University of Victoria Engineering

# Faculty of Engineering
# Department of Mechanical Engineering
# COURSE OUTLINE

## MECH 430 – ROBOTICS

**Term – Summer 2016** (201605)

| **Instructor** | **Office Hours** |
|---|---|
| Dr. Daniela Constantinescu | Days: M |
| Phone: 250.721.6040 | Time: 1:30 pm – 2:30 pm |
| E-mail: danielac@uvic.ca | Location: EOW 541 |

| **Prerequisites and co-requisites: MECH 335 or permission by the department; and MECH 380 or ELEC 360; and MATH 110 or MATH 211.** |
|---|

**LECTURE DATE(S)**

| | | | |
|---|---|---|---|
| Section: A 01/CRN30588 | Days: T, W, F | Time: 10:30 am – 11:20 am | Location: CLE A212 |

**LAB SECTIONS**

| Section: B (Multiple) | Days: | Time: | Location: |
|---|---|---|---|
| B01 | M | 1:00 pm – 3:50 pm | ELW A229 |
| B02 | M | 4:00 pm – 6:50 pm | ELW A229 |
| B03 | T | 4:30 pm – 7:20 pm | ELW A229 |
| B04 | W | 4:30 pm – 7:20 pm | ELW A229 |

Lab times and locations are also available from the timetable through Sign in to UVic, My Page.

| **TA Name** | **E-mail** | **Office hours: ECS 130** |
|---|---|---|
| Amirhosein Khazenifard - laboratory | akhazeni@uvic.ca | |
| Yuan Yang - laboratory | yangyuan@uvic.ca | |
| Hieu Phan – assignment & quiz marking | phanhieu@uvic.ca | W 12:00 pm - 12: 30 pm |

| **Required Text** | **Optional Text** |
|---|---|
| Title: NA | Any text on robot kinematics, dynamics and control. |
| Author: | |
| Publisher/Year: | |
| **Reference Materials**: | |

**COURSE OBJECTIVES:** This course introduces students to the modeling and control of robotic manipulators with serially connected links. The course investigates the connections between the kinematic and kinetic connections between the Cartesian/task and joint/configuration spaces for the purpose of using them to control the robot to perform a desired motion/interaction task.

The topics taught in this course build on rigid body kinematics and dynamics concepts from MECH 242 and MECH 335, and on automatic control concepts from MECH 380 or ELEC 360. They also require good

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familiarity with matrix algebra concepts from MATH 110 or MATH 211. Concepts from CSC 349A Numerical Analysis and MECH 458 Mechatronics will also be beneficial. The assignments and laboratory experiments require the use of Matlab and Simulink.

The topics taught in MECH 430 are precursor to more advanced courses on medical robots, teleoperation, human-robot interaction/cooperation, autonomous robots.

**LEARNING OUTCOMES:** At the end of this course, students will be able to:

1. Develop the mathematical model of a robotic system with serially connected links.
2. Design task and joint space paths to meet specified motion objectives.
3. Design a controller to obtain a desired robot motion.
4. Design a controller to obtain a desired interaction of a robot with its environment.
5. Use Matlab and its toolboxes to simulate a robotic system with serially connected links.
6. Investigate the performance of a robot controller using Matlab and Simulink.
7. Prepare assignment solutions and project reports according to professional writing standards for engineering problem sets and for formal reports.
8. Uphold the APEGBC Code of Ethics in their interactions with other students, their team members, the TAs and the instructor.

| **Weight & Date(s) of Assessments:** | **Weight** | **Date** |
|---|---|---|
| Assignments: | 40% (4 assignments at 10% each) | Date: May 20, June 10, July 4, July 22. |
| Labs | 20% (5 labs at 4% each) | |
| Mid-term | 40% (4 in-class quizzes at 10% each) | Date: May 27, June 17, July 8, July 29. |
| Final Exam | 0% | NA |

**ASSIGNMENTS**

1. Four problem sets will be distributed over the course of the term via the MECH 430 Course Space site. The assignments will require both hand calculations and Matlab to complete.
2. Assignments must be handwritten on "Engineer's pad" paper using only the front side and the Matlab plots must be printed on US letter paper to be accepted. **Any other paper will be rejected**.
3. **30% of assignment grades will be allocated to presentation**. Full presentation grades will be awarded to assignments that comply with all requirements for the preparation of engineering problem sets outlined at http://web.mit.edu/me-ugoffice/communication/pset-format.pdf. Please clarify any unclear requirements with the instructor in advance of the assignment due date.
4. **Assignments are to be completed individually.** Please discuss any difficulties with the instructor or the TAs in advance of the assignment due date.
5. Assignments must be submitted to the box marked "MECH 430" beside ELW A144 and the Matlab/Simulink files used to solve the assignment must be uploaded to the MECH 430 Course Space site by 2:00 pm on the day they are due. **Late assignments will not be accepted.**

| **Assignment #** | **Modules** | **Start** | **Due (2 pm)** |
|---|---|---|---|
| 1 | Spatial transformations & Kinematics | 05.03 | 05.20 |
| 2 | Kinematics, Jacobians & Trajectory planning | 05.20 | 06.10 |
| 3 | Kinematics, Jacobians, Trajectory planning & Dynamics | 06.10 | 07.04 |
| 4 | Kinematics, Jacobians, Trajectory planning, Dynamics & Control | 07.01 | 07.22 |

