

**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI WORK INTEGRATED LEARNING PROGRAMMES**

**COURSE HANDOUT**

**Part A: Content Design**

|  |  |
| --- | --- |
| **Course Title** | Cyber-Physical Systems |
| **Course No(s)** | CSI ZG528/SS ZG528 / SE ZG528 |
| **Credit Units** | 4 |
| **Course Author** | Anita Ramachandran |
| **Version No** | 1.0 |
| **Date** | Nov 9, 2017 |

**Course Description**

|  |
| --- |
| This course provides an overview of Cyber-Physical Systems, with respect to its components and characteristics. As an example of a Cyber-Physical System, this course explains the various aspects of IoT systems, and helps students understand the IoT system components, its protocol stack and design methodologies. The course also enables students to get familiar with the Raspebrry Pi platform, via simple examples/applications. At the end of this course, students will be able to explain the various facets of Cyber Physical Systems, with focus on IoT and demonstrate simple IoT applications. |

**Course Objectives**

|  |  |
| --- | --- |
| **No** | **Objective** |
| **CO1** | Provide an overview of various areas in Cyber-Physical systems such as real-time systems, embedded systems, Wireless Sensor Networks and IoT. |
| **CO2** | Explain the applications of IoT and characteristics of IoT systems, and examine the components of an end-to-end IoT system such as sensors & actuators, protocol stack and cloud storage models |
| **CO3** | Enable students to build simple applications using Raspberry Pi |

**Text Book(s)**

|  |  |
| --- | --- |
| **No** | **Author(s), Title, Edition, Publishing House** |
| T1 | Arshdeep Bahga, Vijay Madisetti; Internet of Things – A Hands-on Approach; Universities Press (India) Pvt Ltd, 2016 |
| T2 | Feng Zhao, Leonidas Guibas; Wireless Sensor Networks – An Information Processing Approach; Elsevier, 2017 |

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

|  |  |
| --- | --- |
| **No** | **Author(s), Title, Edition, Publishing House** |

|  |  |
| --- | --- |
| R1 | Perry Lea; Internet of Things for Architects; Packt Publishing Ltd |
| R2 | Dinkar Sitaram and Geetha Manjunath. Moving to the Cloud. Syngress (Elsevier) Pub, 2011 |
| R3 | Liu, Jane W.S., Real Time Systems, Pearson Education, 2000 |

**Content Structure**

|  |  |  |
| --- | --- | --- |
| **No** | **Title of the Module** | **References** |
| M1 | Introduction to Cyber-Physical Systems  • Introduction to Cyber Physical Systems  • Elements and Enabling Technologies for Cyber-Physical Systems | Instructor  Supplied  Material |
| M2 | Characteristics of Real Time & Embedded Systems  • Characteristics & Classification of Embedded Systems  • Hardware Components in an Embedded System – Processor Architectures, Memory Types & Organization, Cache Organization, Interrupts, Timers, ADC/DAC  • Software Components of an Embedded System – RTOS & Tasks, System on Chip | Instructor  Supplied  Material, R2 |
| M3 | Wireless Sensor Networks  • Introduction, Advantages  • Significance of Localization & Tracking, Clustering, Time  synchronization  • Example applications  • Considerations for building and deploying WSN applications | T2 |
| M4 | Internet of Things  • Introduction  • Applications  • Characteristics  • Enabling Technologies  • Communication Models – P2P, Client-Server, PubSub | T1 |
| M5 | IoT Design Methodology & Life Cycle  • Physical & Logical Design  • IoT Enabling Technologies  • IoT Levels & Deployment Templates  • Example 1 :Level 1 System - Smart Lighting  • Example 2: Level 6 System - Weather Monitoring | T1 |
| M6 | IoT Platforms & End Devices  • Introduction to IoT Physical End Points & Platforms  • Raspberry Architecture  • Raspberry OS & Programming  • Raspberry PI I/O Interfaces  • Raspberry PI Communication Interfaces | T1 |
| M7 | IoT Network Protocol Stack  • Introduction to Networking in IoT  • Layer 2 - 802.11, 802.15.4, BLE, LoRA  • Layer 3 – 6LoWPAN  • Application Layer – CoAP, MQTT, XMPP | Instructor  Supplied  Material  (Relevant  Specs) |

