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**DEPARTMENT OF ELECTRICAL ENGINEERING**

**Course Descriptive File**

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| 1 | Course Title | Embedded Systems |
| 2 | Course Code | EE-305 |
| 3 | Credit Hours | 4(3,1) |
| 4 | Pre-requisites | - |
|  5 |  Co-requisites | PF, DLD |
| 6 | Semester | 4th |
| 7 | Resource Person | Muhammad Umar Rana |
| 8 | Contact Hours (Theory) | 3 + 1T (per week) |
| 9 | Contact Hours (Lab) | 3 (per week) |
| 10 | Office Hours  | 8:30-3:00 |
| 11 | Email | umerrana@msn.com |
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| 12 | Course Descritpion |
| Embedded Systems (ES) introduces students to the design and analysis of computational systems that interact with physical processes. Applications of such systems include medical devices and systems, consumer electronics, toys and games, assisted living, traffic control and safety, automotive systems, process control, energy management and conservation, environmental control, aircraft control systems, communications systems, instrumentation, critical infrastructure control (electric power, water resources, and communications systems for example), robotics and distributed robotics, defense systems, manufacturing, and IoT.A major theme of this course is on the interplay of practical design with models of systems, including both software components and physical dynamics. A major emphasis will be on building high confidence systems with real-time and concurrent behaviors. |
| 13 | Course Outline as per Scheme of Studies ( SoS) |
| This course will cover the basics of embedded system organization, system on programmable-chip technologies and real-time systems. It provides the advance knowledge required for embedded computer design and development as well as real-time operating systems. Students are introduced to software development concepts applicable to real time and embedded systems. Particularly ARM Cortex M3 will be studied as a representative embedded processor and embedded software development is carried out for ARM Cortex CPUs. The students will be able to grasp the main principles of embedded system design and understand the concept of hardware-software co-design, system on programmable chip (SoPC), real-time operating systems and scheduling techniques. Embedded system co-specification and partitioning is also introduced in the course. |
| 14 | Course Objectives as per SoS |
| At the end of this course, the successful student will be able to: 1. Interconnect engineering concepts related to microprocessors, computer hardware and real-time software systems to design embedded systems for real-world applications. Learn to employ specialized knowledge of subsystems like processor cores and other hardware/software system components to design an embedded computer system.
2. Improve capabilities of using the technical knowledge of processor architecture, peripherals, programming, and CAD tools to design specific embedded computer systems. Solve various challenges of embedded software system design by employing real-time system software design methodologies to design, test and verify embedded software system design.
3. Demonstrate the main features of the course-project and answer critical and project specific questions during project demo and oral sessions. Write project report by following a standard IEEE like format, where all the reports are evaluated based on their completeness, English, and citations.
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| 15 | Books  |
| Textbook [Derek Molloy](http://exploringbeaglebone.com/about/), "Exploring Raspberry PI", Wiley, 978-1119188687, 720ppReference Books 1. T. Martin, The Designer's Guide to the Cortex-M Processor Family: A Tutorial Approach, Elsevier, 2013, ISBN 978-0080982960
2. M. Wolf, Computer as Components: Principles of Embedded Computing System Design, 4th Edition, Morgan Kaufman Publishers 2016, ISBN 978-0-12-805387-4
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| 16 | Course Learning Outcomes (CLOs) |
| Theory CLOs:

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| **Sr. No.** | **CLO** | **Domain** | **Taxonomy Level** | **PLO** |
| 1. | Introduction to Embedded and Real-time Systems. Eco cycle of embedded systems design. Introduction to Embedded Linux, getting familiarization with embedded Linux Environment.  | Cognitive | C1 | 1 |
| 2. | Subsystems and peripheral initialization and interfacing. Writing user space applications in Linux. Timers, PWM, Serial Port programming and Interrupt handling. | Cognitive | C1, C2 | 1 |
| 4. | System Level Design and Implementation Considerations. Term projects for different applications selected by students. | Psychomotor | P1, P2, P3 | 5 |

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|  17 | Marks Breakup  |
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| Quizzes | 15% |
| Homework/assignments  | 15% |
| Midterm exam | 30% |
| Terminal exam (3 hours) | 40% |
| Total (theory) | 100% |

Theory

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| Lab Assessments | 30% |
| Lab Sessional Exams(xx% Lab performance + xx% Lab Assessments) | 30% |
| Lab Terminal Exam  (xx% Lab performance + xx% Lab Assessments) | 40% |
| Total (lab) | 100% |

Lab

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| Final marks | Theory marks \* 0.75 + Lab marks \* 0.25 |

