ELEC466

Advanced Mechatronic Engineering

S1 Day 2019

School of Engineering

Contents

General Information

Unit convenor and teaching staff Unit Convenor David Inglis david.inglis@mq.edu.au Contact via david.inglis@mq.edu.au E6B-122 Mondays 4-5pm, Thursday 9-10am
Credit points 3
Prerequisites (60cp at 100 level or above) including (ELEC326 and ELEC324)
Corequisites
Co-badged status
Unit description This unit integrates prior learning in a specialist area of engineering with problem solving, emerging technology and aspects of engineering application, technical reporting and self-management to prepare students to work at a professional capacity. The unit aims to address the application of fundamental principles and methods at an advanced level in the context of standards and practices, modelling, analysis, design and practical implementation. The unit also develops skills in the critical evaluation of information, software and sources of error, and experimental methods. Learning will be achieved using case studies, laboratories, presentations, group work and/or traditional lecture format. The specific topics will focus on current advances in the area such as microcontrollers, MEMs, nanotechnologies, control systems, sensors and actuators and electro-mechanical interfacing.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

Design, numerically-model, implement, and test a digital motion control system for a non-linear problem

Demonstrate, problem solving, initiative, time management, and record keeping, skills in the completion of a significant project

Demonstrate knowledge of MEMS, microfluidics, and manufacturing processes including 3D printing and microfabrication

Understand and apply deep learning, including convolutional neural networks

Demonstrate understanding of robotics system software, such as ROS

General Assessment Information

Grading and passing requirement for unit

In order to pass this unit a student must obtain a mark of 50 or more for the unit (i.e. obtain a passing grade P/ CR/ D/ HD).

For further details about grading, please refer below in the policies and procedures section.

Hurdle Requirements

The final examination is a hurdle requirement. A grade of 40% or more in the final examination is a condition of passing this unit. If you are given a second opportunity to sit the final examination as a result of failing to meet the minimum mark required, you will be offered that chance during the supplementary examination period and will be notified of the exact day and time after the publication of final results for the unit. The second attempt at a hurdle assessment is graded as pass fail. The maximum grade for a second attempt is the hurdle threshold grade.

Participation in tutorial/practical sessions is a hurdle requirement and students are required to attend at least 8 practical sessions to pass this unit.

Late submissions and Resubmissions

Late submissions will attract a penalty of 10/100 marks per day. Extenuating circumstances will be considered upon lodgment of a formal notice of disruption of studies.

Resubmissions of work are not allowed.

Assessment Tasks

Name	Weighting	Hurdle	Due
Report 1 – System Parameters	8%	No	Week 2
Homework / Problem sets	0%	Yes	See individual tasks
Report 2 – Circuit diagram	8%	No	Week 3
Report 3 - System model	8%	No	Week 5
Report 4 – System Performance	8%	No	Week 7

Name	Weighting	Hurdle	Due
Project Demonstration	8%	No	Week 11
Report 5 - Complete Report	8%	No	week 11
Project Logbook	12%	No	Week 11 Prac
Final Exam	40%	Yes	exam period

Report 1 – System Parameters

Due: **Week 2**
Weighting: **8%**

Your task for this unit is to model and develop a digital servo controller for an arm of known mass. In addition to being well controlled, the system must take action in response to a live feed processed by a neural network. You will be given a motor, gearbox, encoder, arm, load, Arduino, motor driver, and power supply.

You will be building a project report throughout the first 11 weeks of this unit. By week 11 each of you will have produced a report that includes the following headings: Introduction, Electrical & Mechanical Parameters, Control System Model, Control System Performance, Neural Network. Use 2 cm margins and Arial 10 pt font.

The first step is to measure your system parameters and begin to write your report. This first submission should contain a very brief introduction to the task and contain all the key system parameters section. Important system parameters include:

- Mass and dimensions of any moving components.
- Current and voltage limitations of supplies, sources, drivers etc.
- Friction torques
- DC motor characteristics
- Mechanical layout (a simple diagram indication coordinate frames)

This part of the report should not exceed 2 pages, and may need to be shorter to allow your full report in 5 pages. Consider breaking your parameters section into two parts: electrical and mechanical. Your report will be graded as follows for a maximum of 15 marks.

0-5 marks: presentation and report structure. Use a consistent style. Proof-read your document for grammatical and typographical mistakes. Use accurate and concise language. Examples of inaccurate language include: “An elephant went to the store to buy milk. It was awesome” What was awesome, the milk or the trip? “Last night I shot an elephant in my pajamas.” Who was wearing the pajamas, you or the elephant?

0-10 marks: Accurate description of all relevant system parameters.

