COURSE SYLLABUS

**Name of the Group:** *Embedded System Group*

**Name of the Course:** PG Diploma in IoT and AI for Industry 4.0
**Course Code:** *ED 700*

**Starting Date:** *20 August 2018*

**Duration:** *24 Weeks (840 Hours)*

**Course Structure:** *This course contains total six modules. After completing the first five modules, the students have to do a six weeks project using any of the topics studied to earn the PG Diploma.*

| ***ED700*** | ***Module Name*** | ***Weeks*** |
|---|---|---|
| *ED701* | *Embedded C and ARM Cortex Microcontrollers* | *4* |
| *ED702* | *Embedded Linux Porting on ARM Cortex Microcontrollers* | *4* |
| *ED703* | *IoT (Internet of Things) - platforms & Tools for Application Development* | *4* |
| *ED704* | *Introduction to AI and Programming Tools* | *3* |
| *ED705* | *Machine Learning & Deep Learning* | *3* |
| *ED706* | *Project Work* | *6* |
| | ***Total*** | *24* |

**Course Contents:**

**ED 701: Embedded C and ARM Cortex Microcontrollers**

**Module Duration: 4 Weeks**

**Objective**

This module is framed to set the required background in embedded system concepts and 'C' language for the rest of the modules. It aims at familiarizing the students in embedded concepts and programming in 'C'. This module covers the advanced topics in 'C' such as Memory management, Pointers, Data structures which are of high relevance in embedded software is considered in depth. This module makes use of KEIL C Compiler along with ARM Cortex Microcontrollers.

This module covers the architecture of the popular 32-bit bit Microcontroller such as ARM. The ARM Cortex processor is the industry-leading 32-bit processor for highly deterministic real-time applications, specifically developed to enable partners to develop high-performance low-cost platforms for a broad

range of devices including microcontrollers, automotive body systems, industrial control systems and wireless networking and sensors.

**Course Description**

**Embedded Concepts**

Introduction to embedded systems, Application Areas, Categories of embedded systems, Overview of embedded system architecture, Specialties of embedded systems, recent trends in embedded systems, Architecture of embedded systems, Hardware architecture, Software architecture, Application Software, Communication Software, Development and debugging Tools.

**'C' and Embedded C**

Introduction to 'C' programming, Storage Classes, Data Types, Controlling program flow, Arrays, Functions, Memory Management, Pointers, Arrays and Pointers, Pointer to Functions and advanced topics on Pointers, Structures and Unions, Data Structures, Linked List, Stacks, Queues, Conditional Compilation, Preprocessor directives, File operations, Variable arguments in Functions, Command line arguments, bitwise operations, Typecasting.

**Introduction to ARM Cortex Architecture**

Introduction to ARM Architecture, Overview of ARM, Overview of Cortex Architecture

**Cortex M3 Microcontrollers & Peripherals**

Cortex M3 based controller architecture, Memory mapping, Cortex M3 Peripherals –GPIOs, Timers, UARTs, ADC, Cortex M3 interrupt handling – NVIC. Application development with Cortex M3 controllers with standard peripheral libraries.

**Learning Outcomes**

After successful completion of the module, the students shall be able to:

- Develop Embedded application using Embedded C Programming
- Use ARM Cortex M with Embedded C Programming for Application Development

**Text Books:**

1. Embedded/Real Time Systems Concepts, Design and Programming Black Book, Prasad, KVK.
2. Let us C by YashwantKanetkar.
3. The Definitive Guide to the ARM Cortex M3, Joseph Yiu, Newnes.

**Reference Books:**

1. Embedded Systems Architecture Programming and Design: Raj Kamal, Tata McGraw Hill.
2. Embedded C, Pont, Michael J
3. Embedded Systems an Integrated Approach: Lyla B Das, Pearson
4. C Programming by Worthington, Steve
5. C Programming language, Kernighan, Brian W, Ritchie, Dennis M
6. Art of C Programming, JONES, ROBIN,STEWART, IAN
7. C Programming for Embedded systems, Zurell, Kirk

8. ARM System Developer's Guide - Designing and Optimizing System Software by: Andrew N Sloss, Dominic Symes, Chris Wright; 2004, Elseiver.
9. Cortex M3 Reference manual.
10. STM32Ldiscovery datasheets, reference manuals & Application notes.

**ED 702: Embedded Linux and Porting on ARM**

**Module Duration: 4 Weeks**

**Objective**

The objective of the course is to provide understanding of the techniques essential to the design and implementation of embedded systems with embedded operating systems and to port on ARM Processor based systems.

**Course Description**

- **Introduction**
  Basic Operating System Concepts, Linux as Embedded Operating System, Comparison of Embedded OS, Embedded OS Tools and Development, Discussion on Embedded OS Applications and Products.
- **System architecture of a Basic OS**
  Internals of Linux OS, System Calls, Linux Compiler options, Process, Multithreading and Synchronization, Serial port and Network programming, Kernel module programming and Device drivers
- **Inter Process Communication**
  Pipe and FIFOs, Shared memory, Sockets
- **Getting Linux on a device**
  Linux boot sequence, Building Kernel, Building Boot image
- **Porting OS on ARM**
  Building root file system, Kernel Compilation for ARM, Porting of OS to ARM
- **Practical Sessions**
  Embedded Linux Applications and Porting on ARM

**Learning Outcomes**

After successful completion of the module, the students shall be able to:

- Implement Embedded systems with Embedded operating systems
- Develop applications with Embedded Linux
- Port the OS with applications on ARM

**Reading List**

1. GNU/LINUX Application Programming, Jones, M Tims
2. Embedded Linux: Hardware, Software, and Interfacing, Hollabaugh, Craig,
3. Building Embedded Linux Systems: Yaghmour, Karim
4. Embedded Software Primer: Simon, David E.
5. Linux Kernel Internals: Beck, Michael At Al
6. UNIX Network Programming : Steven, Richard
7. Linux: The Complete Reference: Petersen, Richard
8. Linux Device Drivers: Rubini, Alessandro, Corbet, Jonathan
9. Linux Kernel Programming: Algorithms and Structures of version 2.4: Beck, Michael At Al
10. Linux Kernel Development: Love, Robert
11. Operating System Concepts, Peter B. Galvin, Abraham Silberschatz, Gerg Gagne, Wiley Publishers
12. Embedded/Real-Time Systems: Concepts, Design and Programming: The Ultimate Reference, Dr. K.V.K.K. Prasad, Published by Wiley DreamTech, 2003
13. ARM System Developer's Guide - Designing and Optimizing System Software by: Andrew N Sloss, Dominic Symes, Chris Wright; 2004, Elseiver.
14. ARM Reference manual.

**ED703:** ***IoT (Internet of Things) - platforms & Tools for Application Development***

**Module Duration:** 105 Hours

**Objective**

The objective of the course is to provide the students with understanding of Internet of Things (IoT). The participants of this module will learn about IoT Architecture, IoT platform, wireless sensor networks and IoT Application development.

The Internet of Things (IoT) is a scenario in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The Internet of Things (IoT, sometimes Internet of Everything) is the network of physical objects or "things" embedded with electronics, software, sensors and connectivity to enable it to achieve greater value and service by exchanging data with the manufacturer, operator and/or other connected devices. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

The participants of this module will learn various software tools required for developing IoT Application

**Course Description**

- Wireless Sensor Networks for IoT
- IoT Application Development using Embedded OS
  - Cotiki OS, mbedOS
  - Cooja Simulator
- Iot Database management

- IoT platforms

  - Rpi
  - NodeMCU
- IoT Graphical user interface
  - Appache web servers
  - HTML, PHP
  - Scripting languages - Python, Bash
- IoT application development for Android Mobile phones
- Advanced Application Development Concepts
  - Security aspects for IoT applications
  - Data Analytics for IoT
  - IoT Physical Servers and Cloud offerings

**Learning Outcomes**

After successful completion of this module, students should be able to:

- Understand the IoT platforms
- Understand how to Implement application development and tools..

