Shri Vile Parle Kelavani Mandal's
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING
(Autonomous College Affiliated to the University of Mumbai)
NAAC Accredited with "A" Grade (CGPA : 3.18)

Proposed scheme for Honors in Artificial Intelligence and Machine Learning
(Academic Year 2022-2023)

Sr.	Course Code	Course	Teaching Scheme (hrs.)				Continuous Assessment (A) (marks)			Semester End Assessment (B) (marks)					(A+B)	Total Credits
			Th	P	T	Credits	Th	T/W	Total CA (A)	Th / Cb	O	P	O & P	Total SEA (B)		
SEM V																
1	DJ19ECHN1C1	Mathematics and Statistics for Artificial Intelligence & Machine Learning	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
SEM VI																
2	DJ19ECHN1C2	Concepts and Algorithms of Artificial Intelligence & Machine Learning	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
3	DJ19ECHN1L1	Concepts and Algorithm of Artificial Intelligence & Machine Learning Laboratory	--	2	--	1	--	25	25	--	--	--	--	--	25	**1**
SEM VII																
4	DJ19ECHN1C3	Deep Learning	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
5	DJ19ECHN1L2	Deep Learning Laboratory	--	2	--	1	--	25	25	--	--	--	--	--	25	**1**
SEM VIII																
6	DJ19ECHN1C4	Pattern Recognition & Machine Learning	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
		Total	**16**	**4**	**0**	**18**	**100**	**25**	**150**	**300**	**0**	**0**	**0**	**300**	**450**	**18**

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Proposed scheme for Honors in Intelligent Connectivity : 5G & IoT
(Academic Year 2022-2023)

Sr. No.	Course Code	Course	Teaching Scheme (hrs.)				Continuous Assessment (A) (marks)			Semester End Assessment (B) (marks)					(A+B)	Total Credits
			Th	P	T	Credits	Th	T/W	Total CA (A)	Th / Cb	O	P	O & P	Total SEA (B)		
SEM V																
1	DJ19ECHN2C1	Sensor and Actuator Technology for IoT	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
SEM VI																
2	DJ19ECHN2C2	IoT System Design	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
3	DJ19ECHN2L1	Real Time System Design Laboratory	--	2	--	1	--	25	25	--	25	--	--	25	50	**1**
SEM VII																
4	DJ19ECHN2C3	Intelligent IoT Systems	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
5	DJ19ECHN2L2	Intelligent IoT Systems Laboratory	--	2	--	1	--	25	25	--	25	--	--	25	50	**1**
SEM VIII																
6	DJ19ECHN2C4	Fifth Generation Technology	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
		Total	**16**	**4**	**0**	**18**	**100**	**50**	**150**	**300**	**25**	**0**	**25**	**350**	**500**	**18**

Shri Vile Parle Kelavani Mandal's
DWARKADAS J. SANGHVI COLLEGE OF ENGINEERING
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NAAC Accredited with "A" Grade (CGPA : 3.18)

Proposed scheme for Minor in IoT and Industry 4.0
(Academic Year 2022-2023)

Sr.	Course Code	Course	Teaching Scheme (hrs.)				Continuous Assessment (A) (marks)			Semester End Assessment (B) (marks)					(A+B)	Total Credits
			Th	P	T	Credits	Th	T/W	Total CA (A)	Th / Cb	O	P	O & P	Total SEA (B)		
SEM V																
1	DJ19MN8C1	Sensor Technology	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
SEM VI																
2	DJ19MN8C2	IoT System Design	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
SEM VII																
3	DJ19MN8C3	IoT Network Design	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
4	DJ19MN8L1	IoT System and Network Design Laboratory	--	2	--	1	--	25	25	--	25	--	--	25	50	**1**
SEM VIII																
5	DJ19MN8C4	Industry 4.0	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
6	DJ19MN8L2	Industry 4.0 Laboratory	--	2	--	1	--	25	25	--	25	--	--	25	50	**1**
		Total	**16**	**4**	**0**	**18**	**100**	**50**	**150**	**300**	**25**	**0**	**50**	**350**	**500**	**18**

Evaluation Scheme:

Continuous Assessment (A):

Course	**Assessment Tools**	**Marks**	**Time (hrs.)**
Theory	Mid Term test (50 % syllabus) / presentation / assignment / course project / group discussion / any other.	25	as applicable
Laboratory	Performance in the laboratory and documentation.	25	

The final certification and acceptance of term work will be subject to satisfactory performance upon fulfilling minimum passing criteria in the term work / completion of audit course.

Semester End Assessment (B):

Course	**Assessment Tools**	**Marks**	**Time (hrs.)**
Theory / * Computer based	Written paper based on the entire syllabus.	75	3
	* Computer based assessment in the college premises.		
Oral & Practical	Project based courses - Performance of the practical assigned during the examination and the output / results obtained. Based on the practical performed during the examination and on the entire syllabus.	as per the scheme	2

Prepared by Checked by Head of the Department Principal

Honors in Artificial Intelligence & Machine Learning	**Semester: V**
Program: Electronics and Telecommunication Engineering	
Course: Mathematics and Statistics for Artificial Intelligence & Machine Learning (DJ19ECHN1C1)	

Pre-requisite: --

1. Engineering Mathematics – IV

Objectives:

1. To build an intuitive understanding of Mathematics and relating it to Artificial Intelligence, Machine Learning.
2. To provide a strong foundation for probabilistic and statistical analysis mostly used in varied applications in Engineering.
3. To explore optimization and dimensionality reduction techniques.

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

1. Apply linear algebra concepts to model, solve, and analyze real-world problems.
2. Apply probability distributions and sampling distributions to
3. Analyze various optimization techniques.
4. Describe Dimension Reduction Algorithms

Mathematics and Statistics for Artificial Intelligence & Machine Learning (DJ19ECHN1C1)		
Unit	**Description**	**Duration**
1	**Linear Algebra**	**16**
	1.1 Matrices and Gaussian Elimination The geometry of linear equations, Elimination with matrices, Multiplication and inverse matrices, Factorization into A = LU form, Inverses and Transposes. **1.2 Vector Spaces** Vectors, Lengths and distances, angles, Inner Product, Vector Spaces and Subspaces Solving Ax = 0; pivot variables, solving Ax = b; Rank and nullity of a matrix, Row reduced form R. Linear Independence, Basis, Dimension, Span, Norm. The four fundamental subspaces, Change of basis. **1.3 Orthogonality** Orthogonal vectors and subspaces, Orthogonal and orthonormal Basis. **1.4 Projections onto Subspaces** Projection onto 1-D subspaces, Projection onto 2-D subspaces, Projection matrices and least squares, Orthogonal matrices and Gram-Schmidt procedure. **1.5 Eigen Values and Eigen Vectors** Concepts of Eigen values and Eigen vectors; Diagonalization of a matrix, Eigen decomposition.	