On successful completion you will be able to:

- Design, numerically-model, implement, and test a digital motion control system for a non-linear problem

Homework / Problem sets

Due: **See individual tasks**
Weighting: **0%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

4 Assignments will be given. All tasks on each assignment must be completed by the given deadlines. Each will be marked as complete or incomplete. Questions and rubrics to be posted with questions.

On successful completion you will be able to:

- Design, numerically-model, implement, and test a digital motion control system for a non-linear problem
- Demonstrate knowledge of MEMS, microfluidics, and manufacturing processes including 3D printing and microfabrication
- Understand and apply deep learning, including convolutional neural networks
- Demonstrate understanding of robotics system software, such as ROS

Report 2 – Circuit diagram

Due: **Week 3**
Weighting: **8%**

Respond to feedback on Report 1. Prepare a circuit diagram for your system and add it to the section on electrical parameters. You may wish to add a functional block diagram for your control system (consider using simulink/simscape), and include it in a new section on the Control System Model. Your diagrams should be small, but contain legible text. The page limit for this report is 3 pages. Additional pages will be penalized by 1 mark out of 15 per page.

0-5 marks: presentation and report structure. Use a consistent style. Proof-read your document for grammatical and typographical mistakes. Use accurate and concise language.

0-5 marks: Diagram presentation, including clearly labelled components.

0-5 marks: Accurate diagrams that align with report details.

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Report 3 - System model

Due: **Week 5**
Weighting: **8%**

Complete a section describing an electro-mechanical model of the system. Here you must derive an equation of motion for your system. Describe assumptions and expected limitations of the model. Do not ignore friction. First present the open loop equation of motion, then propose a control approach. Finally present the equation of motion after implementing your control approach. The input to the closed loop system should be a demanded angle.

0-5 marks: presentation and report structure. Use a consistent style. Proof-read your document for grammatical and typographical mistakes. Use accurate and concise language. Additional pages will be penalized by 1 mark out of 15 per page.

0-10 marks: Clear, accurate, and concise treatment of the electromechanical system. Ensure that all symbols used in the equations are defined in the text.

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Report 4 – System Performance

Due: **Week 7**
Weighting: **8%**

Model your control system performance using simscape and simulink. Create an electrical plant, a mechanical plant, and a controller. Develop a system that is stable for any movement command up to 45 degrees. Create a plot showing 45 degree movements from -90 to 270 degrees. Show the demanded position and actual position on the same plot. Measure the maximum settling time, overshoot, and steady state error. Consider an additional plot showing some system parameter that you find informative.

0-5 marks: presentation and report structure. Use a consistent style. Proof-read your document for grammatical and typographical mistakes. Use accurate and concise language.

0-10 marks: Well-presented numerical model with clear plots and performance indicators.

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Project Demonstration

Due: **Week 11**
Weighting: **8%**

Use your system model to program the physical control system. Make measurements of real system performance and compare them to your model performance. Update your report to include measured performance. Your system will be graded in week 11 after you submit your final report. Observed performance should match reported performance. For full marks, control the demanded position using the output of a CNN in Matlab. Each system (for a group of 2) will receive 1 grade. Log books for that group will be used to create individual grades for the demonstration where the average of the individual grades will equal the group grade

Assessment criteria: 15/100 marks for CNN control of the arm position. Full marks if operating at more than 1 position command per second.

For any step change of 45 degrees from any position.

20 marks for a system with less than 10 degree of overshoot,

20 marks for less than 2 degrees of SSE at all position,

20 marks for less than 1 second response time.

25 marks for a control system that is always stable.

Half marks for getting about half way there for each criteria.

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- Demonstrate, problem solving, initiative, time management, and record keeping, skills in the completion of a significant project

Report 5 - Complete Report

Due: **week 11**
Weighting: **8%**

Complete your report by adding measured data to your system response plots. Compare the measured data to the model predictions. Be sure the model data reflects system parameters described earlier in the report. Include descriptions of how the measurements were made and what their significance is.

Include a brief section describing any deep learning control that you may have incorporated.

0-5 marks for presentation

0-10 marks for clear, concise and complete description and specification.

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- Understand and apply deep learning, including convolutional neural networks

Project Logbook

Due: **Week 11 Prac**
Weighting: **12%**

Whenever working on your major project you should use an individual log book to document your progress. This may be a bound paper document or an electronic log. In grading you log book, we will be looking for dates and times of work done, as well as evidence of quality work, especially the application of science or engineering practice. This is your chance to show the good work you have done on the group project. Include sketches, diagrams, calculations, data etc. A table of contents, which is completed as you go, and points to significant or useful pages can also be useful. (One third of marks for evidence of work and attendance in pracs; one third for legibility, traceability and organisation; one third for evidence of Technical content including sketches, calculations etc.

