Minor Degree in Internet of Things (IoT)

Course Structure and Syllabus

Year & Semester	Theory Subject	Theory Credits	Laboratory Subject	Lab Credits	Total Credits
II Year II Sem	Introduction to IoT	3	—	—	3
III Year I Sem	Privacy and Security in IoT	3	IoT Applications Laboratory	1	4
III Year II Sem	Pattern Recognition and Machine Learning	3	Machine Learning Laboratory	1	4
IV Year I Sem	Fog and Edge Computing	3	—	—	3
IV Year II Sem	Project / Experiential Learning	4	—	—	4
				Total Credits	**18**

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INTRODUCTION TO IOT

II B.Tech II Semester (Minor Degree in IoT)
Course Code:

L	T	P	C
3	0	0	3

Course Objectives: The objectives of the course are to

1. To provide information on the concepts of Internet of Things and applications.
2. To learn how to use of Arduino and Raspberry Pi boards.
3. To know about data handling in SDN.

Course Outcomes: Upon completing this course, the student will be able to

1. Explore various protocols of sensor networks.
2. Program and configure Arduino boards for real world connectivity.
3. Python programming and interfacing for Raspberry Pi.

Detailed Syllabus

UNITI

Introduction to Internet of Things, Characteristics of loT, Physical design of IOT, Functional blocks of IOT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks.

UNIT II

Machine-to-Machine Communications, Difference between IOT and M2M, Interoperability in IOT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino,

UNIT Ill

Introduction to Python programming, Introduction to Raspberry Pi, Interfacing Raspberry Pi with basic peripherals, Implementation of IOT with Raspberry Pi

UNIT IV

Introduction to Software defined Network (SDN), SDN for IOT, Data Handling and Analytics, Cloud Computing

UNIT V-Applications of IOT

Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IOT. Case study - Agriculture, Healthcare, Activity Monitoring.

TEXT BOOKS

1. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, by Pethuru Raj and Anupama C. Raman (CRC Press)
2. Make sensors: Terokarvinen, kemo, karvinen and villey valtokari, 1st Ed., Maker Media, 2014.

REFERENCES

1. Internet of Things: A Hands-on Approach, by Arshdeep Bahga and Vijay Madisetti.
2. Fundamentals of Wireless Sensor Networks: Theory and Practice - Waltenegus Dargie, Christian PoeIlabauer.
3. Beginning Sensor networks with Arduino and Raspberry Pi - Charles Bell, Apress, 201

PRIVACY AND SECURITY IN IOT

III B.Tech I Semester (Minor Degree in IoT)
Course Code:

L	T	P	C
3	0	0	3

Course Objectives

1. To understand the fundamental security architectures and the "Security by Design" principle for IOT ecosystems.
2. To analyze cryptographic solutions, identity management, and privacy-preserving protocols for constrained devices.
3. To explore defensive strategies against evolving threats in cloud-integrated and edge-based loT environments.

Course Outcomes

CO1: Identify vulnerabilities across the loT stack, from physical sensors to cloud interfaces. (L2)

CO2: Implement lightweight cryptographic protocols suitable for resource-constrained loT nodes. (L3)

CO3: Design robust Identity and Access Management (IAM) frameworks for Device-to-Cloud (D2C) integration. (LG)

CO4: Analyze privacy risks in data virtualization and edge analytics platforms. (L4)

CO5: Evaluate the security of industrial and smart home use cases against standard attack vectors. (LS)

Detailed Syllabus

Unit 1: Foundations of loT Security: The "Security of Things" ; Design Principles for Secure Connected Devices; Open Source vs. Closed Source security auditing; Tapping into the security community for vulnerability disclosure; Prototyping secure firmware.

Unit 2: Secure Paradigms & Integration: Security as a strategic sound; M2M/D2D security challenges; Securing Device-to-Cloud (D2C) and Sensor-to-Cloud pathways; Trust boundaries in Cloud-to-Cloud (C2C) integration; Authentication in emerging loT flavors.

Unit 3: Wireless & Power Security: Architecture for secure mobile-loT ecosystems; Security implications of Energy Harvesting; Secure Low Power Wide Area Networks (LPWAN); Vulnerabilities in LoRa WAN join procedures; Side-channel attacks on power-constrained devices.