	1.6 Positive Definite Matrices Symmetric matrices and positive definiteness, Positive definite matrices, Similar matrices and Jordan Form, Singular Value Decomposition, Linear Transformation of matrices.	
2	**Probability and Statistics**	**14**
	2.1 Probability Probability definition, Conditional Probability, The Chain Rule of Conditional Probabilities, Independence and Conditional Independence. **2.2 Probability distribution** Binary variables, Bernoulli distribution, Binomial Distribution, Normal Distribution, Student's *t* distribution, chi-squared distribution, Sample and sampling, sampling distribution and Central Limit Theorem. **2.3 Statistics** Mean, Variance and Covariance, Covariance matrix, Covariance and Correlation. Mean of a dataset, Variance of one-dimensional datasets, Variance of higher-dimensional datasets. Linear Transformation of datasets: Effect on the mean, Effect on the (co)variance. **2.4 Statistical Inference** Estimation, Hypothesis Testing, Confidence Interval **2.5 Bayesian Statistics** Bayesian concept learning: Likelihood, Prior, Posterior, Posterior Predictive distribution, MAP estimation.	
3	**Information Theory** Entropy, KL divergence, Mutual information.	**3**
4	**Continuous Optimization** Optimization Using Gradient Descent, Stochastic Gradient Descent, Convex Optimization.	**5**
5	**Mixture Models and EM algorithm** Mixture Models: Mixtures of Gaussians The EM algorithm: Basic idea, EM for GMMs.	**5**
6	**Dimension Reduction Algorithms** **6.1 Introduction** Linear Dimensionality Reduction, Principal component analysis, Factor Analysis, Linear discriminant analysis. **6.2 Non-Linear Dimensionality Reduction** Multidimensional Scaling, Isometric Feature Mapping. Minimal polynomial	**5**
7	**Markov Process** Definition of Markov Process, Discrete Markov chains, The n–step transition probabilities, Steady state probabilities, Chapman-Kolmogorov Theorem, Classification of states of Markov Chain, HMM.	**4**
	Total	**52**

Books Recommended:

Text books:

1. Gilbert Strang, *Linear Algebra and its Applications*, 4th edn, Cengage India Private Limited,2005.
2. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, *Mathematics for Machine Learning*, Cambridge University Press,2020.
3. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.

Reference Books:

1. Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. *Foundations of Machine Learning*, MIT Press, 2018.
2. Ian J. Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press, 2016.

Useful Links:

1. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/
2. *https://archive.nptel.ac.in/courses/111/107/111107137/*

Prepared by Checked by Head of the Department Principal

Honors in Artificial Intelligence & Machine Learning		
Program: Electronics and Telecommunication Engineering	**T. Y. B. Tech**	**Semester: VI**
Course: Concepts and Algorithms of Artificial Intelligence & Machine Learning (DJ19ECHN1C2)		
Course: Concepts and Algorithms of Artificial Intelligence & Machine Learning Laboratory (DJ19ECHN1L1)		

Pre-requisite: --

1. **Mathematics and Statistics for Artificial Intelligence & Machine Learning (DJ19ECHN1C1)**

Objectives:

1. To conceptualize the basic ideas and techniques underlying the design of intelligent systems.
2. To make students understand advanced representation formalism and search techniques.
3. To acquire in depth understanding of various supervised and unsupervised algorithms
4. To demonstrate dimensionality reduction techniques.

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

1. Understand basic building blocks of AI present in intelligent agents.
2. Apply an appropriate problem-solving method and knowledge representation technique.
3. Understand fundamental knowledge of developing machine learning models.
4. Design and evaluate an appropriate machine learning model.

Concepts and Algorithms of Artificial Intelligence & Machine Learning (DJ19ECHN1C2)		
Unit	**Description**	**Duration**
1	**Intelligent Agents:** Introduction, AI Intelligent Agents; Structure of Intelligent Agents; Agents and Environments, Types of Agents.	**03**
2	**Introduction to AI Problems** Introduction; Turing Test; Problems in AI.	**02**
3	**Solving Problems in AI: Searching Algorithms as Applied in AI.** Uninformed search BFS, DFS, Depth First with Iterative Deepening, Generate and Test Search Algorithms. Informed/Heuristic search Hill Climbing, Steepest Ascent Hill Climbing, Problems in Hill Climbing, Greedy Nearest Neighbor, Best First Search, Greedy Best First Search, Beam Search, A* search, AO* search algorithms. Constraint satisfaction Search Crypto Arithmetic, Back Tracking: N Queens Problem. Problem Reduction Search AND/OR Graphs, Game Trees. Adversarial search in Games**:** The Min-Max Algorithm on Exhaustively Searchable Graphs, Minimaxing to Fixed Ply Depth, Alpha Beta Pruning.	**10**
4	**Knowledge Representation and Reasoning** Logical Agents Knowledge Based Agents, Wumpus World Knowledge Base Propositional Logic Syntax, Semantics, Inference, Resolution, Problems in Propositional Logic. First Order Logic: Syntax and Semantic of FOL, Using FOL	**08**

	Inference in FOL Propositional vs. First-Order Inference, Unification, Resolution.	
5	**Preparing to model: Data Visualization and Preprocessing**	**05**
	Basic Types of Data in Machine Learning: Plotting and exploring numerical, categorical data, Exploring relationship between variables. Reading Data from varied data sources into Pandas Dataframe, Data visualization in Pie chart, Tree map, Heat map, Scatter plot, Histogram, Box plot. Data Cleaning with Pandas: Filling in Missing values, Cleaning and Filling Missing Data, Drop missing values, Smoothing Noisy data, Removing inconsistencies, Functions in Python Pandas.	
6	**Modelling and Evaluation** Selecting a model: Predictive Models, Descriptive models**.** Training a model: K-fold cross validation method Model representation and Interpretability: Under fitting, Over fitting, Bias-variance Trade off. Evaluating Performance of a Model in Supervised and Unsupervised Learning.	**04**
7	**Supervised Learning:** Linear Regression Algorithms: Simple Linear Regression, Multiple Linear regression, Need for Feature Scaling, Different types of Feature Scaling, Gradient Descent in LR. Logistic Regression : Building Logistic Regression model. Maximum Likelihood Estimation.	**08**
8	**Supervised Learning: Classification** K- Nearest Neighbor Classifier: Choosing Parameters for KNN classifier, KNN Algorithm. Decision Tree Steps to construct a Decision Tree, Classification using Decision Trees. Issues using Decision Tree: Underfitting, Overfitting.Random Tree model. Support Vector Machine Linear SVM: Separating Hyperplane. Optimal Hyperplane: Relationship between Margin and optimal Hyperplane. Equation of Hyperplane, Computation of Distance from a point to the Hyperplane, Computationof the Margin of the Hyperplane.	**07**
9	**Unsupervised Learning** Clustering Different Types of clustering techniques. Partitioning methods.K- means clustering, K-medoids.	**05**
	Total	**52**

Concepts and Algorithms of Artificial Intelligence & Machine Learning Laboratory (DJ19ECHN1L1)	
Sr. No.	**Suggested Experiments List:**
1	Data Visualization with Pandas/Seaborn.
2	Data Cleaning and Pre-processing in Python.
3	Exploratory Data Analysis in Python.
4	Modelling and evaluation with Python.
5	Implement BFS search algorithms to reach goal state
6	Implement DFS search algorithms to reach goal state

7	Implement DFID search algorithms to reach goal state
8	Implement Generate and Test search algorithms to reach goal state
9	Identify and analyze informed search Algorithm to solve the problem. Implement A* search algorithm to reach goal state.
10	Program to implement Local Search algorithm: Hill climbing search
11	Program on Genetic Algorithm to solve an optimization problem in AI.
12	To implement Linear Regression.
13	To implement Logistic Regression.
14	To implement Decision tree algorithm
15	To Implement Naïve Bayes Classifier algorithm.
17	To implement Support Vector Machine.
18	To implement K-Nearest Neighbor.
19	To implement K means Clustering.

