CEG 4158 - Computer Control in Robotics  
Course Outline  
Fall 2019

Professor: Pierre Payeur, SITE 5066

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Lectures: Tuesday, 5:30 PM to 7:00 PM, SMD 425  
Thursday, 8:30 AM to 10:00 AM, MNT 207

Tutorials: Thursday, 5:30 PM to 7:00 PM, SMD 425  
(every week from September 19th, 2019)

Lab Sessions: Monday, 1:00PM to 4:00PM, STE 3040 OR  
Wednesday, 7:00 PM to 10:00 PM, STE 3040 OR  
Monday, 7:00PM to 10:00PM, STE 3040 (limited space)  
(every week from September 30th, 2019)

Professor Consultation: Thursday, 10:15 AM to 11:30 AM, SITE 5066

Course Notes:  
• CEG-4158 COMPUTER CONTROL IN ROBOTICS  
by P. Payeur (will be available online, via Virtual Campus)

Optional Reference Manuals:  
• “Introduction to Robotics, Analysis, Control, Applications”,  

• “Introduction to Robotics, Mechanics and Control”, 3rd edition,  

Mandatory Tool: It is required to have a scientific calculator which is able to handle  
operations on 4x4 matrices (TI-83, TI-84 series are popular models,  
but other brands and models are also appropriate). It is your sole  
responsibility to have one available for midterm and final exams, and  
to know how to operate it.

Calendar Description: “Evolution of robotics, mobile and manipulator robots, coordinate  
systems, kinematic models of manipulators, position, velocity and  
force control, sensors and actuators, robotic vision, workspace  
modeling, task and path planning, industrial robots, manufacturing  
and autonomous systems, robot programming.” (Extract from  
calendar)
**Objectives:**

CEG4158 is a specialization course targeting students interested in automation, robotics and autonomous systems in general. It provides the knowledge required to understand how robots work and to apply conceptual approaches to achieve practical implementations involving elements of robotics, either in industry or research & development. It also aims at developing design and integration abilities as well as teamwork and project management skills, while providing hands-on experience on real robotic and sensor systems by transposing theory into practice.

**Course Contents:**

**Introduction**
- History, definitions, robotic systems design, applications.

**Coordinate systems**
- Cartesian coordinates, degrees of freedom, reference frames, orientation, bidimensional and tridimensional transformation matrices, relative and general transformations, homogeneous transformations, inverse transformations, graphs.

**Robots systems and structures**
- Robot architectures, technical concepts of robotics, actuation.

**Robot kinematics: position**
- Joints, members, reference frames, A matrices, direct and inverse kinematics, trigonometric solutions, precision, efficiency/complexity of kinematic solutions.

**Robot kinematics: velocity**
- Derivatives, velocity of rigid bodies, differential movement, Jacobian, singularities.

**Sensors and perception**
- Internal and external sensors, sensors hierarchy, interfaces, data fusion, classification, localization, robotic vision, applications.

**Control**
- Classical approaches for robot control, feedback loops, position and force control, compliance, fuzzy logic control.

**Task and path planning**
- Action-level planning, workspace modeling, path planning, collision avoidance.
Evaluation:

Project: 20%  A team-based design and implementation project in robotics will be completed and will involve a demonstration at the end of the semester. Intermediate milestones will also be set and evaluated during some LAB sessions. A final report will have to be submitted for each team of 3 students. Deadlines must be respected. Late submissions/demonstrations will be graded 0.

Milestone 2 demo: **Mon., Nov. 18th, OR Wed., Nov. 20th, 2019**
Final demo: **Mon., Dec. 2nd, OR Wed., Dec. 4th, 2019**
Final report: **Wed., Dec. 11th, 2019 before 4:00PM**

Quizzes: 10%  Two short closed-book quizzes will be written over the semester during the tutorial periods. These evaluations are mandatory. No take-up will be possible for missed quizzes. An absence will result in a mark 0 for the quiz.

Dates: Quiz 1: **Thursday, October 10th, 2019, 5:30 to 5:45PM**
Quiz 2: **Thursday, November 21st, 2019, 5:30 to 5:45PM**

Midterm Exam: 30%  A mandatory closed-book midterm examen will be written. No take-up will be possible for the midterm. Students are responsible for bringing their own calculator to efficiently handle operations on matrices.
Date: **Tuesday, October 22nd, 2019, 5:30PM to 7:00PM (date and time subject change)**.

Final Exam: 40%  A closed-book final exam will be written during the exam period at the end of the semester. Students are responsible for bringing their own calculator to efficiently handle operations on matrices.
Date: to be determined by the faculty.

Final Mark: The final mark (FM) will be computed using the following rule (no exception):

IF $[0.3\text{Midterm}()+0.4\text{Final}()] \geq 35$
THEN:
FM=0.2\text{Project}()+0.05\text{Quiz1}()+0.05\text{Quiz2}()+0.3\text{Midterm}()+0.4\text{Final}()$
ELSE:
FM=1.4286*[0.3\text{Midterm}()+0.4\text{Final}()]$
(which results in D, E or F, that is a failure mark)!!!
**Rules:**

Note: **Plagiarism and academic fraud will not be tolerated** on any component of the course. Any such situation will be brought to the attention of the faculty and procedures will follow. The University of Ottawa’s regulation on academic integrity which addresses plagiarism and academic fraud can be found here: [http://web5.uottawa.ca/mcs-smc/academicintegrity/regulation.php](http://web5.uottawa.ca/mcs-smc/academicintegrity/regulation.php)

Note: In accordance with Faculty’s regulation, **class attendance is mandatory** for all lectures, tutorials and laboratory sessions. Also, all components of the course (project, lab reports, milestone and final demos, quizzes, and exams) must be fulfilled as scheduled, otherwise students will receive an EIN as a final mark (equivalent to a failure). This is also valid for students who are taking the course for a second time.

Note: **Cellphones must be in silent mode** before entering the class. The use of a smartphone, tablet, or any other electronic device for the purpose of taking pictures, videos, or recording any part of lectures or tutorial sessions **is prohibited in class**.

Extract from APUO policies (2018): ‘’**Recording lectures in any way, including the taking of photographs, is prohibited** in this course unless specific permission has been granted by the professor. The educational materials developed for this course, including, but not limited to, lecture notes and slides, handout materials, examinations and assignments, and any materials posted to Brightspace, are the intellectual property of the professor. These materials have been developed for student use only and are not intended for wider dissemination and/or communication outside of a given course. Participation in this course constitutes an agreement by all parties to abide by the relevant University Policies, and to respect the intellectual property of others during and after their association with the University of Ottawa. **Students creating unauthorized audio and/or video recordings of lectures, and/or redistributing or providing unauthorized audio, video, photographic or textual material of lecture content violates the professor’s intellectual property rights, and the Canadian Copyright Act.**‘’

Update: August 22nd, 2019