

Department of Electronics and Communication Engineering, JNTUH

Course Structure and Syllabus for a Minor Degree in Internet of Things (IoT)

Minor Degree (4 Semesters)

	Theory (# Credits)	Laboratory (# 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 Lab (1)	4
IV Year I Sem	Fog and Edge Computing (3)	--	3
IV Year II Sem	Project/ Experiential Learning (4)	--	4
Total Credits			18

INTRODUCTION TO IOT

B.Tech II Yr II Sem

LTPC: 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.

UNIT I

Introduction to Internet of Things, Characteristics of IoT, 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 III

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, SmartGrid, 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 Madiseti.

2. Fundamentals of Wireless Sensor Networks: Theory and Practice - Waltenegus Dargie, Christian Poellabauer.
3. Beginning Sensor networks with Arduino and Raspberry Pi – Charles Bell, Apress, 201

Privacy and Security in IOT

III Year B.Tech. I Semester

| 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 IoT environments.

Course Outcomes

- **CO1:** Identify vulnerabilities across the IoT stack, from physical sensors to cloud interfaces. (L2)
- **CO2:** Implement lightweight cryptographic protocols suitable for resource-constrained IoT nodes. (L3)
- **CO3:** Design robust Identity and Access Management (IAM) frameworks for Device-to-Cloud (D2C) integration. (L6)
- **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. (L5)

Detailed Syllabus

Unit 1: Foundations of IoT 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 IoT flavors.

Unit 3: Wireless & Power Security: Architecture for secure mobile-IoT ecosystems; Security implications of Energy Harvesting; Secure Low Power Wide Area Networks (LPWAN); Vulnerabilities in LoRaWAN 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: IPv6, Static vs. Dynamic IP security; Port security (TCP/UDP); Application layer security (CoAP, HTTPs). 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 MQTT, 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 & References

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.

- 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, IFTTT and MQTT
- 14 Capturing images using web camera with Raspberry Pi and applying image processing filters
- 15 Accessing and controlling a remote computer from Raspberry Pi

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, Naïve Bayes Classifier, Application of Naïve Bayes classifier, Handling Continuous Numeric Features in Naïve Bayes Classifier, Bayesian Belief Network: Independence and conditional independence, Use of the Bayesian Belief network in machine learning.

UNIT –III

Supervised learning-Classification: Examples of Supervised Learning, Classification Model, Classification Learning Steps, Common Classification Algorithms: k-Nearest Neighbour (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: McCulloch-Pitts Model of Neuron, Rosenblatt's 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, Backpropagation Algorithm. Types of

Learning: Representation Learning :Supervised neural networks and multilayerperceptron, Independent component analysis(Unsupervised),Autoencoders, Various forms ofclustering, Active Learning: Heuristics for active learning, Active learning query strategies,Instance –Based Learning(Memory- Based Learning): Radial basis function, Pros and cons ofinstance- based learning method, Association Rule Learning Algorithm: Aprioro algorithm, Eclatalgorithm, Ensemble Learning Algorithm: Bootstrap aggregation, Boosting, Gradient boostingmachines(GBM), Regularization Algorithm.

UNIT – V

Introduction to Simple Deep Feed Forward Neural Network, Hidden Units and their ActivationFunctions, 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 TermMemory(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 everyone 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.

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:
- Understand modern notions in predictive data analysis
- Select data, model selection, model complexity and identify the trends
- Understand a range of machine learning algorithms along with their strengths and
- weaknesses
- 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:

1. Machine Learning: An Algorithmic Perspective, Stephen Marshland, Taylor & Francis.

Fog and Edge Computing

B.Tech IV Yr I Semester

L T P C: 3 0 0 3

Course Outcomes

CO1: Understand the foundations of fog and edge computing networks and different architectures

CO2: Design fog and edge computing-based systems and applications using reference architectures

CO3: Understand and apply data collection, analysis, decision making and learning methodologies over the edge for different applications

CO4: Apply optimization techniques for edge and fog computing

UNIT-1

Foundations: Introduction to IoT, 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-III

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

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-ISTE, 2022.

4. Xin Sun and Amin Vahdat, "Edge Computing: A Primer", CRC Press, 2019.
5. "OpenFog Reference Architecture for Fog Computing", Industry IoT Consortium, OpenFog_Reference_Architecture_2_09_17.pdf (iiconsortium.org)
6. "IEEE Standard for Adoption of Openfog Reference Architecture for Fog Computing," Aug. 2018, standard No. 1934-2018", [online] Available: <https://standards.ieee.org/standard/1934-2018.html>.

Project

B.Tech IV Yr II Semester

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 IoT protocols (MQTT/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. (L6)
- **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. (L6)