Minimum eight experiments from the above suggested list or any other experiment based on syllabus will be included, which would help the learner to apply the concept learnt.

Books Recommended:

Text books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", Fourth Edition" Pearson Education, 2020.
2. Tom M. Mitchell, "Machine Learning", McGraw Hill, 2020.

Reference Books:

1. Saikat Dutt, Amit Das, "Machine Learning," Pearson,2022.
2. Seema Acharya, "Reimagining Data Visualization Using Python," Wiley 2022.
3. Lavika Goel, "Artificial Intelligence: Concepts and Applications," Wiley 2021.

Honors in Artificial Intelligence & Machine Learning	**Semester: VII**
Program: Electronics and Telecommunication Engineering	
Course: Deep Learning (DJ19ECHN1C3)	
Course: Deep Learning Laboratory (DJ19ECHN1L2)	

Pre-requisite:

1. **Mathematics and Statistics for Artificial Intelligence & Machine Learning**
2. **Concepts and Algorithms of Artificial Intelligence & Machine Learning**

Objectives:

1. To understand Hyper Parameter Tuning
2. To explore Deep Learning Techniques with different learning strategies
3. To design Deep Learning Models for real time applications

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

1. Understand and Apply Hyper Parameters Tuning
2. Interpret working of deep learning models
3. Create Deep Learning Models for real-world problems
4. Investigate suitable deep learning algorithms for various applications.

Deep Learning (DJ19ECHN1C3)		
Unit	**Description**	**Duration**
1	**Introduction to Deep Learning**	**12**
	History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Multilayer Perceptron (MLPs), Representation Power of MLPs, Sigmoid Neurons, Feed Forward MLPs, Error Function, Back propagation in MLPs, Updating weights. **Optimization techniques:** Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Ada Grad, RMS Prop, AdaDelta. **Vanishing and Exploding Gradient Problem:** Fixing the vanishing Gradient problem, Gradient Clipping, over fitting, L1 and L2 Regularization.	
2	**Hyper Parameter Tuning Batch Normalization**	**08**
	Tuning Process, using an Appropriate Scale to pick Hyper parameters, Hyper parameters Tuning in Practice: Pandas vs. Caviar, Normalizing Activations in a Network, Fitting Batch Norm into a Neural Network, why does Batch Norm work, Batch Norm at Test Time.	

	Effective training in Deep Net: Early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization.	
3	**Convolution Neural Networks**	**12**
	Components of CNN architecture: Convolution layer, Pooling or Down Sampling Layer, Flattening Layer, Fully Connected layer, Transfer Learning. **Non-Linearity:** Rectified Linear Unit (ReLU), Leaky ReLU Layer. **Properties of CNN:** Weight Sharing, Translation Invariance. **Architectures of CNN:** LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet.	
4	**Recurrent Neural Networks**	**08**
	Simple Recurrent Neural Network Training an RNN: Back Propagation through time (BPTT) RNN Topology, Vanishing and Exploding Gradients. Long Short-Term Memory (LSTM), Grated Recurrent Unit (GRU).	
5	**Autoencoder**	**08**
	Types of Auto encoders, Structure of Auto encoders, Regularization in auto encoders, Denoising auto encoders, Sparse auto encoders.	
6	**Applications:** Face Recognition, Optical Character Recognition, Hand written digit recognition	**04**
	Total	**52**

Books Recommended:

Text books:

1. *Ian Goodfellow, Yoshua Benjio, Deep Learning-, Alanna Maldonado Publications, 1st ed. 2023.*
2. *Jon Krohn, Grant Beyleveld, Deep Learning Illustrated, Pearson Education, 1st ed., 2020.*

Reference Books:

1. *Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Recognition. Wiley, 2nd ed.,2021.*
2. *Francois Chollet, Deep Learning with Python, Manning Publications, 2nd ed., 2022.*

Suggested List of Experiments:

Sr. No.	Title of the Experiment
1.	Implementation of different Activation functions and Cost functions in Neural Network.
2.	Implementation of different learning rules in MLP.
3.	Implementation of Feed Forward networks in a Multilayer Perceptron.
4.	Build a three-layer Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.
5.	Implementation of Curve Fitting with Deep Neural Networks.
6.	Binary Planar data classification with Deep Neural Networks.
7.	Hand written digit—Multiclass classification with Deep Neural Networks.
8.	Image Classification with Convolution Neural networks.
9.	Audio Classification with Convolution Neural networks.
10.	Prediction of a data sequence with simple Recurrent Neural Network.
11.	Language Modelling and Generating Text with RNN
12.	Handwriting Recognition with LSTM
13.	Image Compression with Autoencoders.
14.	Image Denoising with Autoencoders.

Minimum ten experiments from the above suggested list or any other experiment based on syllabus will be included, which would help the learner to apply the concept learnt.

Honors in Artificial Intelligence & Machine Learning		
Program: Electronics and Telecommunication Engineering	**Final Year B.Tech**	**Semester: VIII**
Course: Pattern Recognition and Machine Learning (DJ19ECHN1C4)		

Pre-requisite: --

1. Mathematics and Statistics for Artificial Intelligence & Machine Learning. (DJ19ECHN1C1)
2. Concepts and Algorithms of Artificial Intelligence & Machine Learning. (DJ19ECHN1C2)
3. Deep Learning. (DJ19ECHN1C3)

Objectives:

1. To Extract patterns of a given dataset.
2. To Perform Feature Selection and Extraction.
3. To Design efficient models.

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

1. Understand fundamental concepts and theories for pattern recognition
2. Apply different algorithms for pattern recognition.
3. Perform Feature Extraction and Feature Selection.
4. Design efficient classifier or clustering model.

Pattern Recognition and Machine Learning (DJ19ECHN1C4)		
Unit	**Description**	**Duration**
1	**Introduction** What is Pattern Recognition? Data Sets for Pattern Recognition Different Paradigms for Pattern Recognition. Statistical Pattern Recognition	05
2	**Representation** Data Structures for Pattern Representation. Patterns as Vectors, Patterns as Strings, Logical Descriptions , Patterns as Trees and Graphs, Representation of Clusters, Proximity Measures, Distance Measure, Weighted Distance Measure, Non-Metric Similarity Function, Edit Distance 19 Mutual Neighbourhood Distance (MND) Size of Patterns Normalisation of Data, Use of Appropriate Similarity Measures, Abstractions of the Data Set	10
3	**Feature Extraction** Fisher's Linear Discriminant Principal Component Analysis (PCA)	05
4	**Feature Selection** Exhaustive Search**.** Branch and Bound Search	05

5	**Nearest Neighbour Classifier** Nearest Neighbour Classifier and its Variants, Efficient Algorithms for Nearest Neighbour, Classification The Branch and Bound Algorithm, Prototype Selection, Minimal Distance Classifier, Condensed Nearest Neighbour Classifier.	06
6	**Bayes Classifier** Bayes Classifier. Naive Bayes Classifier. Bayesian Belief Networks	06
7	**Clustering Large Datasets** Incremental Clustering , Divide-and-Conquer Clustering	05
8	**Combination of Classifiers** Introduction to Combining Classifiers. AdaBoost for Classification	05
9	**Application - Document Recognition** Document Processing. Document Classification and Retrieval	05
	Total	**52**

Books Recommended:

Text book:

1. Pattern Recognition, 2ed, Richard O. Duda, Peter E. Hard, David G. Stork,Wiley,2021.

Reference Book:

1. Pattern Recognition And Machine Learning, Christopher M. Bishop, Springer ,2020.

Prepared by Checked by Head of the Department Principal

Honors in Intelligent Connectivity : 5G & IoT	**Semester: V**
Program: Electronics & Telecommunication Engineering	
Course: Sensor and Actuator Technology for IoT (DJ19CHHN2C1)	

Pre-requisite: --

1. Basics of Electrical and Electronics Engineering
2. Electronic Devices and Circuits
3. Integrated Circuits

Objectives:

1. To provide understanding of physical parameters and sensing techniques of various sensors.
2. To provide Understanding about signal conditioning principle.
3. To familiarize about MEMS sensors and actuators

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

1. To understand the transduction principle of various sensors.
2. To select sensors suitable for required application.
3. To analyze wireless sensing technique.
4. To design data acquisition system.
5. Identify signal conditioning method for particular application.