Unit 4: Protocol Security & Enablement Platforms: Security in IEEE 802.15.4, BLE, and ZigBee; Secure Service Discovery; Infrastructure security: 1Pv6, Static vs. Dynamic IP security; Port security (TCP/UDP); Application layer security (CoAP, HTIPs). Secure Gateway design; Data Virtualization and Privacy at the Edge.

Unit 5: Robust Integration & Case Studies: Robustness and Scalability in Open Service Gateways; Security in MQTI, XMPP, and Data Distribution Bus; Secure Smarter Enterprises; Case studies: Privacy in Smart Homes, Security in Smart Transportation, and protecting wearable data in Education Systems.

TEXTBOOKS:

1. Brian Russell and Drew Van Duren, *Practical Internet of Things Security,* Packt Publishing.
2. Pethuru Raj and Anupama C. Raman, *The Internet of Things: Enabling Technologies, Platforms, and Applications,* CRC Press.

REFERENCES:

1. Feifei Dai, Security and Privacy in the Internet of Things, CRC Press.
2. Adrain McEwen & Hakim Cassimally, Designing the Internet of Things, Wiley.

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IOT APPLICATIONS LABORATORY

III B.Tech I Semester (Minor Degree in IoT)
Course Code:

L	T	P	C
0	0	2	1

1. Arduino program to demonstrate UART communication protocol
2. Arduino program to demonstrate Interrupt handling
3. OLED display interfacing with ESP8266 NodeMCU
4. Motion detection using PIR sensor with ESP8266 NodeMCU
5. Sound detection system using sound sensor interfaced with ESP8266 NodeMCU
6. Obstacle detection and Distance measurement using HC-SR04 ultrasonic sensor with NodeMCU
7. Flex sensor interfacing and Interfacing MPU-6050 accelerometer with ESP8266 NodeMCU
8. Automatic irrigation system using soil moisture sensor and NodeMCU
9. Wireless communication using NRF24L01 transceiver modules
10. Interfacing DHT11 sensor with Raspberry Pi and uploading temperature and humidity values to cloud
11. Interfacing NodeMCU/Raspberry Pi with Cloud using REST API and MQTT protocol
12. Remote switching of lights using Arduino/NodeMCU/Raspberry Pi through Internet
13. Voice-based Home Automation using Google Assistant, IFTTI and MQTI
14. Capturing images using web camera with Raspberry Pi and applying image processing filters
15. Accessing and controlling a remote computer from Raspberry Pi

PATTERN RECOGNITION AND MACHINE LEARNING

III B.Tech II Semester (Minor Degree in IoT)
Course Code:

L	T	P	C
3	0	0	3

UNIT-I

Introduction to Machine Learning: Human learning and its types; Machine learning and its types; well- posed learning problem; applications of machine learning; issues in machine learning. Preparing to model: Basic data types; exploring numerical data; exploring categorical data; exploring relationship between variables; data issues and remediation; data pre-processing. Modelling and Evaluation: Selecting a model; training model-holdout, k-fold cross-validation, bootstrap sampling; model representation and interpretability - under-fitting, over-fitting, bias variance tradeoff; model performance evaluation - classification, regression, clustering; performance improvement. Feature engineering: Feature construction; feature extraction; feature selection.

UNIT-II

Brief review of probability: Concept of Probability, Random Variables, Some Common Discrete Distributions: Bernoulli distributions, Binomial distribution, The multinomial and multinoulli distributions, Poisson distribution, Some Common Continuous Distributions: Uniform distribution, Gaussian (normal) distribution, The Laplace distribution, Multiple Random Variables: Bivariate random variables, Joint distribution Functions, Joint probability density functions, Conditional distributions, Covariance and correlation, Central Limit Theorem, Hypothesis Testing, Monte Carlo Approximation. Bayesian Concept Learning: Bayes Theorem: Prior, Posterior, Likelihood, Bayes Theorem and Concept Learning: Brute-force Bayesian algorithm, Concept of consistent learners, Bayes optimal classifier, Native Bayes Classifier, Application of Naïve Bayes classifier, Handling Continuous Numeric Features in Naive Bayes Classifier, Bayesian Belief Network: independence and conditional independence, Use of the Bayesian Belief network in machine learning.