**LABORATORIES (Description & Method of Delivery)** (remove example text)

1. The laboratory sessions will be used to carry out experiments using Omni robots. In preparation for the laboratory, the students should perform the pre-laboratory assignments indicated in the Omni Workbook available on the MECH 430 Course Space site.
2. **Lab reports are to be completed in teams of 2 students. Students are required to work with a different partner on each lab.**
**3.** Laboratory submissions are due 7 days after the students have completed the laboratory session, via uploading them to the MECH 430 Course Space site. A 20% penalty will be applied for each day of lateness to submissions after 11:59 pm on the due date.

| Lab # | Modules | Start | Due (11:59 pm) |
|---|---|---|---|
| 1 | Forward & inverse kinematics | 05.17 | 05.27 |
| 2 | Teach pendant in joint & task space | 05.31 | 06.10 |
| 3 | Jacobian & force rendering | 06.14 | 06.24 |
| 4 | Haptic well & haptic wall | 06.28 | 07.08 |
| 5 | Haptic pong | 07.12 | 07.22 |

**NOTE:**

Failure to complete all laboratory requirements will result in a grade of N being awarded for the course. Failure to pass all assignments will result in a failing grade for the course.

The final grade obtained from the above marking scheme for the purpose of GPA calculation will be based on the percentage-to-grade point conversion table as listed in the current Undergraduate Calendar.

**COURSE LECTURE NOTES**

Unless otherwise noted, all course materials supplied to students in this course have been prepared by the instructor and are intended for use in this course only. These materials are NOT to be re-circulated digitally, whether by email or by uploading or copying to websites, or to others not enrolled in this course. Violation of this policy may in some cases constitute a breach of academic integrity as defined in the UVic Calendar.

**There will be no supplemental examination for this course.**

**GENERAL INFORMATION**

**Note to Students:**

Students who have issues with the conduct of the course should discuss them with the instructor first. If these discussions do not resolve the issue, then students should feel free to contact the Chair of the Department by email or the Chair's Secretary to set up an appointment.

"**Attendance**

Students are expected to attend all classes in which they are enrolled. An academic unit may require a student to withdraw from a course if the student is registered in another course that occurs at the same time….

An instructor may refuse a student admission to a lecture, laboratory, online course discussion or learning activity, tutorial or other learning activity set out in the course outline because of lateness, misconduct, inattention or failure to meet the responsibilities of the course set out in the course outline. Students who neglect their academic work may be assigned a final grade of N or debarred from final examinations.

Students who do not attend classes must not assume that they have been dropped from a course by an academic unit or an instructor. Courses that are not formally dropped will be given a failing grade, students may be required to withdraw and will be required to pay the tuition fee for the course." UVic Calendar, (2015) http://web.uvic.ca/calendar2015-09/FACS/UnIn/UARe/Atte.html

**Accommodation of Religious Observance (AC1210)**
http://web.uvic.ca/calendar2015-09/GI/GUPo.html

**Discrimination and Harassment Policy (GV0205)**
http://web.uvic.ca/calendar2015-09/GI/GUPo.html

**Faculty of Engineering, University of Victoria**
**Standards for Professional Behaviour**

*"It is the responsibility of all members of the Faculty of Engineering, students, staff and faculty, to adhere to and promote standards of professional behaviour that support an effective learning environment that prepares graduates for careers as professionals…."*

You are advised to read the Faculty of Engineering document Standards for Professional Behaviour which contains important information regarding conduct in courses, labs, and in the general use of facilities.
http://www.uvic.ca/engineering/current/undergrad/index.php#section0-23

Cheating, plagiarism and other forms of academic fraud are taken very seriously by both the University and the Department. You should consult the Undergraduate Calendar for the UVic policy on academic integrity.

**Policy on Academic Integrity**
http://web.uvic.ca/calendar2015-09/FACS/UnIn/UARe/PoAcI.html

# Course Schedule

| Module | Topics | Date/Week |
|---|---|---|
| 1 | Spatial descriptions and transformations. Spatial descriptions: positions, orientations, frames. Coordinate transformations. Operators: translations, rotations, rigid body transformations. | 05.03 – 05.17 |
| 2 | Kinematics. Forward kinematics. Inverse kinematics. Velocity of a rigid body. Jacobians. Static forces. | 05.18 – 06.03 |
| 3 | Trajectory generation. Path description and generation in joint and task spaces. Path planning using the dynamics. Collision-free path planning. | 06.07 – 06.17 |
| 4 | Dynamics. Acceleration of a rigid body. Mass distribution. Iterative Newton-Euler dynamics. Lagrangian dynamics in joint and task spaces. | 06.21 – 07.08 |
| 5 | Control. Position and motion control in joint and task space. Interaction control. | 07.12 – 07.29 |