Sensor and Actuator Technology for IoT (DJ19ECHN2C1)		
Unit	**Description**	**Duration**
1	**Classification and Performance Characteristics of Sensors and Actuators:** Classification of Sensors and Actuators: General Requirements for Interfacing, Units and Measures, Transfer function, Impedance and Impedance matching, Range, Span, Resolution, Accuracy, Errors, Repeatability, Sensitivity and Sensitivity analysis, Hysteresis, Nonlinearity and saturation, Frequency Response, Response Time and Bandwidth, Calibration, Excitation – Deadband, Reliability.	10
2	**Temperature and Optical Sensors and Actuators:** Thermo resistive Sensors: Thermistors, Resistance temperature sensors, Silicon resistive sensors, Thermoelectric Sensors, PN Junction Temperature Sensors, Optical and Acoustical Sensors, Thermo mechanical sensors and Actuators. Optical Sensors and Actuators: Effects of Optical Radiation, Quantum Based Optical Sensors, Photoelectric Sensors, Coupled Charge (CCD) Sensors and Detectors, Thermal Based Optical Sensors, Active Far Infrared (AFIR) Sensors, Optical Actuators	10
3	**Electric, Magnetic, Mechanical Sensors and Actuators:** The Electric Field: Capacitive Sensors and Actuators	10

	Magnetic Fields: Inductive sensors and Hall effect sensors, Magneto hydro dynamic (MHD) Sensors and Actuators, Magnetometers Magnetic Actuators, Voltage and Current Sensors. Mechanical Sensors and Actuators, Radiation Sensors, Mems and Smart Sensors Force Sensors, Accelerometers, Pressure Sensors, Gyroscopes	
4	**Signal Conditioning:** Fundamentals of data Acquisition: Analog and Digital Data acquisition system with different configurations, data loggers, noise and interference. Signal Conditioning: Wheatstone bridge, Flash ADC, R2R DAC. Utilization of Signal Conditioning circuits for Temperature, Pressure, Optical, Strain Gauges, Displacement and Piezoelectric transducers.	06
5	**Current Trends in sensors and Technology Smart Sensors:** Introduction, Primary sensors, Excitation, Amplification, Filters, Converters, Compensation, Information Coding/Processing, Data Communication, Standards for Smart Sensor Interface, The Automation Sensor Technologies: Introduction, Film Sensors, Thick Film Sensors, Thin Film Sensors, Semiconductor IC Technology Standard Methods, Microelectromechanical Systems (MEMS), Nano-sensors Sensor Applications: On-board Automobile sensors, Home appliances sensors, Aerospace Sensors, Sensors for Environmental Monitoring Self-learning Topics: Energy Harvesting, Self-powered Wireless Sensing in ground, Ground penetrating sensors.	10
	Total	**46**

Books Recommended:

Text books:

1. D. Patranabis, *Sensor and Actuators*, 2nd Edition, Prentice Hall of India.
2. A. K. Sawhney, *A course in Electronic Measurements and Instrumentation*,19th Edition, Dhanpat Rai & Co.
3. H. S. Kalsi, *Electronic Instrumentation and Measurements*,4th Edition, McGraw-Hill.
4. Nathan Ida, *Sensors, Actuators and their Interfaces*, SciTech Publishing,2013.

Reference Books:

1. Clarence. W. de Silva, *Sensors and Actuators: Engineering System Instrumentation*, 2nd Edition, CRC Press, 2015.
2. Ernest. O. Doebelin, *Measurement Systems, Application and design*, Tata McGraw- Hill, Publishing Company Ltd., 5th Edition, 2004.
3. D. A. Bradley, D. Dawson, N. C. Burd, A. J. Loader, *Mechatronics*, Thomson Press India Ltd., 2004.
4. S. Renganathan, *Transducer Engineering*, Allied Publishers (P) Ltd., 2003.
5. W. Bolton, Mechatronics, 4th Edition, Pearson Education, 2011.

Prepared by Checked by Head of the Department Principal

Honors in Intelligent Connectivity : 5G & IoT	**Semester: VI**
Program: Electronics & Telecommunication Engineering	
Course: IoT System Design (DJ19ECHN2C2)	
Course: Real Time System Design Laboratory (DJ19ECHN2L1)	

Pre-requisite: --

1. Sensor and Actuator Technology for IoT
2. Computer Networks

Objectives:

1. To provide understanding of enabling technologies.
2. To provide Understanding about IoT sensors and their interfacing.
3. To familiarize about protocols for IoT, Application building with IoT.

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

1. To understand the enabling technologies.
2. To select sensors suitable for required application.
3. To analyze protocols for IoT.
4. To Visualize the power of data from the IoT
5. To build the application with IoT

IoT System Design (DJ19ECHN2C2)		
Unit	**Description**	**Duration**
1	**Introduction to Internet of Things** Introduction and Definition of Internet of Things , IoT Growth- A statistical View, Application areas of IoT, Characteristics of IoT, Things in IoT, IoT stack, IoT Enabling Technologies, IoT Challenges, IoT Levels, Cyber Physical system versus IoT, Wireless sensor Network versus IoT, Interfacing with any sensor, Microcontrollers : A Quick walkthrough, Advanced RISC Machine : A Quick Overview.	**10**
2	**Protocols for IoT** Messaging and Transport: Messaging Protocols: Message Queuing Telemetry Transport (MQTT), Constrained Application Protocol (CoAP), Extensible Messaging and Presence Protocol **(**XMPP), Data Distribution Service (DDS)**,** Transport Protocols: Bluetooth Low Energy, Light Fidelity(Li-Fi), Addressing and Identification: A Quick Overview- IPv4,IPv6,IPv5, Uniform Resource Identifier (URI)	**10**

3	**Cloud for IoT** IoT with Cloud- Challenges, Selection of cloud service provider, Introduction to Fog Computing, Cloud computing : security aspects, Architectural Design of Compute and Storage Clouds AWS and AZURE	**6**
4	**Data Analytics- Visualising the power of data from IoT.** Data Analysis, Machine Learning, Types of Machine learning Models, Model building process, Modelling algorithms, Model Performance, Big data Platform, Big Data Pipeline, Real Life Projects, Recommendation in IoT Gadgets	**10**
5	**Application Building with IoT** Introduction, Smart Perishable Tracking with IoT and sensors, Smart Healthcare, Smart Inflight lavatory maintence with IoT, IoT – Based Application to monitor water quality, Smart warehouse Monitoring, Smart Retail, Integrated Vehicle Health management	**9**
	Total	**45**

Books Recommended:

Text books:

1. Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, “Internet of Things”, 2nd Edn, Wiley, 2020.
2. Dac-Nhuong Le, Chintan Bhatt, Mani Madhukar “Security Designs for the Cloud, IoT, and Social Networking” John Wiley & Sons, 2019.
3. Marco Schwatrz, “Internet of Things with Arduino Cookbook”, Packt Publications, 2016.
4. Rajkumar Buyya, Christian Vecchiola. S. Thamarai Selvi, “Mastering Cloud Computing”, McGraw Hill Education, 2013.

