PG Diploma in Internet of Things (PG-DIOT)

Course Objective & Scope:

- To utilize various Embedded Technologies related to IoT, Sensor Networks, Communication Protocols, Cloud Computing, Accessing Resources and Services needed to perform functions with dynamically changing needs.
- To understand the IoT privacy and Security Concepts for secured IoT environment.
- To utilize the various IoT Platforms to explore Real Time IoT Applications Areas.
- To explore Modern IoT Trends
- To undertake industrial research projects for the development of future solutions in the domain of Data Analytics to make an impact in the technological advancement.
- To use advanced IoT Tools/ Decision-Making Tools/ Operation Research Techniques to analyze the complex problems and get ready to develop such new techniques for the future.

Eligibility Criteria:

Graduate in Engineering or equivalent (e.g. BE / B.Tech / 4-year BSc Engg / AMIE / DoEACC B Level, etc.) in Electronics/ Computer Science/ IT or related areas

OR

Post Graduate in Engineering Sciences (e.g. MCA, MSc in Computer Science, IT, Electronics, etc.)

Pre- Requisites:

Candidate should have sound knowledge of:

- Fundamentals of C Programming
- Basics of Operating System Concepts and Basics of Linux
- Basics of Electronics

Course Modules:

Sr. No.	Module Name	Hours
1.	Fundamentals of IoT	40
2.	Programming Technologies	100
3.	Microcontrollers Programming & OS / RTOS	80
4.	Embedded Linux	80
5.	Sensor Networks	80
6.	Communication Models & Protocols	60
7.	Data Management & Analytics	90
8.	Cloud Computing	30
9.	Technological Aggregation & Case Studies	60
10.	Mobile Application Development	80
11.	Aptitude and English	50
12.	Effective Communication	50
13.	Project	100
	Total	**900**

Contents:

1. Fundamentals of IoT (40 Hours)

- Introduction to IOT
- Evolution of IOT, History
- M2M and/or IOT
- Applications of IOT
- Use cases of IOT
- Reference Architecture of IOT
- Things in IOT
- IOT Functional Blocks
- Sensors & Actuators
- Target Boards
- IOT Servers/Cloud Platforms
- Functionality
- API models
- Need for gateway/middleware solutions
- Role of IOT gateway
- Case Study – OpenIOT
- Case Study – LinkSmart/Hydra Middleware
- IOT Standards
- IOT-A Reference Architecture
- IOT-A Architecture Reference Model(ARM)
- Programming for IOT
- Choice of language
- Open and Closed source models
- IOT Development Methodology
  - Requirements Gathering
  - Process,domain model,information model
  - IOT levels
  - Functional,Operational View
  - Integration
- Business Models
  - Cost Analysis
  - Crowd Sourcing,funding
  - Prototyping vs Production
  - Mass Production
- IOT Design Patterns for
  - Data,Information models
  - Communication
  - Infrastructure
- Challenges in IOT

2. Programming Technologies (100 Hours)

C Language:

- Introduction to C Standards
- Programming Environment – Building Phases
- GNU Tool chain, tools for development,analysis
- Layout of a C program
- Language Basics
- Internal representation of data types
- Qualifiers
- Operators
- Control Structures
- Pointers & Arrays
- const,volatile keywords
- Functions
- Parameter Passing, Returning data
- Recursion
- Function Pointers
- Linkage Rules
- Strings
- Library functions
- Command Line Arguments
- Structures & Unions
- Alignment, Packing Issues
- Bit Fields
- Dynamic Memory Management
- Detecting Memory Leaks,Heap analysis
- Preprocessor
- Enumeration Types
- File Handling
- Single Linked Lists

Stacks and Queues

- Searching Techniques
- Sorting Techniques

Python

- Introduction to Python,Scope in IOT
- Setting up environment
- Simple programs
- Console I/O Operations
- Data Types,Variables,Literals
- Operators
- Control Structures
- Arrays
- String handling
- Regular expressions,pattern matching
- Functions
- File Handling
- Exception handling
- Modules
- Packages

- Building custom packages
- Data Structures in Python
- Standard Library
- Example library - os Module
- Object Oriented Python
- Dialects of pyhthon – cpython,micropython
- Introduction to Nodejs,Setting up environment
- Writing Simple scripts,Console I/O
- Package Management,importing libraries
- Running simple web server
- Nodejs objects,fields
- Event handling,callbacks
- Error handling
- String handling
- Buffer management
- File handling
- Example modules(os,path etc.)

