ENGG*4480: Advanced Mechatronic Systems Design
Winter 2014

School of Engineering

(Revision 2: Jan. 6, 2014)

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1 INSTRUCTIONAL SUPPORT

1.1 Instructor

Instructor: Peter Won, Ph.D
Office: THRN 2401
Email: swon@uoguelph.ca

Lab Technician
Technician: Nate Groendyk
Office: THRN 2308, ext. 53873
Email: groendyk@uoguelph.ca

1.2 Teaching Assistants

GTA	Email	Office Hours
TBA		

1.3 Lecture

Tuesday/Thursday, 8:30am-10:00pm
Room: MACK 305

1.4 Lab

Room: RICH 2510

2 LEARNING RESOURCES

2.1 Course Website

Course material, news, announcements, and grades will be regularly posted to the ENGG*4480 Courselink site. You are responsible for checking the site regularly.

2.2 Recommended Resources

1. Arduino board website: http://arduino.cc/
2. Raspberry PI website : http://www.raspberrypi.org/
    a. Basics of Raspberry PI: http://www.makeuseof.com/pages/great-things-small-package-your-unofficial-raspberry-pi-manual
    b. Using GPIO: http://www.raspberrypi.org/archives/1417

2.3 Communication & Email Policy

Please use lectures as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. It is your responsibility to check the course website regularly. As per university regulations, all students are required to check their <uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its students.

3 ASSESSMENT

3.1 Dates and Distribution

Proposal:	5%	Jan. 14th
Preliminary Design Presentation:	20%	Jan. 28th and 30th
Final Report:	30%	Apr. 1st
Final Demonstration and Presentation:	25%	Apr. 1st and 3rd
Participation and individual work	20%	

3.2 Deliverables

3.2.1 Proposal: (January 14 at 8:40 AM in class)

The proposal introduces the team members as well as brief description of the project. The proposal must also include:

- Name, student ID, and email address of group members
- Task descriptions of your mechatronic system
- Constraints (duration, sensor, cost, etc.)
- Material Selection: the number of required actuators and sensors as well as microcontroller. The hardware can be changed later.
- Brief plan for the project with a time line

The proposal should be 1 – 2 pages.

3.2.2 Preliminary Design Presentation (Jan. 28th and 30th during class)

Each group should introduce their project to the classmates for 15 minutes. All members of your group must present. The presentation should describe the project goals, proposed systems, and plans to successfully develop the proposed system. After each presentation, classmates will ask questions for 5 minutes to address any possible problems so that each group can come up with better solutions. The preliminary design presentation should include

- Introduction
- Problem statement
- Project goals and tasks
- Design objectives
- Constraints and criteria
- Main design and alternative designs
- Required analysis and calculation
- Overview of programming
- Gantt chart for project plan

3.2.3 Final Report (Apr. 1st at 8:40 AM in class)

The final report should show the details of your design (mechanical and electrical), calculations and analyses for your mechanical design, and how your completed system meets the design objectives and criteria. The final report should also include actual program with proper comments in appendix. Also, the test results and statistics (if required) should be discussed.

The main body of the report should include:

- Introduction and motivation
- Background (similar products and researches, require citation)
- Design problem and challenges
- Safety concerns
- Goals and tasks
- Design criteria and constraints
- At least two alternative mechanical designs, which you have discussed during the preliminary design presentation. Description of why the current design is chosen.
- List of tasks that your robot should perform
- Project plan (Gantt chart)

NOTE: Any sources you have used or referenced should be included on your reference section. For each section, please indicate who worked on and wrote the section.

The final report should be a complete report (including cover page, list of figures, etc.). While the report should be comprehensive and include all the necessary information, the main body (from introduction to conclusion) should not exceed **10 pages**. Appendices which include program codes are not counted toward the 10 page limit.

3.2.4 Final Demonstration and Presentation (Apr. 1st and 3rd during class)

At the end of the term, you will demonstrate your working system to your classmates and professor. All members of your group must present the final presentation. At the demo, you will show the final checklist of 5 – 10 tasks that the professor can mark on, which should be on your final report.

For the final presentation, you have 20 minutes of presentation including system demo, and 5 minutes of questions from your classmates and professor. The final presentation should include

- Introduction
- Design criteria and constraints
- List of tasks that your robot performed
- Demonstration
- Mechanical design
- Electrical circuit layout
- Flow chart of your program
    - Where you downloaded software (if required, please reference it)
- Challenges
- Conclusions and future work

- Gantt chart

3.3 Project Criteria

Mechatronic systems consist of mechanical engineering, electrical engineering, and programming which are used to control the mechanical parts of the system based on sensor inputs. Through this course, you will learn how to implement sensors and actuators as well as how to control actuators using a microcontroller. Therefore, for the successful completion of this course, each student should demonstrate the project details in mechanical design, electrical design, and programming. The course project should have all three mechatronics components as following:

- A **mechanical** part (i.e. motor connected to robot arm or wheel) which is controlled by an actuator (motor) based on sensor inputs.
- At least two different types of **input** devices (keyboard (or mouse), encoder, inertial, switch (or button), ultrasonic, IR, GPS, and camera) should be used as well as at least two **output** devices (motor, monitor, etc.). If you are developing a mobile robot, you should use at least three output devices.
- Machine intelligence (i.e. if-else statements) should be used to control the system based on sensor input including **program** termination condition.