Reference books:

1. Agus Kurniawan “Learning AWS IoT” Packt Publishing, 2018.
2. Nick Antonopoulos and Lee Gillam, “Cloud Computing: Principles, Systems and Applications”, 2nd Edn, Springer, 2017.

Suggested List of Experiments:

Real Time System Design Laboratory (DJ19ECHN2L1)	
List of Laboratory Experiments: (minimum eight)	
1	Tutorial based on current trends and advancements on IoT
2	Study, discussion, and installation of ARM/Arduino/ESP 32/ RPi
3	Interfacing the sensor with ARM/Arduino / ESP 32 / RPi
4	Interfacing the motor drivers with ARM/ Arduino / ESP 32 / RPi
5	Real time data analysis using sensors, processors, and gateway
6	Interfacing the camera module with ARM/ Arduino / ESP 32 / RPi
7	Real time data base management system using sensors, processors, and gateway
8	Implementation of IoT system Using Messaging and Transport
9	Implementation of data transfer using wireless devices
10	Configuration and using the cloud platform
11	Implementation of IoT system Using Voice Control technique
12	Implementation of IoT system Using Personal Cloud Platform
13	Implementation of IoT system Deep Learning Inference
14	Implementation of IoT system using Artificial Intelligence
15	Implementation of IoT system using Machine Learning
16	Case study based on current trends and advancements on IoT
	Any other experiment may be included, which would help the learner to understand the topic/concept.

Prepared by Checked by Head of the Department Principal

Honors in Intelligent Connectivity : 5G & IoT	**Semester: VII**
Program: Electronics & Telecommunication Engineering	
Course: Intelligent IoT Systems (DJ19ECHN2C3)	

Pre-requisite: --

1. Sensor and Actuator Technology for IoT
2. IoT System Design

Objectives:

1. To provide understanding of physical parameters and sensing techniques of various sensors.
2. To provide Understanding about IIoT Systems.
3. To familiarize about Machine Learning and Data Science for Intelligent systems

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

1. To understand the basics of CPS.
2. To select sensors suitable for required application.
3. To design an industrial internet system.
4. To identify Business opportunities in IIoT Business Models.
5. To evaluate the information's using Machine Learning and Data Science.

Intelligent IoT Systems (DJ19ECHN2C3)		
Unit	**Description**	**Duration**
1	Overview of Industry 4.0 and Industrial Internet of Things: Introduction, Industry 4.0, Industrial revolution: Phases of development Evolution of Industry 4.0 Environmental impacts of industrial revolution Industrial Internet Applications of Industry 4.0 IIoT Prerequisites of IIoT Basics of CPS. CPS and IIoT Applications of IIoT.	10
2	Industrial Internet of Things: Basics Introduction IIoT and Industry 4.0. IIC Industrial Internet Systems. Design of industrial internet systems Impact of industrial internet Benefits of industrial internet Industrial Sensing Traditional Sensing Contemporary Sensing Industrial Processes. Features of IIoT for industrial processes Industrial plant The future architecture View point of industrial processes Digital Enterprise Applications of Industry 4.0.	10
3	Business Models and Reference Architecture of IIoT Introduction, Business models, Definition of a business model, Reference architecture Business Models of IoT, Business models of IIoT, Business opportunities in IIoT, Categorization of business models in IIoT, Reference architecture of IoT, Reference Architecture of IIoT, Categorization of reference architecture in IIoT, IIRA frame work: Basics categorization of IIRA frame works, Key Performance Indicators for Occupational Safety and Health	10

4	**Machine Learning and Data Science in Industries** Introduction, Machine Learning, Categorization of ML Applications of ML in Industries Data Science in Industries Deep Learning Application of Deep Learning in Industries Healthcare Applications in Industries **Inventory Management and Quality Control**: Introduction, Inventory Management Inventory, Types of inventory management Inventory Management and IIoT, Benefits of IIoT applications in inventory management, Quality Control	10
5	**Case Studies** **Introduction** Manufacturing Industry: Background of the industry, Challenges Industrial IoT as a solution, Benefits, Automotive Industry: Background of the industry, Challenges, Industrial IoT as a solution, Benefits, Mining Industry: Background of the industry, Challenges Industrial IoT as a solution Benefits Test Your Understanding: Self Learning Topics based on Problems.	6
	Total	**46**

Books Recommended:

Text books:

1. Sudip Misra, Chandana Roy, Anandarup Mukherjee, Introduction to Industrial Internet of Tings and Industry 4.0. First edition published 2021, CRC Press.
2. Sudip Misra, Subhadeep Sarkar Subarna Chatterjee Sensors, Cloud, and Fog: The Enabling Technologies for the Internet of Things. 2019 by Taylor & Francis Group.

Reference Books:

1. Sravani Bhattacharjee, "Practical Industrial Internet of Things Security", Packt Publishing,2018.

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Honors in Intelligent Connectivity: 5G & IoT	**Semester: VII**
Program: Electronics & Telecommunication Engineering	
Course: Intelligent IoT Systems Laboratory (DJ19ECHN2L2)	

Pre-requisite: --

1. Sensor and Actuator Technology for IoT
2. IoT System Design

Objectives:

1. To provide understanding of enabling technologies.
2. To provide Understanding about IIoT sensors and their interfacing.
3. To familiarize about protocols for IIoT, Application building with IIoT.

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

1. To understand the enabling technologies.
2. To select sensors suitable for required application.
3. To analyze protocols for IIoT.
4. To Visualize the power of data from the IIoT
5. To build the application with IIoT

Real Time System Design Laboratory (DJ19ECHN2L1)	
List of Laboratory Experiments: (minimum eight)	
1	Tutorial based on current trends and advancements on Intelligent IoT Systems
2	Study, discussion, and installation of ARM/Arduino/ESP 32/ RPi /STM32/Rpi PICO
3	Interfacing the sensor with ARM/Arduino / ESP 32 / Rpi/ STM32/Rpi PICO
4	Interfacing the motor drivers with ARM/ Arduino / ESP 32 / Rpi/ STM32/Rpi PICO
5	Real time data analysis using sensors, processors, and gateway
6	Interfacing the camera module with ARM/ Arduino / ESP 32 / RPi / STM32/Rpi PICO
7	Real time data base management system using sensors, processors, and gateway
8	Implementation of IIoT system Using Messaging and Transport
9	Implementation of data transfer using wireless devices
10	Configuration and using the cloud platform
11	Implementation of IIoT system Using Voice Control technique
12	Implementation of IIoT system Using Personal Cloud Platform
13	Implementation of IIoT system Deep Learning Inference
14	Implementation of IIoT system using Artificial Intelligence
15	Implementation of IIoT system using Machine Learning

16	Case study based on current trends and advancements on IIoT
	Any other experiment may be included, which would help the learner to understand the topic/concept.

Books Recommended:

Text books:

1. Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, “Internet of Things”, 2nd Edn, Wiley, 2020.
2. Sudip Misra, Chandana Roy, Anandarup Mukherjee, Introduction to Industrial Internet of Tings and Industry 4.0. First edition published 2021, CRC Press.