NodeRED

- Introduction to NodeRED
- Existing nodes,Simple flow
- Importing,Exporting flows
- Writing functions
- Context management
- Simple UI creation

3. Microcontrollers Programming & OS / RTOS (80 Hours)

- Introduction to MCU Families
- Overview of ARM Cortex-M architecture
- CMSIS standard
- Registers, Operation Modes
- Instruction Set
- Thumb-2 Instructions
- Startup code
- Memory Model
- Linker map
- Bus Interface
- Clock, Timer Management
- Watchdog timers
- RTC
- Interrupt Handling
- Exception handling
- Mode Switching
- Development environment – Keil,arm-gcc etc
- Building phases
- Blinking LED example
- Case Study – mbed.org APIs(or Suitable APIs for target MCU)
- Peripheral management in MCUs
- Peripheral management in MCUs
- Peripheral management in MCUs
- Bus Standards
- CAN Basics
- Designing CAN Slave, CAN Master
- Overview of Arduino Family of Boards, Architecture
- Arduino Shields,Pinout
- Arduino SDK and APIs for peripheral management
- Arduino Examples
- FIRMATA for peripheral management
- Debugging Support, Techniques
  - JTAG
  - CMSIS DAP
  - OpenOCD
- Introduction to RTOS
- What is Real Time, Real Life Examples
- Bare metal code vs RTOS
- GPOS vs RTOS
- Case Study – FreeRTOS/mbed RTOS/CMSIS RTOS
- RTOS Services
  - Task Management (periodic vs aperiodic task)
  - Timer Management (auto reload vs oneshot mode timers)
- RTOS Services
  - Queues, Semaphores,Mutex,Event Flags
  - Priority Inversion, Priority Inheritance Protocols
- Interrupt Management
- Memory Management
- Benchmarking factors
  - Scheduling Latency
  - Interrupt Latency
- Constrained OS for MCUs
- Deploying ContikiOS, RIOT OS on target hardware
- FreeRTOS and Addons for MCUs

4. Embedded Linux (80 Hours)

- Introduction to Linux
- Linux File System
- Command Line overview
- Basic scripting
- Package Management
- Administration essentials
- Networking essentials

- Introduction to Embedded Linux
- Architecture – Kernel , System Calls /proc, /sys interfaces
- Bootloader, Kernel
- Rootfs image
- Setting up Linux for target board(Rpi/BBB/Edison)
- Cross Toolchain
- Building Custom Kernel
- Building user space code (static, dynamic linking)
- Linux Internals
- Process Management
- Linux Internals
- Threading
- Scheduling in linux
- Linux Internals
- Synchronization and Data Exchange(Inter process communication)
- Semaphores,Mutex
- Shared Memory,Message Queues
- Linux Internals
- File Handling, Pipes & Fifos
- Writing Simple Drivers
- Building Drivers for target board
- Clock Management(RTC/NTP)
- Device Tree Concepts
- Memory mapping
- Blinking LEDs on target board
- Peripheral management in Linux using C,Python/Nodejs libraries
- GPIO
- SPI
- I2C
- ADC
- WDT
- Wired connectivity – gateways/bridging solutions
- UART, termios library
- USB – utilities & libraries(libusb)
- Debugging/Tracing Techniques
- Firmata Clients
- Linux for real time

5. Sensor Networks (80 Hours)

- Network Layer Model(OSI or TCP/IP)
- Overview of each layer(Physical, Link, Network, Transport)
- Network Model for IOT Needs
- Network Topologies
- Physical Layer
- Link Layer
- Ethernet(PCI/USB/SPI)
- MAC layer
- IP Layer
- IPv4 and IPv6
- Mobile IP
- TCP & UDP protocols
- TCP,UDP Socket APIs
- Client – Server Examples
- Light Weight Network Stacks
- Case Study – lwip
- WLAN (IEEE 802.11 standard)
- Linux & MCU Support
- WiFi motes
- IEEE 802.15.4 standard
- Wireless PAN
- IEEE 802.15.4 implementations
- Zigbee, Miwi, Nrf24,Thread etc.
- IEEE 802.15.4 implementations
- Linux & MCU Support
- Bridging IP networks
- 6LowPAN
- IPv6 Routing Protocol for Low-Power(RPL) and Lossy Networks
- RPL Border Router
- Bluetooth Basics
- Bluetooth Profiles
- Bridging Bluetooth,IP networks
- Bluetooth Smart/Low Energy
- BLE Profiles
- GATT profile
- BLE Motes. Beacons, EddyStone
- Cellular Technologies
- GSM,GPRS, CDMA, 3G/UMTS, 4G/LTE
- Cellular Technologies
- 3G/UMTS, 4G/LTE
- RFID
- IrDA
- NFC
- Location Tracking – GPS
- GeoMapping
- Case Study – Contiki OS
- Erbium Stack
- RPL Border Router
- Case Study – RIOT OS

6. Communication Models & Protocols (60 Hours)

- M2M vs IOT
- IOT vs WOT
- M2M Protocols
- IOT Protocols
- Communication Models
- Resource Management
- Registration, Discovery
- Data Exchange Formats - XML & JSON
- Integration with Web
- Web Services, WSDL
- SOA vs ROA,SOAP vs REST
- MQTT Protocol
- RESTFul Architecture
- HTTP REST Model
- CoAP Protocol
- CoAP Protocol
- Protocol Interoperability,Bridging
- Convergence of CoAP, HTTP, MQTT etc.
- Example – Eclipse Ponte Bridge
- Security In Protocols
- Gateway Design
- OSGi Architecture,Services
- OSGi Implementations for IOT – Case Study
- Websockets as transport layer
- Overview of other protocols