UNIT-Ill

Supervised learning-Classification: Examples of Supervised Learning, Classification Model, Classification Learning Steps, Common Classification Algorithms: k-Nearest Neighbor (kNN), Decision tree, Random forest model, Support vector machines. Supervised learning-Regression: Examples of Regression, Common Regression Algorithms: Simple Linear Regression, Multi Linear Regression, Assumptions in Regression Analysis, Main Problems in Regression Analysis, Improving Accuracy of the Linear Regression Model, Polynomial Regression Model, Logistic Regression. Unsupervised learning: Unsupervised vs Supervised Learning, Application of Unsupervised Learning, Clustering: Clustering as a machine learning task, Different types of clustering techniques, Partitioning methods, k-Medoids: a representative object-based technique, Hierarchical clustering, Density-based methods -DBSCAN, Finding Pattern using Association Rule: Definition of common terms, Association rule, The apriori algorithm for association rule learning, Build the apriori principle rules.

UNIT-IV

Basics of Neural Network: Understanding the Biological Neuron, Exploring the Artificial Neuron, Types of Activation Functions: Identity function, Threshold/step function ReLU (Rectified Linear Unit) function, Sigmoid function, Hyperbolic tangent function, Early implementations of ANN: McCullochpitts Model of Neuron, Rosenblatts perceptron, ADALINE network model, Architectures of Neural Network: Single-layer feed forward network, Multi-layer feed forward ANNs, Competitive network, Recurrent network, Learning Process in ANN: Number of layers, Direction of signal flow, Number of nodes in layers, Weight of interconnection between neurons, Back propagation Algorithm. Types of Learning: Representation Learning :Supervised neural networks and multilayer perceptron, Independent component analysis(Unsupervised), Auto encoders, Various forms of clustering, Active Learning: Heuristics for active learning, Active learning query strategies, instance -Based Learning(Memory- Based Learning): Radial basis function, Pros and cons of instance- based learning method, Association Rule Learning Algorithm: Aprioro algorithm, Eclat algorithm, Ensemble Learning Algorithm: Bootstrap aggregation, Boosting, Gradient boosting machines (GBM), Regularization Algorithm.

UNIT-V

Introduction to Simple Deep Feed Forward Neural Network, Hidden Units and their Activation Functions, Architecture Design, Regularization Methods for Deep learning: Early Slopping, Drop out. Convolutional Neural Networks: Introduction to CNN, Convolution operation, Pooling, Normalization, Application in Computer Vision-Image Net, Sequence Modeling- VGG Net, LeNet. Recurrent Neural Networks: RNN Topologies, Difficulty in Training RNN, Long Short Term Memory (LSTM): Architecture and Learning Strategy.

TEXT BOOKS:

1. Machine learning by Saikat Dutt, Subramanian Chandramouli, Amit K.Das Pearson Publishers, 2019.
2. Ian Good fellow, Yoshva Bengio, Aaron Courville, Deep Learning,MIT Press,2016.

REFERENCE BOOKS:

1. Machine learning with python for everyoone by Mark E- Fenner, Pearson Publishers, 2020.
2. Introduction Neural Networks using MATLAB 6.0 - S.N. Shivanandam, S. Sumathi, S. N.Deepa, 1/e, TMH,New Delhi.

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MACHINE LEARNING LABORATORY

III B.Tech II Semester (Minor Degree in IoT)
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L	T	P	C
0	0	2	1

Course Objective:

- The objective of this lab is to get an overview of the various machine learning techniques and can demonstrate them using python.

Course Outcomes:

1. Understand modern notions in predictive data analysis
2. Select data, model selection, model complexity and identify the trends
3. Understand a range of machine learning algorithms along with their strengths and weaknesses
4. Build predictive models from data and analyze their performance

List of Experiments

1. Write a python program to compute Central Tendency Measures: Mean, Median, Mode Measure of Dispersion: Variance, Standard Deviation
2. Study of Python Basic Libraries such as Statistics, Math, Numpy and Scipy
3. Study of Python Libraries for ML application such as Pandas and Matplotlib
4. Write a Python program to implement Simple Linear Regression
5. Implementation of Multiple Linear Regression for House Price Prediction using sklearn
6. Implementation of Decision tree using sklearn and its parameter tuning
7. Implementation of KNN using sklearn
8. Implementation of Logistic Regression using sklearn
9. Implementation of K-Means Clustering
10. Performance analysis of Classification Algorithms on a specific dataset (Mini Project)

TEXT BOOK:

1. Machine Learning-Tom M. Mitchell, - MGH. REFERENCE BOOK:
2. Machine Learning: An Algorithmic Perspective, Stephen Marshland, Taylor & Francis.