Reference books:

1. Agus Kurniawan “Learning AWS IoT” Packt Publishing, 2018.
2. Nick Antonopoulos and Lee Gillam, “Cloud Computing: Principles, Systems and Applications”, 2nd Edn, Springer, 2017.

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Program: Electronics & Telecommunication Engineering Honors in Intelligent Connectivity : 5G & IoT	Final Y. B.Tech	Semester: VIII
Course: Fifth Generation Technology (DJ19ECHN2C4)		

Pre-requisite:

1. Digital Communication
2. Mobile Communication System

Objectives:

1. Learn the basics of 5G and beyond wireless communication
2. Study 5G network architecture, Heterogeneous Network and Small cells
3. Provide an understanding of the key technologies and enablers of 5G and beyond communication systems.
4. Learn 5G technology like massive MIMO, mmWave, etc.

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

1. Distinguish between the major cellular communication standards (1G/2G/3G/4G/5G systems) and the architecture of wireless communications networks.
2. Apply the 5G techniques e.g., massive MIMO, mmWave, etc. for the design of communication systems.
3. Analyse various modulation and multiplexing techniques e.g., OFDM, NOMA, etc.
4. Describe applications of cognitive radio in 5G Wireless Communication

Fifth Generation Technology (DJ19ECHN2C4)		
Unit	**Description**	**Duration**
1	**Introduction** Introduction to 5G Technology, Features, Requirements, Applications, 5G Services, Introduction to 5G Digital modulations (OFDM, 5G Technology Modulation Techniques) and performance metrics, Evolution of Air Interface Towards 5G, 5G Internet, Internet of Things and Context-Awareness, Software Defined Networking, 5G NR Network Function Virtualization (NFV) 5G NR	08
2	**5G Architecture** 5G Network Architecture, Cloud RAN(C-RAN), Definitions of Heterogeneous Networks, Radio Resource and Interference Management for Heterogeneous Networks, Traffic offloading scenarios for heterogeneous networks, mobility management, and handover, Small cell deployments: different types, Deployment scenarios, performance, and analysis, Energy-efficient mechanism with BS sleep mode in green small cell networks, Game theory and learning techniques for self-organization in small cell networks, 3GPP RAN standards for small cell	12

3	**mmWave** mmWave Millimeter bands, radio-wave propagation Physical layer design and algorithms, mmWave MIMO challenges, channel modelling, channel estimation, and Beam-forming. Types of transceivers, Merits, and Demerits, Applications - Beamforming Physical or Radio layer Technologies - Massive MIMO (Sub 6Ghz) mmWave MIMO (above 6 GHz)	10
4	**NOMA** Nonorthogonal Multiple Access (NOMA), Different Types: power domain NOMA and code domain NOMA, Difference between Orthogonal multiple access and NOMA, Filter Bank multi-carrier -Full duplex Radio Techniques, Precoding	08
5	**Trends in 5G** 5G NR, Carrier Aggregation in 5G, Open RAN, Use cases of 5G: eMBB, URLLC, and mMTC, Advance applications: Robotic surgery, driverless car and Industrial IoT(IIoT), Tactile Internet, 5G-IoT applications, AR/VR in 5G (The Next Generation Wireless Access Technology)	08
	Total	**46**

Books Recommended:

Text books:

1. Aditya K. Jagannatham, “Principles of Modern Wireless Communication Systems Theory and Practice”, McGraw Hill Education, 2017.
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014.

Reference Books:

1. R. Vannithamby and S. Talwar, Towards 5G: Applications, Requirements and Candidate Technologies., John Willey & Sons, West Sussex, 2017.
2. Manish, M., Devendra, G., Pattanayak, P., Ha, N., 5G and Beyond Wireless Systems PHY Layer Perspective, Series in Wireless Technology Springer, 2021.
3. M. Vaezi, Z. Ding, and H. V. Poor, Multiple Access techniques for 5G Wireless Networks and Beyond., Springer Nature, Switzerland, 2019.
4. Sassan Ahmadi, “5G NR: Architecture, Technology, Implementation, and Operation of 3GPP New Radio Standards”, Academic Press,2019.
5. Suvra Sekhar Das, Ramjee Prasad “Evolution of Air Interface Towards 5G: Radio Access Technology and Performance Analysis”, River Publishers, 2018.

Prepared by Checked by Head of the Department Principal

Minor in IoT and Industry 4.0	**Semester: V**
Program: Common for All Programs (except EXTC Engineering)	
Course: Sensor Technology (DJ19MN8C1)	

Pre-requisite: --

1. Basics of Electrical and Electronics Engineering

Objectives:

1. To provide understanding of physical parameters and sensing techniques of various sensors.
2. To provide Understanding about signal conditioning principle.
3. To familiarize about MEMS sensors and actuators.

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

1. To understand the transduction principle of various sensors
2. To select sensors suitable for required application
3. To analyze wireless sensing technique
4. To design data acquisition system.
5. Identify signal conditioning method for particular application

IoT and Industry 4.0 (DJ19MN8C1)		
Unit	**Description**	**Duration**
1	**Classification and Performance Characteristics of Sensors and Actuators:** Classification of Sensors and Actuators: General Requirements for Interfacing, Units and Measures, Transfer function, Impedance and Impedance matching, Range, Span, Resolution, Accuracy, Errors, Repeatability, Sensitivity and Sensitivity analysis, Hysteresis, Nonlinearity and saturation, Frequency Response, Response Time and Bandwidth, Calibration, Excitation, Deadband, Reliability.	10
2	**Temperature and Optical Sensors and Actuators:** Thermo resistive Sensors: Thermistors, Resistance temperature sensors, Silicon resistive sensors, Thermoelectric Sensors, PN Junction Temperature Sensors, Optical and Acoustical Sensors, Thermo mechanical sensors and Actuators. Optical Sensors and Actuators: Effects of Optical Radiation, Quantum Based Optical Sensors, Photoelectric Sensors, Coupled Charge (CCD) Sensors and Detectors, Thermal Based Optical Sensors, Optical Actuators.	10
3	**Electric, Magnetic, Mechanical Sensors and Actuators:** The Electric Field: Capacitive Sensors and Actuators Magnetic Fields: Inductive sensors and Hall effect sensors, Sensors and Actuators, Magnetometers Magnetic Actuators, Voltage and Current Sensors.	10

	Mechanical Sensors And Actuators, Radiation Sensors, Accelerometers, Pressure Sensors, Gyroscopes.	
4	**Signal Conditioning:** Fundamentals of data Acquisition: Analog and Digital Data acquisition system with different configurations, data loggers, noise and interference. Signal Conditioning: Wheatstone bridge, Flash ADC, R2R DAC. Utilization of Signal Conditioning circuits for Temperature, Pressure, Optical, Strain Gauges, Displacement and Piezoelectric transducers.	06
5	**Current Trends in sensors:** Introduction, Primary sensors, Excitation, Amplification, Filters, Converters, Compensation, Information Coding/Processing, Data Communication, Standards for Smart Sensor Interface, The Automation Sensor Technologies: Introduction, Film Sensors, Thick Film Sensors, Thin Film Sensors, Semiconductor IC Technology Standard Methods, Microelectromechanical Systems (MEMS), Nano-sensors Sensor Applications: On-board Automobile sensors, Home appliances sensors, Aerospace Sensors, Sensors for Environmental Monitoring Self-learning Topics: Energy Harvesting, Self-powered Wireless Sensing in ground, Ground penetrating sensors.	10
	Total	**46**

Books Recommended:

Text books:

1. D. Patranabis, *Sensor and Actuators*, 2nd Edition, Prentice Hall of India.
2. A. K. Sawhney, *A course in Electronic Measurements and Instrumentation*,19th Edition, Dhanpat Rai & Co.
3. H. S. Kalsi, *Electronic Instrumentation and Measurements*,4th Edition, McGraw-Hill.
4. Nathan Ida, *Sensors, Actuators and their Interfaces*, SciTech Publishing,2013.