- AMQP
- XMPP
- WebRTC

7. Data Management & Analytics (90 Hours)

- Introduction to DBMS
- RDBMS,SQL vs NoSQL
- Implementations – closed vs open source
- Database Storage Structure
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- Structured and Unstructured Data
- Introduction to SQL
- DDL Commands
- DML & DCL Commands
- Grouping Things Together (Group by , Having)
- Sorting Data (Order By)
- Advance Subqueries (Correlated Sub query, Outer Joins)
- Queries containing Group By, Having Clause,
- Order by
- Correlated Queries, SubQueries, Outer Joins
- Data Ware Housing Concepts and Introduction to Tools
- NOSQL
- Introduction to NoSQL
- Difference between a RDBMS and a NoSQL database
- Understanding the Storage Architecture
- Working with Column-Oriented Databases
- HBase Distributed Storage Architecture
- Document Store Internals
- Schema structure for Oracle NoSQL database
- Changing Document Databases
- Schema Evolution in Column-Oriented Databases
- HBase Data Import and Export
- Data Evolution in Key/Value Stores
- Time Series Data Model(Using InfluxDb,OpenTSDB,KairosDB or similar one)
- Installation
- Using shell,web console,HTTP APIs
- Time Series Data Model
- Query Language
- Write Protocols
- Time Series Data Model
- Continuous Queries
- Downsampling data
- Retention Policies
- Time Series Data Model
- SDKs, APIs for talking to database
- Visualizing time series data, eg:-using grafana
- Data Analytics (Using ApacheSpark,InfluxData TICK stack or a similar framework with one of the backends like MongoDB, Hadoop/HBase, InfluxDb etc.)
- Data Modelling - Tools & Techniques
- Data Storage & Retrieval (MongoDb, Hadoop, InfluxData)
- Integration with External Data Sources
- Data Analysing – Intelligent Data Analysis - Tools & Techniques
- Data analytic frameworks/Case Studies
- Nimbits
- Sitewhere
- Apache Spark
- Apache Storm
- Influx TICK stack
- MuleSoft/AnyPoint Platform
- Data Optimization

- Introduction of visualization tools, Libraries
- Visual Analytics

8. Cloud Computing (30 Hours)

- Cloud Based Architecture
- Basics of Virtualization
- Specific Characteristics that Define a Cloud
- Understanding Elasticity, Resiliency, On-Demand and Measured Usage
- Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) Cloud Delivery Models
- Public Cloud, Private Cloud, Hybrid Cloud and Community Cloud Deployment Models
- Benefits, Challenges and Risks of Cloud Computing Platforms and Cloud Services
- Introduction to cloud based IoT platforms like IBM Bluemix, carriot etc.
- IoT Cloud Platforms, Visualization (case studies)

9. Technological Aggregation & Case Studies (60 Hours)

- System Design
- Real-life/Thematic Area wise Applications, Sensor Analysis
- Home Automation /Smart Home
- Smart Cities
- Smart Agriculture
- Healthcare System
- Real-life/Thematic Area wise Applications, Sensor Analysis(Contd.)
- Use Cases – Smart Infrastructure/Buildings
- Hands-on for Prototypes
- Modern IoT framework / Platforms
- Wearables
- Signalling
- Presence detection
- Power Consumption
- Bandwidth/ Challenges in Connectivity
- Smart Sensor nodes (Motes)
- Structural Aspects of IoT
- Environmental Characteristics
- Traffic Characteristics
- Scalability
- Interoperability
- Latest technologies
- Application Areas
- IoT - Use Case, Case Study, Prototyping, Real-life/Thematic Area wise Applications/Solutions
- SCADA Systems (Supervisory control and data acquisition-industrial control system)
- Remote terminal units (RTUs)
- A telemetry system
- A human–machine interface or HMI
- Security & Privacy
- IoT Ethics, Security & Privacy, Challenges & Standards
- IoT Ethics
- Introduction
- Ethical Challenges In IoT
- Central ICT ethics issues
- The impact of IoT technologies
- Accessibility, Privacy, Property and Integrity of Information
- IoT Security & Privacy Mechanisms
- Security and Interoperability
- Understanding the risks
- Modes of attack
- Techniques for achieving security
- The need for interoperability
- Combining security and interoperability
- Challenges & Standards
- Overview of challenges in IoT
- Evolving architectures
- protocol wars
- competing standards
- case studies
- Open Data & IoT
- Introduction of platforms & APIs

10. Mobile Application Development(80 hrs)

- Object-Oriented Programming Concepts
- Fundamentals of Object-Oriented Programming
- Java Evolution
- Overview of Java Language
- Constants, Variables and Data Types
- Operators and Expressions
- Decision making, Branching and Looping Classes, Objects and Methods, Arrays, String and Collections, Interfaces, Packages, Managing Errors

and Exceptions, Java Multithreading, Java I/O Handling.

- Mobile Development Platforms (Eg - Android),
- Mobile Programming Languages,
- Design & Development of Mobile User Interfaces,
- Mobile Application Development,
- Customizing of Android apps,
- Hardware Abstraction Layers, Android Framework
- Connectivity in Android
- Wifi, BTLE, 2G, 3G/4G etc.
- Support for IoT protocols
- Hands On & Case Studies

11. Project