P**	**C**
Year	**II**	**Semester**	**IV**	**0**	**0**	**16**	**16**
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	1. To develop individuality and problem analysis skills. 2. To nurture the ability to perform literature review. 3. To improve critical thinking ability for formulation of plan. 4. To develop skills to use various engineering and technological tools. 5. To develop the skill to think critically on research results. 6. To enhance the writing skill for research papers and dissertations.						

Course Outcomes	
CO1	Capability to work independently on a research-based problem
CO2	Skill to perform review of available literature effectively to present research gap
CO3	Aptitude to plan methodology for the attainment of various research objectives.
CO4	Competency to apply of various engineering and technological tools to carry research
CO5	Ability to conclude work using critical thinking.
CO6	Proficiency in preparing presentation and report.

Project :

The course is not divided into Units. The course comprises interdisciplinary work, scientific reasons and ethical mindset, innovation process, presentation and communication.

PO-PS O CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	0	0	0	3	3	0	0	3	3	3	0	0	1	0	0
CO 2	0	0	0	3	3	0	0	3	3	3	0	0	0	2	0
CO 3	0	0	0	0	3	0	0	0	3	3	0	0	0	0	0
CO 4	0	0	0	3	3	0	0	0	3	0	0	0	0	1	0
CO 5	0	0	0	3	3	0	0	3	3	3	0	0	1	0	0

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation