**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI**



**WORK INTEGRATED LEARNING PROGRAMMES**

**COURSE HANDOUT**

**Part A: Content Design**

|  |  |
| --- | --- |
| **Course Title** | **Network Embedded Applications** |
| **Course No(s)** | **CSI ZG656/ ES ZG656 / MEL ZG656 / SS ZG656** |
| **Credit Units** | **5** |
| **Course Author** | **K.R.Anupama** |
| **Version No** | **Version 1.0** |
| **Date** | **May 27th 2019** |
| **Instructor In charge** | **Meetha Shenoy** |

**Course Objectives**

|  |  |
| --- | --- |
| **No** | **Objectives** |
| **CO1** | To get an overview of various network embedded applications, architectures, available protocols |
| **CO2** | Understand the application of Wireless Sensor Networks in depth |
| **CO3** | Understand the application of Industrial Networks in depth |
| **CO4** | Understand the application of Automotive Networks in depth |
| **CO5** | Develop Deeply Embedded Systems and IoT Applications |

**Text Book(s)**

|  |  |
| --- | --- |
| No | Author(s), Title, Edition, Publishing House |
| T1 | **R.Zurawski, Network Embedded Systems, CRC press, 2009.** |

**Reference Book(s) & other resources**

|  |  |
| --- | --- |
| No | Author(s), Title, Edition, Publishing House |
| R1 | G.Pottie, W.Kaiser, Principles of Embedded Networked System Design |
| R2 | IEEE Journals and Transactions.  IETF Drafts and RFCs  ACM Transactions  Elsiever Journals |

**Modular Content Structure**

**M1. INTRODUCTION TO NETWORKED EMBEDDED SYSTEMS**

* Introduction to the course
* Introduction to various classes of Networked Embedded Applications
* Multi-processing, Distributed and Networked Systems - Differences

**M2. APPLICATION CLASS -1 WIRELESS SENSOR NETWORKS**

* Introduction
  + What is WSN?
  + Monitoring Space
  + Monitoring Objects
  + Monitoring the Interactions between Space and Objects
  + Basic Building Blocks of WSN
  + Design Challenges of WSN
* Deployment of WSN
  + Deployment Issues
  + Deployment Patterns
* WSN Protocol Stack Introduction
  + Role of each layer
  + Cross Layer Architecture
* WSN Time Synchronization
  + Time Synchronization Requirements and Issues
  + Sender- Receiver Synchronization
  + Receiver- Receiver Synchronization
* WSN Localization
  + Need for Localization and Issues
  + Distance Estimation - ToA
  + Distance Estimation - TDoA
  + Distance Estimation - RSSI
  + Classical Localization Techniques
  + WCL
  + APIT
* WSN Routing
  + Introduction
  + Optimization-based
  + Data-centric
  + Cluster-based
  + Location-based
  + QoS Enabled
* WSN Topology Control
  + Introduction
  + GAF,SPAN
* WSN MAC
  + Introduction
  + SMAC
  + TMAC
  + DMAC
  + LMAC
  + EMAC
* WSN – Other Issues
* WSN Example – Red Pine Monitoring

**M3. INDUSTRIAL CONTROL NETWORKS**

* Introduction
  + Industrial Networks -Levels of Hierarchy
  + History of Industrial Networks
  + Industrial Networks - Issues
  + Characteristics of Industrial Networks
* Field Buses
  + Characteristics of Field Buses
  + Field Buses – MAC
  + Field Buses – TDMA
  + Field Buses – CSMA
  + Field Buses - ModBus
* Industrial Ethernet
  + Field Bus Vs Industrial Ethernet
  + Modified Ethernet
  + SERCOS
  + Ethercat
  + Top of Ethernet
  + EPL
  + TCNet
  + EPA
  + Top of TCP/IP
  + ModBus over TCP/IP
* Wireless Industrial Networks
  + Wireless Ethernet
  + 802.11
  + Bluetooth
  + ZigBee
  + Hybrid Wired/Wireless Networks

**M4. VEHICULAR NETWORKS**

* Intra-vehicular Networks
  + Domains
  + Vehicular Buses
  + TTBuses – TTP/C
  + TTBuses – Flexray
  + TTBuses – TT Ethernet
  + TTBuses – TTCAN
  + Event Triggered Buses - LIN
* Inter-Vehicular Networks
  + V2I and V2V Communication and ITS
  + Types of Traffic
  + VANETS- MAC
  + VANETS – Routing
  + VANETS – PBR
  + VANETS – Routing Classification
  + VANETS – Flooding based Routing - UMB
  + SB and IB
  + Geographic Routing - Gytar

**Learning Outcomes:**

|  |  |
| --- | --- |
| **No** | **Learning Outcomes** |
| **LO1** | Design and Implementation of Wireless Sensor Networks |
| **LO2** | Design and Implementation of Industrial Networks |
| **LO3** | Design and Implementation of Automotive Networks |
| **LO4** | Design and Implementation of end-to-end IoT Networks |

**Part B: Contact Session Plan**

|  |  |
| --- | --- |
| **Academic Term** | Second Semester 2020-2021 |
| **Course Title** | Networked Embedded Applications |
| **Course No** | CSI ZG656/ ES ZG656 / MEL ZG656 / SS ZG656 |
| **Lead Instructor** | MEETHA V SHENOY |

## Glossary of Terms

1. Contact Hour (CH) stands for a hour long live session with students conducted either in a physical classroom or enabled through technology. In this model of instruction, instructor led sessions will be for 22 CH.
   1. Pre CH = Self Learning done prior to a given contact hour
   2. During CH = Content to be discussed during the contact hour by the course instructor
   3. Post CH = Self Learning done post the contact hour
2. Contact Hour (CS) stands for a two-hour long live session with students conducted either in a physical classroom or enabled through technology. In this model of instruction, instructor led sessions will be for 11 CS.
   1. Pre CS = Self Learning done prior to a given contact session
   2. During CS = Content to be discussed during the contact session by the course instructor
   3. Post CS = Self Learning done post the contact session
3. RL stands for Recorded Lecture or Recorded Lesson. It is presented to the student through an online portal. A given RL unfolds as a sequences of video segments interleaved with exercises
4. SS stands for Self-Study to be done as a study of relevant sections from textbooks and reference books. It could also include study of external resources.
5. LE stands for Lab Exercises
6. HW stands for Home Work.
7. M stands for module. Module is a standalone quantum of designed content. A typical course is delivered using a string of modules. M2 means module 2.

## Teaching Methodology (Flipped Learning Model)

The pedagogy for this course is centered around flipped learning model in which the traditional class-room instruction is replaced with recorded lectures to be watched at home as per the student’s convenience and the erstwhile home-working or tutorials become the focus of classroom contact sessions. Students are expected to finish the home works on time.

## Contact Session Plan

* Each Module (M#) covers an independent topic and module may encompass more than one Recorded Lecture (RL) or Lecture Segment (LS).
* Contact Sessions **(2hrs each week)** are scheduled alternate weeks after the student watches all Recorded Lectures (RLs) of the specified Modules (listed below) during the previous week
* In the flipped learning model, Contact Sessions are meant for in-classroom discussions on cases, tutorials/exercises or responding to student’s questions/clarification--- may encompass more than one Module/RLs/CS topic.
* Contact Session topics listed in course structure (numbered CSx.y) may cover several RLs; and as per the pace of instructor/students’ learning, the instructor may take up more than one CS topic during each of the below sessions.

## Course Contents

<From content structure in Part A of this document. Detail the plan of delivery across each contact hour or each contact session. 1 contact session = 2 contact hours>

|  |  |  |  |
| --- | --- | --- | --- |
| **Time** | **Type** | **Description** | **References** |
| **M1. INTRODUCTION TO NETWORKED EMBEDDED SYSTEMS** | | | |
| Pre-CH/CS | RL1.1, RL 1.2 | * Introduction to various classes of Networked Embedded Applications * Multi-processing, Distributed and Networked Systems - Differences | Notes |
| During CS | CS 1 | * Introduction to the course – evaluation components * IoT Vs NEA * Buses Vs Networks | Notes |
|  |  |  |  |
| **M2. Wireless Sensor Networks** | | | |
| Pre-CH/CS | RL 2.1  RL 2.2  RL 2.3 | * Introduction to WSN * WSN Deployment * Network Protocol Stack | T1 – Part II Ch 3,4 |
| During CS | CS 2 | * Application Examples – Long Term & Short Term Monitoring * Importance of Cross Layer Protocol Stack |  |
| Post-CH/CS |  | * WSN Application Examples | Papers |
|  | | | |
| Pre-CH/CS | RL 2.4 | * WSN Time Synchronization   + Time Synchronization Requirements and Issues   + Sender- Receiver Synchronization   + Receiver- Receiver Synchronization | T1 – Part II Ch 5 |
| During CS | CS 3 | * NTP, HBS, TDP, RBD |  |
| Post-CH/CS |  | * More Time Synchronization Protocols - THSL | Papers |
|  | | | |
| Pre-CH/CS | RL 2.5 | * WSN Localization   + Need for Localization and Issues   + Distance Estimation - ToA   + Distance Estimation - TDoA   + Distance Estimation - RSSI   + Classical Localization Techniques   + WCL   + APIT | T1 – Part II Ch 6 |
| During CS | CS 4 | * Bounding Box Algorithm, Distributed Least Squares, Sweeps |  |
| Post-CH/CS |  | * FGL, Assumption-Based Coordinates | Papers |
|  | | | |
| Pre-CH/CS | RL 2.6, RL 2.7 | * WSN Routing   + Introduction   + Optimization-based   + Data-centric   + Cluster-based   + Location-based   + QoS Enabled | T1 – Part II Ch 7 |
| During CS | CS 5,6,7 | * Sensor Protocols for Information via Negotiation, Sequential Assigned Routing Protocol, Energy-Aware Routing Protocol in Cluster-Based Sensor Networks * MECN, STEM |  |
| Post-CH/CS |  | * Pegasis, Maximum Lifetime Routing Protocol, TTDD, RPAR, Constrained Anisotropic Diffusion Routing Protocol | Papers |
|  | | | |
| Pre-CH/CS | RL 2.9 | * WSN MAC   + Introduction   + SMAC   + TMAC   + DMAC   + LMAC   + EMAC | T1 – Part II Ch 8 |
| During CS | CS 8,9 | * BMAC,TRAMA * Mobility and Multi-Channel MAC |  |
| Post-CH/CS |  | * Wise MAC, ZMAC, Crankshaft and other MAC Protocols | Papers |
|  | | | |
| Pre-CH/CS | RL 2.10, RL 2.11 | * WSN – Other Issues * WSN Example – Red Pine Monitoring |  |
| During CS | CS 10 | * WSN Examples |  |
| Post-CH/CS |  | * WSN Examples | Papers |
| **M3. INDUSTRIAL CONTROL NETWORKS** | | | |
| Pre-CH/CS | RL 3.1, RL 3.2 | * Introduction   + Industrial Networks -Levels of Hierarchy   + History of Industrial Networks   + Industrial Networks - Issues   + Characteristics of Industrial Networks * Field Buses   + Characteristics of Field Buses   + Field Buses – MAC   + Field Buses – TDMA   + Field Buses – CSMA   + Field Buses - ModBus |  |
| During CS | CS 11, CS 12 | * Summary, OSI Model and Industrial Networks, NOAH Approach, Protocol Tunneling, LonWorks |  |
| Post-CH/CS | Case Study | * Building Automation |  |
|  | | | |
| Pre-CH/CS | RL 3.3 | * Industrial Ethernet   + Field Bus Vs Industrial Ethernet   + Modified Ethernet   + SERCOS   + Ethercat   + Top of Ethernet   + EPL   + TCNet   + EPA   + Top of TCP/IP   + ModBus over TCP/IP |  |
| During CS | CS 13, CS 14 | * Summary & Comparison * Ethernet IP and other Protocol |  |
| Post-CH/CS | Case Study | * Hierarchical Industrial Control |  |
|  | | | |
| Pre-CH/CS | RL 3.4 | * Wireless Network for Industrial Networks |  |
| During CS | CS 15, CS 16 | * 802.11 * Bluetooth * 802.15.4 |  |
| Post-CH/CS | Case Study | * Hybrid Wired/Wireless Industrial Networks |  |
| **M4. Automotive Electronics** | | | |
| Pre-CH/CS | RL 4.1 | * Intra-vehicular Networks * Domains * Vehicular Buses * TTBuses – TTP/C * TTBuses – Flexray * TTBuses – TT Ethernet * TTBuses – TTCAN * Event Triggered Buses - LIN |  |
| During CS | CS 17,18 | * Fault Tolerance, Fault & Error Confinement * Fault Tolerant Buses * AutoSAR * Middleware and Automotive OS |  |
| Post-CH/CS | Case Study | * Volcano |  |
|  | | | |
| Pre-CH/CS | RL 4.2 | * V2I and V2V Communication and ITS * Types of Traffic * VANETS- MAC * VANETS – Routing * VANETS – PBR * VANETS – Routing Classification * VANETS – Flooding based Routing - UMB * SB and IB * Geographic Routing - Gytar |  |
| During CS | CS 5, 6 | * Geographic Broadcast Routing * Non Safety-Critical Applications – Network Protocol Stack * System Design Example – Mining System * Summary of Course |  |
| Post-CH/CS | Case Study | * System Design Examples |  |

## Evaluation Scheme

Legend: EC = Evaluation Component

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Name** | **Type** | **Duration** | **Weight** | **Day, Date, Session, Time** |
| EC-1 | Assignment |  | \* | 25% | To be announced |
| EC-2 | Mid-Semester Test | Closed book | 2 Hours | 30% | Saturday, 06/03/2021 (FN)  10 AM - 12 Noon |
| EC-3 | Comprehensive Exam | Open book | 3 Hours | 45% | Saturday, 01/05/2021 (FN)  9 AM – 12 Noon |

***Note*** *- Evaluation components can be tailored depending on the proposed model.*

## Important Information:

Syllabus for Mid-Semester Test (Closed Book): Topics in CS 1-10.

Syllabus for Comprehensive Exam (Open Book): All topics given in plan of study

Evaluation Guidelines:

1. For Closed Book tests: No books or reference material of any kind will be permitted. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
2. For Open Book exams: Use of prescribed and reference text books, in original (not photocopies) is permitted. Class notes/slides as reference material in filed or bound form is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
3. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam. The genuineness of the reason for absence in the Regular Exam shall be assessed prior to giving permission to appear for the Make-up Exam. Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the lectures, and take all the prescribed evaluation components such as Assignment/Quiz, Mid-Semester Test and Comprehensive Exam according to the evaluation scheme provided in the handout.