

## ECE 9407- Sensor Networks and Embedded Systems

Course Outline-Winter 2019

- Description** This course covers various subjects related to Embedded Systems, Wireless Sensor Networks (WSNs), and Programmable Logic Controllers (PLCs). Embedded systems and PLCs are microprocessor-based systems and they can be used together with WSNs for security monitoring, environmental information collection, tracking, and controlling. This course is designed to train students to acquire theory and practice hands-on skills on embedded systems, microcontrollers, and to understand and learn the fundamentals and architecture of WSNs and PLCs by developing and debugging embedded system hardware and firmware. Student participation in active discussions of the course topics through research papers will be expected. There are five lab sessions in this course. In these sessions, students will gain hands-on design experience through the use of the state-of-art commercial design tools. After completing this course, students should be able to:
- Handle issues such as embedded processor selection, hardware/firmware partitioning, development tools, firmware architecture, firmware design, and firmware debugging,
  - Use sensor networks, and propose, implement and evaluate new ideas for solving sensor network design issues,
  - Work on applications of wireless sensor networks, and describe concepts, protocols, and differences underlying their design and implementation,
  - Describe major components in a PLC and their functional operation, and
  - Write a basic PLC program implementing sensor and relay technology in a circuit.
- Instructor** Reza Jafari, Ph.D.  
E-mail: [jafari@ieee.org](mailto:jafari@ieee.org)  
Office hours: By appointment
- Contact Hours** 3 lecture hours per week, 0.5 course.  
Five lecture sessions will be substituted by lab sessions.
- Enrollment & Prerequisites** A key prerequisite for this course is ES 1036 - (Programming Fundamentals for Engineers), or CS 3307 -(Object-Oriented Design and Analysis), or ECE4470 (Microcomputer Engineering), which may be waived only for Ph.D. students or after passing a test in C Language. The course is purposed for Ph.D., M.Sc., and M.Eng. students with a high-level of analytical ability, self-motivation and a high interest in research and development.

## Course Readings

Chapters of the following books are required in this course:

- J. W. Valvano, *Embedded Systems: Introduction to ARM®Cortex-M Microcontrollers*, Volume 1, 2014, <http://users.ece.utexas.edu/~valvano/>, ISBN: 978-1477508992.
- V. Çağrı Güngör, Gerhard P. Hancke, *Industrial Wireless Sensor Networks: Applications, Protocols, and Standards*, CRC Press, 2013.
- Programmable Logic Controllers, 4th ed. Frank D. Petruzella (2011), McGraw Hill. ISBN # 0-07-351088-0.

Recommended books:

- M. Tahir, K. Javed, *ARM Microprocessor Systems: Cortex-M Architecture, Programming, And Interfacing*, CRC Press, 2017.
- Bhaskar Krishnamachari, *Networking Wireless Sensors*, Cambridge University Press, 2005.
- Some recent papers from the literature will also be discussed.

## Course Topics

The following items describe the topics:

1. Introduction to Embedded Systems
2. Embedded Microcontroller Systems
3. Introduction to Industrial WSNs
4. Architecture of WSNs and its programming
5. Industrial WSN Standards
6. Applications of Industrial WSNs
7. Overview of PLC logic and relays
8. PLC programming

## Evaluation

In this advanced Graduate-level course, it is expected that all students will be motivated, responsible for their own learning, and participate actively in the lecture and laboratory sessions. Each student must present and participate actively in the discussions each week in class, complete all assignments in a timely manner (reading assignments may be tested using quizzes), and contribute significantly to the group research project. The course evaluation is based on the following table:

Course Component	Weight	Maximum Penalties*	
		English	Presentation
Homework Assignments	10%	10%	10%
Midterm Exam	30%	10%	10%
Final Exam	30%	10%	10%
Lab	20%	10%	10%
Project	10%	10%	10%

*\*In accordance with the policy of the University, the grade assigned to all written and oral work presented in English shall take into account syntax, diction, grammar and spelling. In the professional life of an engineer, the manner in which oral and written communications are presented is extremely important. An engineering student must develop these skills as an integral part of the graduate program. To encourage the student to do so, the grades assigned to all written and oral work will take into account all aspects of presentation including conciseness, organization, neatness, use of headings, and the preparation and use of tables and figures. All work will be marked first for content after which a penalty not to exceed the maximum shown above may be applied for lack of proficiency in English and/or presentation.*

**Homework Assignments:** There will be two assignments. Both homework assignments have equal weights. Homework assignments may be programming-based.

**Project:** There will be a course project that should be completed. More details will be announced on the course website.

**Final Examination:** The exam will be closed-book. During the exam, all electronic devices must be powered off and stored out of reach. The only exception is a simple scientific nonprogrammable calculator, which is permitted. Other devices capable of substituting for a simple calculator (e.g. a phone, laptop, iPad) are not permitted.

**Late Submission Policy:** Assignments should be submitted by 5:00 pm on the specified due date. Late assignment submissions will be penalized 10% per day.

**Use of English:** In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

**Attendance:** Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

**Absence Due to Illness or Other Circumstances:** Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached “Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled”). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook: [http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_medical.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf)

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/accommodation\\_religious.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf)

**Cheating and Plagiarism:** Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (<http://www.turnitin.com>).

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

[http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_undergrad.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf)

**Use of Electronic Devices:** In-class use of electronic devices, i.e., laptops, iPods, ... is strongly discouraged, while the use of headphones and/or phones is not permitted. Any student who, in the opinion of the instructor, is too much distracted by the electronic devices may be asked to leave the current lecture and/or reported to the Dean. In the case of repeated behavior, on the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

During exams/tests/quizzes all electronic devices must be powered down and stored out of reach. The only exception is a simple scientific non-programmable, which is permitted. Other devices capable of substituting for a simple calculator (e.g. a phone, laptop, iPad), are not permitted.

**Internet and Electronic Mail:** Students are responsible for regularly checking their Western email and the course web site (<https://owl.uwo.ca/portal/>) and making themselves aware of any information that is posted about the course.

**Accessibility:** Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

**Support Services:**

Office of the Registrar, <http://www.registrar.uwo.ca/>

Student Development Centre, <http://www.sdc.uwo.ca/>

Engineering Undergraduate Services, <http://www.eng.uwo.ca/undergraduate/>

USC Student Support Services, <http://westernusc.ca/services/>

Students who are in emotional/mental distress should refer to Mental Health @ Western,

[http://www.health.uwo.ca/mental\\_health/](http://www.health.uwo.ca/mental_health/), for a complete list of options about how to obtain help.