Reference Books:

1. Clarence. W. de Silva, *Sensors and Actuators: Engineering System Instrumentation*, 2nd Edition, CRC Press, 2015.
2. Ernest. O. Doebelin, *Measurement Systems, Application and design*, Tata McGraw- Hill, Publishing Company Ltd., 5th Edition, 2004.
3. D. A. Bradley, D. Dawson, N. C. Burd, A. J. Loader, *Mechatronics*, Thomson Press India Ltd., 2004.
4. S. Renganathan, *Transducer Engineering*, Allied Publishers (P) Ltd., 2003.
5. W. Bolton, Mechatronics, 4th Edition, Pearson Education, 2011.

Prepared by Checked by Head of the Department Principal

Minors in IoT and Industry 4.0	**Semester:** VI
Program: Common for All Programs (Except Electronics & Telecommunication Engineering)	
Course: IoT System Design	

Pre-requisite: --

1. Sensor and Actuator Technology for IoT
2. Computer Networks

Objectives:

1. To provide understanding of enabling technologies.
2. To provide Understanding about IoT sensors and their interfacing.
3. To familiarize about protocols for IoT, Application building with IoT.

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

1. To understand the enabling technologies.
2. To select sensors suitable for required application.
3. To analyze protocols for IoT.
4. To Visualize the power of data from the IoT
5. To build the application with IoT

IoT System Design (DJ19MN8C2)		
Unit	**Description**	**Duration**
1	**Introduction to Internet of Things** Introduction and Definition of Internet of Things , IoT Growth- A statistical View, Application areas of IoT, Characteristics of IoT, Things in IoT, IoT stack, IoT Enabling Technologies, IoT Challenges, IoT Levels, Cyber Physical system versus IoT, Wireless sensor Network versus IoT, Interfacing with any sensor	**10**
2	**Protocols for IoT** Messaging and Transport: Messaging Protocols : Message Queuing Telemetry Transport (MQTT),Constrained Application Protocol (CoAP), Extensible Messaging and Presence Protocol **(**XMPP) , Data Distribution Service (DDS) **,** Transport Protocols : Bluetooth Low Energy, Light Fidelity(Li-Fi),	**10**
3	**Cloud for IoT** IoT with Cloud- Challenges, Selection of cloud service provider, Introduction to Fog Computing, Cloud computing : security aspects, Architectural Design of Compute and Storage Clouds AWS and AZURE	**6**

4	**Data Analytics- Visualising the power of data from IoT.** Data Analysis, Machine Learning, Types of Machine learning Models, Model building process, Modelling algorithms, Model Performance, Big data Platform, Big Data Pipeline, Real Life Projects, Recommendation in IoT Gadgets	**10**
5	**Application Building with IoT** Introduction, Smart Perishable Tracking with IoT and sensors, Smart Healthcare, Smart Inflight lavatory maintence with IoT, IoT – Based Application to monitor water quality, Smart warehouse Monitoring, Smart Retail, Integrated Vehicle Health management	**9**
	Total	**45**

Books Recommended:

Text books:

1. Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, "Internet of Things", 2nd Edn, Wiley, 2020.
2. Dac-Nhuong Le, Chintan Bhatt, Mani Madhukar "Security Designs for the Cloud, IoT, and Social Networking" John Wiley & Sons, 2019.
3. Marco Schwatrz, "Internet of Things with Arduino Cookbook", Packt Publications, 2016.
4. Rajkumar Buyya, Christian Vecchiola. S. ThamaraiSelvi, "Mastering Cloud Computing", McGraw Hill Education, 2013.

Reference books:

1. Agus Kurniawan "Learning AWS IoT" Packt Publishing, 2018.
2. Nick Antonopoulos and Lee Gillam, "Cloud Computing: Principles, Systems and Applications", 2nd Edn, Springer, 2017.

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Program: Common for all Programs	Group A	F.Y B.Tech	Semester: VII
Course: IoT Network Design			

Pre-requisite: --

1. Sensor and Actuator Technology for IoT
2. IoT System Design

Objectives:

1. To provide understanding of physical parameters and sensing techniques of various sensors.
2. To provide Understanding about IIoT Systems.
3. To familiarize about Machine Learning and Data Science for Intelligent systems

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

1. To understand the basics of CPS.
2. To select sensors suitable for required application.
3. To design an industrial internet system.
4. To identify Business opportunities in IIoT Business Models.
5. To evaluate the information's using Machine Learning and Data Science.

IoT Network Design (DJ19MN8C3)		
Unit	**Description**	**Duration**
1	**Overview of Industry 4.0 and Industrial Internet of Things** Introduction, Industry 4.0, Industrial revolution: Phases of development Evolution of Industry 4.0 Environmental impacts of industrial revolution Industrial Internet Applications of Industry 4.0 IIoT Prerequisites of IIoT Basics of CPS. CPS and IIoT Applications of IIoT.	10
2	**Industrial Internet of Things**: Basics Introduction IIoT and Industry 4.0. IIC Industrial Internet Systems. Design of industrial internet systems Impact of industrial internet Benefits of industrial internet Industrial Sensing Traditional Sensing Contemporary Sensing Industrial Processes. Features of IIoT for industrial processes Industrial plant The future architecture View point of industrial processes Digital Enterprise Applications of Industry 4.0.	10
3	**Business Models and Reference Architecture of IIoT** Introduction, Business models, Definition of a business model, Reference architecture Business Models of IoT, Business models of IIoT, Business opportunities in IIoT, Categorization of business models in IIoT, Reference architecture of IoT, Reference Architecture of IIoT, Categorization of reference architecture in IIoT	10

4	**Machine Learning and Data Science in Industries** Introduction, Machine Learning, Categorization of ML Applications of ML in Industries Data Science in Industries Deep Learning Application of Deep Learning in Industries Healthcare Applications in Industries **Inventory Management and Quality Control**: Introduction, Inventory Management Inventory, Types of inventory management Inventory Management and IIoT, Benefits of IIoT applications in inventory management, Quality Control	10
5	**IIoT Analytics** Introduction to IIoT Analytics, Introduction., Necessity of analytics. IIoT Analytics Categorization of analytics: IIoTandIndustry4.0 Usefulness of IIoT analytics Challenges of analytics in industries Mapping of analytics with the IIRA architecture Deployment of analytics. Artificial intelligence. Applications of analytics across value chain	6
	Total	**46**

Books Recommended:

Text books:

1. Sudip Misra, Chandana Roy, Anandarup Mukherjee, Introduction to Industrial Internet of Tings and Industry 4.0. First edition published 2021, CRC Press.
2. Sudip Misra, Subhadeep Sarkar Subarna Chatterjee Sensors, Cloud, and Fog: The Enabling Technologies for the Internet of Things. 2019 by Taylor & Francis Group.