**Reading List**

1. 6LoWPAN: The Wireless Embedded Internet, Zach Shelby, Carsten Bormann, Wiley
2. Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, Dr. Ovidiu Vermesan, Dr. Peter Friess, River Publishers
3. Interconnecting Smart Objects with IP: The Next Internet, Jean-Philippe Vasseur, Adam Dunkels, Morgan Kuffmann
4. The Internet of Things: From RFID to the Next-Generation Pervasive Networked Lu Yan, Yan Zhang, Laurence T. Yang, Huansheng Ning
5. Internet of Things (A Hands-on-Approach) , Vijay Madisetti , Arshdeep Bahga
6. Designing the Internet of Things , Adrian McEwen (Author), Hakim Cassimally
7. Asoke K Talukder and Roopa R Yavagal, “Mobile Computing,” Tata McGraw Hill, 2010.
8. Computer Networks; By: Tanenbaum, Andrew S; Pearson Education Pte. Ltd., Delhi, 4th Edition
9. Data and Computer Communications; By: Stallings, William; Pearson Education Pte. Ltd., Delhi, 6th Edition
10. F. Adelstein and S.K.S. Gupta, “Fundamentals of Mobile and Pervasive Computing,” McGraw Hill, 2009.
11. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010
12. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley-India, 2010

**ED 704: Introduction to AI and Programming Tools**

**Module Duration: 3 Weeks**

**Objective**

The objective of the course is to present an overview of artificial intelligence (AI) principles and approaches. Develop a basic understanding of the building blocks of AI as presented in terms of

intelligent agents: Search, Knowledge representation, inference, logic, and learning. Students will implement a small AI system in a team environment. The knowledge of artificial intelligence plays a considerable role in some applications students develop for courses in the program

**Course Description**

**Introduction to AI and its applications**

**Python**:- Basics Data Types, Conditional Statements, Looping, Control Statements, String, List And Dictionary Manipulations, Python Functions, Modules And Packages, Object Oriented Programming in Python, Regular Expressions, Exception Handling.

**Database Management System :-**Introduction to Database Management System & SQL, Database Interaction in Python.

**Data Analysis & visualization** – using numpy, matplotlib, scipy

**R Programming:-** Basics - Vectors, Factors, Lists, Matrices, Arrays, Data Frames, Reading data.

**Data visualization** - barplot, pie, scatterplot, histogram, scatter matrix Statistical Analysis -Summary Statistics, Probability distributions in RNormal distribution, Poisson distribution, Binomial distribution. Correlation and Regression

**Learning Outcomes**

Upon successful completion of this course student will:

- be able to design a knowledge based system
- be familiar with terminology used in this topical area
- have read and analyzed important historical and current trends addressing artificial intelligence.

**Reading List**

1. Introduction to Artificial Intelligence, Rajendra Akerkar; Prentice Hall of India, 2005.
2. Artificial Intelligence: Structures and Strategies for Complex Problem Solving, George Luger; Benjamin Cummings, 2004
3. Artificial Intelligence: A Modern Approach (2nd edition), Russell & Norvig; Prentice Hall. 2003
4. Introduction to AI and Expert Systems, D. W. Patterson; PHI, 1992.
5. Other course material will be provided during the course.

**ED 705: Machine Learning & Deep Learning**

**Module Duration:3 Weeks**

**Objective**

The objective of this module is to help fresh graduates and practicing engineers to enhance their knowledge and skills of Machine Learning and Deep learning. as a part of this module introduce major deep learning algorithms, the problem settings, and their applications to solve real world problems.

**Course Description**

Linear Regression, Supervised Learning, Unsupervised Learning, Support Vector Machines(SVM),Decision Trees, Basics of Neural Network, Boosting and Optimization

Deep Learning Concepts, Deep Neural Networks, Convolutional Neural Network(CNN), Recurrent Neural Network(RNN), Tensorflow/Theano, Keras(o), Introduction to Generative Adversarial Networks(GAN)

**Learning Outcomes**

After successful completion of the module, the students shall be able to

- Identify the machine learning and deep learning algorithms which are more appropriate for various types of learning tasks in various domains.
- Implement deep learning algorithms and solve real-world problems.

**Reading List**

1. T1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016..
2. T2. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
3. Ravindran, K. M. Ragsdell , and G. V. Reklaitis , ENGINEERING OPTIMIZATION: Methods and Applications , John Wiley & Sons, Inc. , 2016.
4. Antoniou, W. S. Lu, PRACTICAL OPTIMIZATION Algorithms and Engineering Applications, Springer , 2007.

**ED 706: Project Work**

**Module Duration: 6 Weeks**

**Course Description**

The students can select hardware, software or system level projects. The project can be implemented using **Microcontrollers, Open Source Hardware Platforms, IoT, AI, ML and DL algorithms,** which students have studied and used during the course. A total product or project can be selected.