It is encouraged for the students to come up with their own Mechatronics project. Also you can choose one of the following projects:

- Tic-ta-toe game player
- Coffee machine
- Trajectory following robot
- 2D printer
- Cleaning robot (Roomba)
- Color block sorter
- Running away alarm clock with your own alarm design
- Light following robot
- Human controlled RF robot

NOTE: you MUST choose the project which is completely different from your Mechanical design course or you will get zero on this course. This is the school policy.

If you use mechanical design or program from website, or other sources, you must reference it and inform your professor which parts are from open source. Otherwise, it will be treated as academic misconduct, and you may fail this course.

3.4 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. Please see below for specific details and consult the undergraduate calendar for information on regulations and procedures for Academic Consideration: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: In order to pass the course, you must obtain a grade of 50% or higher on the final demonstration, a grade of 60% or higher on participation and individual work and overall grade of 50% or higher.

Late Reports or presentation: Late submissions of reports or presentation will not be accepted. All the students should attend for presentation lectures.

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4 DESCRIPTION, AIM, AND OBJECTIVES

4.1 Calendar Description

This course is a project course which uses electronics to control real world mechanical systems. The course covers signal conditioning, system calibration, system models, dynamic models, large scale systems, networking, microprocessors, programmable logic controllers, communication systems and fault finding.

Prerequisite(s): ENGG*3490, ENGG*3640, ENGG*4460

4.2 Course Aim

The aim of this course is to design and implement a mechatronic system using the knowledge and experience you have gained from ENGG*3490, which demonstrated the basics of sensors and actuators as well as variety of mechatronic systems. For this course, the project will be

completed in groups with 2 or 3 students to work on a mechatronics project using Arduino board or Raspberry PI board.

4.3 Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability to:

- Design and implement mechanical parts on mechatronic systems
- Addressing safety concerns of mechatronic systems as well as fabrication process
- Sensor and actuator implementation on Arduino board and/or Raspberry PI board
- Use of variety of sensors and how to use them as input devices of mechatronics system
- How to achieve higher accuracies by combining more than two different sensors
- How to use machine intelligence
- Solve programming and implementation problems, by considering the engineering trade-offs and constraints

4.4 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink/D2L but these are not intended to be stand-alone course notes. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and project.

4.1 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and tutorials. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

4.2 Relationships with other Courses & Labs

Previous Courses:

ENGG*3490: Mechatronics systems, sensors, and actuators

ENGG*3640: Programming microcontrollers, data acquisition systems, and serial I/O interfacing

ENGG*4460: Robot programming, Inverse and forward kinematics, and path generation

5 TEACHING AND LEARNING ACTIVITIES

5.1 Lecture Schedule

Lectures	Lecture Topics	Deliverables
Week 1	Introduction Review of Arduino board. Sensor background and review. How to use sensors	
Week 2	Project proposal review. Introduction to Raspberry PI board	Proposal (Jan. 14th)
Week 3	Review of Arduino board. How to use an IMU	
Week 4	Introduction to Kalman filtering, Progress interview	
Week 5	Motor review, Progress interview	
Week 6	Progress interview (design and presentation)	
Week 7	Preliminary Design Presentation	15 min Presentation
Week 8	Kalman filtering	
Week 9 - 12	Progress interview	
Week 13	Final Demo and Presentation	Report due Apr. 1st. 20 minutes presentation including demonstration

6 LAB SAFETY

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.
If the laboratory rules are not followed, consequences will include removing student's access to the lab.

7 ACADEMIC MISCONDUCT

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.
Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member.

7.1 Resources

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml
A tutorial on Academic Misconduct produced by the Learning Commons can be found at:
http://www.academicintegrity.uoguelph.ca/
Please also review the section on Academic Misconduct in your Engineering Program Guide.
The School of Engineering has adopted a Code of Ethics that can be found at:
http://www.uoguelph.ca/engineering/undergrad-counselling-ethics

8 ACCESSIBILITY

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability for a short-term disability should contact the Centre for Students with Disabilities as soon as possible

For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or see the website: http://www.uoguelph.ca/csd/

9 RECORDING OF MATERIALS

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

10 RESOURCES

The Academic Calendars are the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs: http://www.uoguelph.ca/registrar/calendars/index.cfm?index