FOG AND EDGE COMPUTING

IV B.Tech I Semester (Minor Degree in IoT)
Course Code:

L	T	P	C
3	0	0	3

Course Outcomes

COl: Understand the foundations of fog and edge computing networks and different architectures

C02: Design fog and edge computing-based systems and applications using reference architectures

C03: Understand and apply data collection, analysis, decision making and learning methodologies over the edge for different applications

C04: Apply optimization techniques for edge and fog computing

UNIT-1

Foundations: Introduction to loT, Fog and Edge Computing, hierarchy of Fog and Edge Computing, edge network, Edge computing architectures, OpenFog Reference Architecture for Fog Computing, Optimization in Fog and Edge Computing, Case Study: open source platforms like Apache Edgent.

UNIT-II

Middleware: Middleware for Fog and Edge Computing: Design Issues, Lightweight Container Middleware for Edge Cloud Architectures, Data Management in Fog Computing.

UNIT-Ill

Analysis to Support Fog Application Deployment, Using Machine Learning for Protecting the Security and Privacy of Internet of Things (loT) Systems, Anomaly Detection in Fog-based loT Networks, Federated Learning for Privacy-Preserving loT Analytics

UNIT-IV

Applications: Applications of Fog Computing in Big Data Analytics, health monitoring, smart surveillance, smart transportation, Modeling. Simulation of Fog and Edge Computing Environments Using open source platforms like iFogSim Toolkit

UNIT-V

Emerging Trends in Fog & Edge Computing, Security and Privacy Challenges in Multi-tier IoT, Weather Monitoring with Edge ,Energy-efficient Fog and Edge Computing, Role of Fog Computing in Smart Homes, Weather Monitoring with Edge Devices

TEXT BOOKS

1. Rajkumar Buyya, Satish Narayana Srirama, "Fog and Edge Computing: Principles and Paradigms", Wiley, 2019
2. Javid Taheri, Shuiguang Deng, "Edge Computing: Models, technologies and applications", IET, 2020
3. Khaldoun Al Agha, Pauline Loygue, Guy Pujolle, "Edge Networking", Wiley-STE, 2022.

REFERENCES

1. Xin Sun and Amin Vahdat, "Edge Computing: A Primer", CRC Press, 2019.
2. "Open Fog Reference Architecture for Fog Computing", Industry IoT Consortium, OpenFog_Reference_Architecture_2_09_17.pdf (ii consortium.org)
3. "IEEE Standard for Adoption of Open fog Reference Architecture for Fog Computing," Aug.
4. 2018, standard No. 1934-2018", [online] Available: https://standards.ieee.org/standard/1934- 2018.html.

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PROJECT / EXPERIENTIAL LEARNING

IV B.Tech II Semester (Minor Degree in IoT)
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L	T	P	C
0	0	4	4

Project General Objectives

1. **End-to-End Integration:** To build a system that connects physical sensors to a cloud/edge dashboard using standard loT protocols (MQTI/CoAP).
2. **Security Implementation:** To apply "Security by Design" principles by securing the communication channel and managing device identity.
3. **Edge Intelligence:** To implement local data processing (Edge/Fog) to reduce latency and bandwidth consumption before sending data to the cloud.
4. **Knowledge Continuity:** To demonstrate a clear link between hardware selection, network protocol choice, and data privacy.

Course Outcomes (COs)

CO1: Design a functional IoT prototype using microcontrollers (ESP32/Raspberry Pi) and various sensors. (LG)

CO2: Configure wireless communication stacks (LoRa, BLE, or Wi-Fi) based on the application's range and power requirements. (L3)

CO3: Implement lightweight encryption or authentication to ensure data privacy and security. (L3)

CO4: Develop an Edge/Fog processing layer to perform real-time data filtering or anomaly detection. (L4)

CO5: Create a user interface (Web/Mobile) for real-time monitoring and control of the IoT system. (LG)