|  |  |  |
| --- | --- | --- |
| M8 | IoT System Design Examples  • Example 1 :Level 1 System - Smart Lighting  • Example 2: Level 6 System - Weather Monitoring | T1 |
| M9 | Cloud Service Models  • Characteristics of Cloud Infrastructure  • Virtualization  • SaaS, PaaS, IaaS  • Deploying Cyber-Physical Systems on the Cloud | Instructor  Supplied  Material, R1 |
| M10 | IoT Applications  • Healthcare – Applications  o Overview, Enabling Technologies, Challenges in Design &  Development  o Health Care Example – Fitness Tracking Systems  ▪ Key Design Challenges  ▪ Generic Fitness Tracking System Architecture  ▪ Building Blocks- Processor  ▪ Building Blocks - Sensors  ▪ Building Blocks -Cloud & Communication  ▪ Building Blocks-OS  • Smart Environments - Industrial application (Process control), Home automation  o Overview, Enabling Technologies, Challenges in Design &  Development  o Smart Environment Example - Smart Home  ▪ Introduction  ▪ Generic Architecture  ▪ Building Blocks  ▪ Existing - Home Automation Systems  ▪ Design Challenges & Issues  ▪ Platforms for Home Automation Systems | T1 |
| M11 | Security in Cyber-Physical Systems  • Types of security attacks in Cyber-Physical Systems (devices, messaging & applications)  • Security solutions in Cyber-Physical Systems | Instructor  Supplied  Material |

**Learning Outcomes:**

|  |  |
| --- | --- |
| No | Learning Outcomes |
| LO1 | Identify the components of Cyber-Physical Systems and list the enabling technologies for the same |
| L02 | List the various alternatives for building Cyber-Physical Systems with respect to hardware and software components, and identify the kind of applications where each of these can be used towards building a solution |
| LO3 | Given a set of application requirements, analyze the application characteristics, identify the end to-end solution components and their alternatives with respect to various facets such as system components, communication models, communication protocol stack and cloud service delivery models |

|  |  |
| --- | --- |
| LO4 | Given a set of possible technologies/alternatives for a set of application requirements, choose the best fit technology/alternative for the given problem and justify the choice of the solution |

**Part B: Contact Session Plan**

|  |  |
| --- | --- |
| **Academic Term** | Second Semester 2020-2021 |
| **Course Title** | Cyber-Physical Systems |
| **Course No** | CSI ZG528/SS ZG528 / SE ZG528 |
| **Lead Instructor** | LUCY GUIDNO |

***Course Contents***

|  |  |  |
| --- | --- | --- |
| **Contact**  **Hours(#)** | **List of Topic Title**  **(from content structure in Course Handout)** | **Text/Ref**  **Book/external resource** |
| 1, 2 | M1: Introduction to Cyber-Physical Systems | Instructor Supplied Material |
| 3, 4 | M2: Characteristics of Real Time & Embedded Systems | Instructor Supplied Material, R2 |
| 5, 6  7, 8 | M3: Wireless Sensor Networks | T2 |
| 9, 10 | M4: Internet of Things | T1 |
| 11, 12 | M5: IoT Design Methodology & Life Cycle | T1 |
| 13, 14  15, 16 | M6: IoT Platforms & End Devices  Lab: Setting up Raspberry Pi  Lab: Run demo programs on Raspberry Pi | T1 |
| 17, 18  19, 20  21, 22 | M7: IoT Network Protocol Stack | Instructor Supplied Material (Relevant Specs) |

|  |  |  |
| --- | --- | --- |
| 23, 24 | M8: IoT System Design Examples | T1 |
| 25, 26 | M9: Cloud Service Models | Instructor Supplied Material, R1 |
| 27, 28 | Lab: Running an IoT application on the cloud | Instructor Supplied Material |
| 29, 30 | M10: IoT Applications | T1 |
| 31, 32 | M11: Security in Cyber-Physical Systems | Instructor Supplied Material |

*# The above contact hours and topics can be adapted for non-specific and specific WILP programs depending on the requirements and class interests.*

***Lab Details***

|  |  |
| --- | --- |
| **Title** | **Access URL** |
| Lab Setup Instructions | CS&IS Lab Setup Instruction Manual & Video:  https://elearn.bits-pilani.ac.in/ |
| Lab Capsules | Instructor Supplied Material |
| Additional References | https://projects.raspberrypi.org/en/projects/demo programs |

***Evaluation Scheme***

Legend: EC = Evaluation Component

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **No** | **Name** | **Type** | **Duration** | **Weight** | **Day, Date, Session, Time** |
| EC1 | Quiz 1 |  |  | 10% | February 1-15, 2021 |
| Assignment |  |  | 25% | To be announced |
| EC2 | Mid-sem | Closed book | 2 hrs | 25% | Friday, 05/03/2021 (AN) 2 PM – 4 PM |
| EC3 | Comprehensive | Open book | 3 hrs | 40% | Friday, 30/04/2021 (AN) 2 PM – 5 PM |

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

***Important Information***

Syllabus for Mid-Semester Test (Closed Book): Topics in Weeks 1-7

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

1. EC-1 consists of one Assignment and one Quiz. Announcements regarding the same will be made in a timely manner.

2. 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.

3. 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.

4. 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.