

NIRMA UNIVERSITY
SCHOOL OF TECHNOLOGY, INSTITUTE OF TECHNOLOGY
M. Tech. in Electronics and Communication Engineering (Embedded System)
M.Tech. Semester - II
Department Elective II

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Course Code	36EC270ME22
Course Title	Cyber Physical Systems

Course Learning Outcomes (CLOs):

At the end of the course, students will be able to -

1. Address challenges in implementing a cyber-physical system from a computational perspective.
2. Integrate real valued and dense time real time systems with software based discrete automated control.
3. Design and validate problems for Cyber Physical Systems using formal methods, safety assurance and security aspects.

Syllabus:

Teaching Hours:45

UNIT I: Introduction to Cyber-Physical Systems

05

Cyber-Physical Systems (CPS) in the real world , Basic principles of design and validation of CPS, Industry 4.0, AutoSAR, IIOT implications, Building Automation, Medical CPS

UNIT II: CPS - Platform components

06

CPS HW platforms - Processors, Sensors, Actuators, CPS Network – Wireless Hart, CAN, Automotive Ethernet, CPS Sw stack - RTOS , Scheduling Real Time control tasks

UNIT III: Principles of Automated Control Design

08

Basic control theory, Dynamical Systems and Stability , Controller Design Techniques, Stability Analysis: CLFs, MLFs, stability under slow switching, Performance under Packet drop and Noise, Tutorial: MATLAB toolboxes - Simulink, Stateflow

UNIT IV: CPS Implementation

07

Features, software components, Mapping software components to ECUs, CPS Performance Analysis - effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion, Control, Bus and Network Scheduling using True time

UNIT V: Formal Methods for Safety Assurance of Cyber-Physical Systems

07

Advanced Automata based modeling and analysis, Basic introduction and examples, Timed and Hybrid Automata Formal Analysis, Flow pipe construction, reachability analysis, Analysis of CPS Software, Weakest Pre-conditions, Hybrid Automata Modeling, Flow pipe construction using SpaceX and Phaver tools CPS SW Verification, Frama-C, CBMC

UNIT VI: Secure Deployment of CPS

07

Attack models, Secure Task mapping and Partitioning, State estimation for attack detection, Case study - Vehicle ABS hacking, Power Distribution, and Attacks on Smart Grids

UNIT VII: CPS Case studies and Tutorials

05

Automotive : SW controllers for ABS, ACC, Lane Departure Warning, Suspension Control, Healthcare : Artificial Pancreas/Infusion Pump/Pacemaker, Green Buildings : automated lighting, AC control

Self-Study:

The self-study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self-study contents.

Suggested Readings:

1. E. A. Lee, Sanjit Seshia, Introduction to Embedded Systems – A Cyber-Physical Systems Approach , MIT Press
2. Rajeev Alur , Principles of Cyber-Physical Systems, MIT Press