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| **18** |
| **Week** | **Topic** | **CLO** | **Taxonomy****Level** | **Specific Outcome** | **Contact Hours** | **Assessment** |
| 1 | Embedded Systems, introduction, issues, challenges, trends, etc. Embedded Processor Architecture ARM7 and other CPU Cores | CLO1 | C1 | Get familiarized with embedded systems | 3 | Assignment 1Quiz 1 |
| 2 | ARMv7 and Cortex M3 Architecture. ARM Cortex M3 for Multitasking Applications. | CLO1 | C1 | Understand the architecture of ARMv7. | 3 |
| 3 | RTOS: Real time Operating Systems Pre-emptive and Non-preemptive Scheduling. Introduction to Real-time operating system (RTX environment). Embedded Linux with Preempt RT patching. | CLO1 | C1 | Understand the concepts and working principles of resource sharing in RT systems. Get familiarized with practical RTOS(s) | 3 |
| 4 | Overview of embedded system architecture, I/O / memory interface, device drivers, etc. | CLO2 | C1 | Understand the hardware components of different embedded systems. | 3 | Assignment 2Quiz 2 |
| 5 | Introduction to Wiring Pi Library. Introduction to user space applications. Writing user space application for GPIOs | CLO2 | C1,C2 | 3 |
| 6 | Introduction to Communication peripherals. UART, SPI, TWI. User space application using Wiring Pi library. | CLO2 | C1, C2 | 3 |
| 7 | Mid Term Project: Design of intelligent dual-tank water controller and monitoring system | CLO2CLO3 | C1, C2P1, P2 | Term Project: To apply the concepts studied so far. | 3 | N/A |
| 8 | Project: Hardware and Application development. | CLO2CLO3 | C1, C2P1, P2 | 3 |
| **MID TERM EXAM (27th February – 7th March 2020)** |

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| **Week** | **Topic** | **CLO** | **Taxonomy****Level** | **Specific Outcome** | **Contact Hours** | **Assessment** |
| 9 | Introduction of Timers. Using timers to generate the delay. Introduction to Tick Timer. Concept of blocking and non-blocking delays. | CLO2 | C1, C2 | Understanding to programming practice for Embedded Applications | 3 | Assignment 3Quiz 3 |
| 10 | Introduction to Interrupts. Interrupt handling routines. Interrupt handling in Embedded Linux. Introduction to LKM. | CLO2 | C1, C2 | 3 |
| 11 | Understanding device drivers and developing “char” type drivers for LINUX desktops | CLO2 | C1, C2 | Understanding of BSP | 3 |
| 12 | Introduction to HMI. Webservers in Linux. Creating a test html to display I/O data. Introduction to MySQL database. Creating a database. Database queries. | CLO2 | C1, C2 | Application of Embedded systems with real-world applications | 3 | Presentation 4 Quiz 4 |
| 13 | Introduction to IoT. Concept of Sensors Network. Techniques for development of IoT Systems. Power consumption conside-rations and ultra-low power systems.  | CLO2CLO3 | C2, P1 | 3 |
| 14 | Introduction to sampled system. Introduction to Z-tranform. Implementation of DSP algorithms, filters in embedded systems. Discrete PID controllers. | CLO2 | C1, C2 | Discrete Controllers Implementation in Embedded Systems. | 3 |
| 15 | Term Project: System require-ments analysis. Algorithms development.  | CLO2CLO3 | C1, C2P1,P2,P3 | Term Project | 3 | Project Presentations |
| 16 | Term Project: Hardware design considerations. Application development. IoT implementation. | CLO2CLO3 | C1, C2P1,P2,P3 | 3 |
| **FINAL TERM EXAM (16th January – 28th January 2019)** |

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| **19** | **Course Learning Outcomes (CLOs) and Assessment Plan** |
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| CLOActivity  | CLO 1 | CLO 2 | CLO 3 | CLO 4 |
| Quiz 1 | √ |  |  |  |
| Quiz 2 | √ | √ |  |  |
| Quiz 3 | √ | √ |  |  |
| Assignment 1 |  | √ |  |  |
| Presentation 1 | √ |  |  |  |
| Assignment 2 | √ |  |  |  |
| MID TERM EXAM | √ | √ |  |  |
| Quiz 4 | √ |  |  |  |
| Quiz 5 |  | √ |  |  |
| Quiz 6 |  |  | √ |  |
| Assignment 3 |  | √ |  |  |
| Presentation 2 |  | √ |  |  |
| FINAL TERM EXAM | √ | √ | √ |  |
| Lab Final Exam | √ |  |  | √ |

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| CLOExperiment  | CLO1 | CLO2 | CLO3 | CLO4 |
| Lab 1 |  |  |  | P1, P2, P3 |
| Lab 2 |  |  |  | P1, P2, P3 |
| Lab 3 |  |  |  | P1, P2, P3 |
| Lab 4 |  |  |  | P1, P2, P3 |
| Lab 5 |  |  |  | P1, P2, P3 |
| Lab 6 |  |  |  | P1, P2, P3 |
| Lab 7 |  |  |  | P1, P2, P3 |
| Lab 8 |  |  |  | P1, P2, P3 |
| Lab 9 |  |  |  | P1, P2, P3 |
| Lab 10 |  |  |  | P1, P2, P3 |
| Lab 11 |  |  |  | P1, P2, P3 |
| Lab 12 |  |  |  | P1, P2, P3 |
| Final Term Project |  |  |  | P1, P2, P3 |
| Lab Final Exam |  |  |  | P1, P2, P3 |

\*Add columns according to number of course CLO’s and Lab CLO’s for your respective course. Complete as per your planned quiz and assignments for this session.  |

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| **20** | **Lab Details** |
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| **Laboratory Resources** |
| * Theory and Hardware based
 |
| **Computer Resources** |
| * Cisco Packet Tracer Software
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| **21** | **Mapping of CLOs to PLOs**  |

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| PLOCLOs | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 |
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| CLO1 | C1 |  |  |  |  |  |  |  |  |  |  |  |
| CLO2 | C1, C2 |  |  |  |  |  |  |  |  |  |  |  |
| CLO3 | C1, C2 |  |  |  |  |  |  |  |  |  |  |  |
| CLO4 |  |  |  |  | P1, P2, P3 |  |  |  |  |  |  |  |