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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
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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.