# Course Name: Embedded Real-Time Systems

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## Course Description

This course begins with an introduction to microprocessor-based embedded systems, their elements and types. The real-time constraints and the role of operating systems open the next chapters. The course continues with the fundamental concepts and practical aspects of Cyber Physical and IoT systems. Afterwards, we get into the details of the most widely-used microprocessor architecture (ARM), open-source OS (Linux), and lighter real-time OSes like FreeRTOS and ARM Mbed. The students learn to use the well-known open hardware boards to develop various embedded applications with various standard interfaces and protocols. The main titles of the course can be summarized as follows:

- Introduction to Embedded Systems,
- Scheduling and Real-Time Systems,
- Cyber Physical System,
- IoT Systems,
- ARM Architecture,
- Peripherals and Interfaces,
- Linux for Embedded and Real-Time Systems,
- Open HW, Open SW and Open Source Libraries/Resources

## Syllabus

- Embedded Systems Definitions, and Classifications
- Embedded Design Considerations, Constraints and Requirements
- Cyber Physical Systems, Architecture, Constraints, …
- IoT Systems, Architecture, Protocols, …
- Modeling, Simulation, Evaluation, Validation and Correctness
- Building Blocks and Related Design Rules
- Selections Rules and Tradeoffs
- Processor Families, Architectures, ISAs
- Fixed-Point vs Floating-Point Programming and Numerical Issues
- Processor Peripherals and Interfaces
- Processors, ARM, DSP Processors, …
- ARM Architecture

- OSes and Task Scheduling
- Embedded Linux, FreeRTOS, ARM Mbed, DSP-BIOS, …
- Linux Architecture and Programming
- Debugging
- Tailoring/Building Linux to Fit Applications Requirement
- Linux Kernel Modules and Interfaces
- Open HW Boards: Raspberry Pie, Orange Pie, BeagleBone, …
- Open Source Libraries and SW Resources: OpenCV, Boost, …
- HW/SW Safety and Security
- Sample Real-World Projects

## Prerequisites

- C/C++ Programming
- Microprocessors (optional)

## Evaluations

- Assignments
- Mid-term and Final Exams
- Final Projects

## References

[1] Embedded System Design, Embedded Systems, Foundations of Cyber-Physical Systems, and the Internet of Things, P. Marvedel, Springer, 3rd Edition, 2018.
[2] Real-T Designing Embedded Systems and the Internet of Things (IoT) with the ARM® Mbed™, P. Xiao, John Willey & Sons, 2018.
[3] High Performance Embedded Computing, M. Wolf, Morgan Kauffmann, 2nd Edition, 2014.
[4] Linux for Embedded and Real-Time Applications, D. Abbot, 3rd Edition, Elsevier, 2013.
[5] Exploring Beaglebone, D. Molloy, Wiley 2015.
[6] Exploring Raspberry Pi, D. Molloy, Wiley 2016.
[7] Real-time Embedded Systems, X. Fan, Elsevier 2015.
[8] Modern Assembly Language Programming with the ARM Processor, L. D. Pyeat, Elsevier 2016.