Reference Books:

1. Sravani Bhattacharjee, "Practical Industrial Internet of Things Security", Packt Publishing,2018.

Program: Common for all Programs	Group A	F.Y B.Tech	Semester: VII
Course: IoT System and Network Design Laboratory			

Pre-requisite: --

1. Sensor and Actuator Technology for IoT
2. Computer Networks

Objectives:

1. To provide understanding of enabling technologies.
2. To provide Understanding about IoT sensors and their interfacing.
3. To familiarize about protocols for IoT, Application building with IoT.

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

1. To understand the enabling technologies.
2. To select sensors suitable for required application.
3. To analyze protocols for IoT.
4. To Visualize the power of data from the IoT
5. To build the application with IoT

IoT System and Network Design Laboratory (DJ19MN8L1)	
List of Laboratory Experiments: (minimum eight)	
1	Tutorial based on current trends and advancements on IoT
2	Study, discussion, and installation of ARM/Arduino/ESP 32/ RPi
3	Interfacing the sensor with ARM/Arduino / ESP 32 / RPi
4	Interfacing the motor drivers with ARM/ Arduino / ESP 32 / RPi
5	Real time data analysis using sensors, processors, and gateway
6	Interfacing the camera module with ARM/ Arduino / ESP 32 / RPi
7	Real time data base management system using sensors, processors, and gateway
8	Implementation of IoT system Using Messaging and Transport
9	Implementation of data transfer using wireless devices
10	Configuration and using the cloud platform
	Any other experiment may be included, which would help the learner to understand the topic/concept.

Books Recommended:

Text books:

1. Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, “Internet of Things”, 2nd Edn, Wiley, 2020.
2. Dac-Nhuong Le, Chintan Bhatt, Mani Madhukar “Security Designs for the Cloud, IoT, and Social Networking” John Wiley & Sons, 2019.
3. Marco Schwatrz, “Internet of Things with Arduino Cookbook”, Packt Publications, 2016.
4. Rajkumar Buyya, Christian Vecchiola. S. Thamarai Selvi, “Mastering Cloud Computing”, McGraw Hill Education, 2013.

Reference books:

1. Agus Kurniawan “Learning AWS IoT” Packt Publishing, 2018.
2. Nick Antonopoulos and Lee Gillam, “Cloud Computing: Principles, Systems and Applications”, 2nd Edn, Springer, 2017.

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Minor in IoT and Industry 4.0 **Semester: VIII**

Program: Common for All Programs (except EXTC Engineering)

Course: Industry 4.0 (DJ19MN8C4)

Pre-requisite: --

1. Sensor Technology
2. IoT System Design
3. IoT Network Design

Objectives:

1. To familiarize the impact of industrial revolution, requirements, drivers of Industry 4.0.
2. To provide the key aspects of cloud computing and fog computing in the industries.
3. To grasp of the terminologies, technologies, and requirements for industrial data transmission.

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

1. To understand the industrial revolution, requirements
2. To select sensors suitable for cloud computing and fog computing
3. To analyze of the terminologies, technologies, and requirements for industrial data transmission
4. To design use cases for industries.

IoT and Industry 4.0 (DJ19MN8C4)		
Unit	**Description**	**Duration**
1	**Industry 4.0: Basics** : Introduction, Historical context ,Significant changes in the industry ,Design requirements of Industry 4.0 ,Drivers of Industry 4.0 ,Megatrends ,Tipping points, Sustainability Assessment of industries, Globalization effects, Socio-economic effects, Smart Business Perspective, Characteristics of smart business model,Cybersecurity,Various cybersecurity threats, Requirements of cybersecurity, Impacts of Industry 4.0, Economy perspective, Business perspective, Global perspective	10
2	**Key Technologies: Off-site Technologies** Introduction, Cloud Computing, Necessity of cloud computing, Cloud computing and IIoT, Industrial cloud platform providers, SLA for IIoT, Requirements of Industry 4.0 and its solution, Fog Computing, Fog computing for IIoT, Applications of fog and their solutions	08
3	**Key Technologies: On-site Technologies** Introduction, need for Industry 4.0, Transformations required, Augmented Reality, History of AR, Categorization of AR, Applications of AR, Virtual Reality, History of VR, Categorization of VR, Applications of VR, Big Data and Advanced Analytics , Characteristics of big data, Big data sources, Big data acquisition and storage, Necessity of data analytics, Types of analytics , Smart factories, Characteristics of smart factory , Technologies used in smart factories, Lean manufacturing	10

	system ,Value streams in lean production system, Necessity of lean production system ,Implementation of lean manufacturing system	
4	**Industrial Data Transmission** Introduction, Foundation Fieldbus, Features, Components, Modbus, Features, Components, Controller Area Network, Features, Components, LoRa and LoRaWAN, Features, Components, Recent and Upcoming Technologies, NB-IoT, IEEE 802.11AH **Industrial Data Acquisition** Introduction, Distributed Control System, Components, PLC, Components, SCADA, Components	08
5	**Healthcare Applications in Industries:** Introduction, Major challenges associated with healthcare, coping with increase in diseases, Applications of Healthcare in Industries, Smart devices, Advanced technologies used in healthcare, Open research issues to be addressed **Inventory Management and Quality Control:** Introduction, Inventory Management, Inventory, Types of inventory management, Inventory Management and IIoT, Benefits of IIoT applications in inventory management, Quality Control **Case Studies** : Introduction Manufacturing Industry, Automotive Industry, Mining Industry	10
	Total	**46**

Books Recommended:

Text books:

1. Sudip Misra, Chandana Roy, Anandarup Mukherjee, Introduction to Industrial Internet of Tings and Industry 4.0. First edition published 2021, CRC Press.
2. Sudip Misra, Subhadeep Sarkar Subarna Chatterjee Sensors, Cloud, and Fog: The Enabling Technologies for the Internet of Things. 2019 by Taylor & Francis Group.

Reference Books:

1. Alasdair Gilchrist, Industry 4.0, The Industrial Internet of Things., apress, 2016.
2. Jörg Bischof, KiCad 7: Short introduction for the practitioner, Amazon Digit Services LLC - Kdp, 2023.

Industry 4.0 Laboratory (DJ19MN8L2)	
Suggested List of Experiments:	
1	Tutorial based on current trends and advancements on Industry 4.0
2	Study, discussion, and installation of ARM/Arduino/ESP 32/ RPi /STM32/Rpi PICO
3	Interfacing the sensor with ARM/Arduino / ESP 32 / Rpi/ STM32/Rpi PICO
4	Interfacing the motor drivers with ARM/ Arduino / ESP 32 / Rpi/ STM32/Rpi PICO

5	Real time data analysis using sensors, processors, and gateway
6	Interfacing the camera module with ARM/ Arduino / ESP 32 / RPi / STM32/Rpi PICO
7	Real time data base management system using sensors, processors, and gateway
8	Implementation of IIoT system Deep Learning Inference
9	Implementation of IIoT system using Artificial Intelligence
10	Implementation of IIoT system using Machine Learning
11	Case study based on current trends and advancements on IIoT
12	Study, discussion, and installation of 3D Printing Software
13	Experiment based on 3D Printing
14	Study, discussion, and installation of PCB Design Software
15	Design and Making of an PCB
	Any other experiment may be included, which would help the learner to understand the topic/concept.

Text books:

1. Jean-Pierre Charras, Fabrizio Tappero, Wayne Stambaugh, "KiCad Complete Reference Manual 12th Media Services, 2018.
2. Richard Sheng, "3D Printing, A Revolutionary Process for Industry Applications" Elsevier Science, 2022.

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