

**CEG 4158 - Computer Control in Robotics**  
**Course Outline**  
**Fall 2011**

- Professor:** Pierre Payeur, SITE 5066
- Email:** [ppayeur@site.uottawa.ca](mailto:ppayeur@site.uottawa.ca)
- WEB Page:** [www.site.uottawa.ca/~ppayeur/CEG4158](http://www.site.uottawa.ca/~ppayeur/CEG4158)
- Lectures:** Tuesday, 8:30 AM to 10:00 AM, MNT 103  
Friday, 10:00 AM to 11:30 AM, MNT 103
- Tutorials:** Monday, 4:00 PM to 5:30 PM, FTX 316  
(every week from September 19, 2011)
- Lab Sessions:** Monday, 5:30 PM to 8:30 PM, CBY B402  
(every week from September 26, 2011)
- Professor Consultation:** Friday, 2:30 PM to 4:30 PM, SITE 5066
- Course Notes:** • ***CEG-4158 COMPUTER CONTROL IN ROBOTICS***  
by P. Payeur, edition 2010.  
(required, available online)
- Optional Reference Manuals:** • *“Introduction to Robotics, Analysis, Systems, Applications”*,  
by S. B. Niku, Prentice Hall, 2001.  
• *“Introduction to Robotics”*, 2<sup>nd</sup> edition,  
by J.J. Craig, Addison-Wesley, 1989.  
• *“Introduction to Robotics”*, 1<sup>st</sup> edition,  
by Phillip John McKerrow, Addison-Wesley, 1991.
- Other:** It is required to have a scientific calculator which is able to handle operations on 4x4 matrices.
- 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 the way robots work and to allow students perform work involving elements of robotics either in industry or research & development. It also aims at developing design and integration abilities as well as team work 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 solution, precision, efficiency/complexity of kinematic solutions.

### *Robot kinematics: velocity and acceleration*

Derivatives, velocity and acceleration of rigid bodies, differential movement, Jacobian, singularities.

### *Sensors and perception*

Internal and external sensors, sensors hierarchy, interfaces, data fusion, classification, localization, machine 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, modeling, motion planning in R-space and C-space, path tracking.

## **Evaluation:**

Project:	25%	A 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. A final report will have to be submitted for each team of 2 or 3 students. Deadlines must be respected. <u>Late submissions/demonstrations will be graded 0.</u> Dates: Milestone 1 demo: <b>Monday, October 31st, 2011</b> (during lab) Milestone 2 demo: <b>Monday, November 21, 2011</b> (during lab) Final demo: <b>Wednesday, December 7, 2011</b> (during lab) Final report: <b>Wednesday, December 14, 2011 before 4:00PM</b>
Quizzes:	10%	Two short closed-book quizzes will be written over the semester during the tutorial periods. <u>These evaluations are mandatory.</u> No take-up will be possible for missed quizzes. An absence will result in a mark 0 for the quiz. Dates: Quiz 1: <b>Monday, October 3, 2011, 4:00-4:15PM</b> Quiz 2: <b>Monday, November 21, 2011, 4:00-4:15PM.</b>
Midterm Exam:	25%	A mandatory closed-book midterm examen will be written. No take-up will be possible for the midterm. Students are responsible to bring their own calculator to efficiently handle operations on matrices. Date: <b>Monday, October 31, 2011, 4:00-5:30PM.</b>

Final Exam: 40% A closed-book final exam will be written during the exam period at the end of the semester. Students are responsible to bring 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  $[0.25 * \text{Midterm}(\%) + 0.4 * \text{Final}(\%)] \geq 32.5(\%)$

THEN:

$\text{FM} = 0.25 * \text{Project}(\%) + 0.05 * \text{Quiz1}(\%) + 0.05 * \text{Quiz2}(\%) + 0.25 * \text{Midterm}(\%) + 0.4 * \text{Final}(\%)$

ELSE:

$\text{FM} = 1.5385 * [0.25 * \text{Midterm}(\%) + 0.4 * \text{Final}(\%)]$

(which results in D, E or F, that is a failure mark)!!!

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 plagiarism and academic fraud can be found here:

(<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 demos, quizzes, and exams) must be fulfilled as scheduled, otherwise students will receive an INC as a final mark (equivalent to an F). This is also valid for a student who is taking the course for the second time.

Update: September 7th, 2011