Your log book will be used to determine an individual grade for the Project Demonstration.

(10 marks total)

1. Dates for work are shown
2. Log book contains raw collected data (where appropriate)
3. Log book contains entries for all weeks
4. Log book contains reflections, conclusions, ideas, etc that give insight into student's thinking and learning
5. represents a living document that is clearly used. It was clearly on hand during pracs and contains notes, marks, edits, diagrams etc from the user, peers, tutors etc.
6. (3 marks) contains substantial content related to all aspects of the project: system parameters, circuit design, system modelling, controller programming
7. Identifying and contact details are given in the first few pages. Date range is also good. -0.5 marks if only 2 identifiers are used (eg. Name and class, or name and student number). 3 identifiers are better: eg. Name, student number, class, email, phone number…
8. ½ mark for table of contents including page numbers
9. ½ mark for being presentable and legible.

On successful completion you will be able to:

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Final Exam

Due: **exam period**
Weighting: **40%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

The final exam will cover topics dealt with in lectures on assignments and in prac. You are permitted one A4 sheet of hand-written notes.

On successful completion you will be able to:

- Design, numerically-model, implement, and test a digital motion control system for a non-linear problem
- Demonstrate knowledge of MEMS, microfluidics, and manufacturing processes including 3D printing and microfabrication
- Understand and apply deep learning, including convolutional neural networks
- Demonstrate understanding of robotics system software, such as ROS

Delivery and Resources

Delivery: Attendance in lectures is strongly recommended. Audio or video recordings of the lecture may not be available.

Textbook Resources: Selected topics from:

A. Smaili and F. Mrad, “Mechatronics, Integrated Technologies for Intelligent Machines”, Oxford University Press, 2008.

Nanua Singh, “Systems Approach to Computer-integrated Design and Manufacturing”

John J. Craig, “Introduction to Robotics”

Serope Kalpakjian, “Manufacturing Engineering and Technology”

Additional recommended readings may be assigned and provided in iLearn.

Technology and Software: We will make use of MATLAB for modelling and Arduino for embedded system programming. Students will also use python and ROS on linux. You will have access to computers with this software during prac, however access to these programs outside of prac will be beneficial. We strongly recommend students bring their own devices with admin privileges.

Late Submissions: Unless agreed to in advance of due dates, late submissions will not be allowed.

Extensions: Extensions may be granted if a valid case for disruption to studies exits. See policies and procedures below.

Unit Schedule

A unit schedule will be available on iLearn.

Learning and Teaching Activities

Project

Students will conduct practical work in pairs, but will submit individual reports.

Assignments

Students will complete assignments/homework to practice and consolidate learning

Log Book

Students must keep a log book demonstrating their work on the project

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Undergraduate students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/p olicy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/student-conduct

Results

Results published on platform other than eStudent, (eg. iLearn, Coursera etc.) or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au or if you are a Global MBA student contact globalmba.support@mq.edu.au

No extensions will be granted. Late tasks will be accepted up to 72* hours after the submission deadline. There will be a deduction of 20%* of the total available marks made from the total awarded mark for each 24 hour period or part thereof that the submission is late (for example, 25 hours late in submission – 40% penalty). This penalty does not apply for cases in which an application for special consideration is made and approved.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

If you are a Global MBA student contact globalmba.support@mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/

offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Assessment task

- Project Logbook

Learning and teaching activity

- Students will conduct practical work in pairs, but will submit individual reports.
- Students must keep a log book demonstrating their work on the project

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcome

- Demonstrate, problem solving, initiative, time management, and record keeping, skills in the completion of a significant project

Assessment tasks

- Project Demonstration
- Project Logbook

Learning and teaching activities

- Students will conduct practical work in pairs, but will submit individual reports.

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcome

- Understand and apply deep learning, including convolutional neural networks

Assessment tasks

- Homework / Problem sets
- Project Demonstration
- Report 5 - Complete Report
- Final Exam

Learning and teaching activities

- Students will conduct practical work in pairs, but will submit individual reports.

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- Design, numerically-model, implement, and test a digital motion control system for a non-linear problem
- Demonstrate knowledge of MEMS, microfluidics, and manufacturing processes including 3D printing and microfabrication
- Understand and apply deep learning, including convolutional neural networks
- Demonstrate understanding of robotics system software, such as ROS

Assessment tasks

- Report 1 – System Parameters
- Homework / Problem sets
- Report 2 – Circuit diagram
- Report 3 - System model

- Report 4 – System Performance
- Project Demonstration
- Report 5 - Complete Report
- Final Exam

Learning and teaching activities

- Students will conduct practical work in pairs, but will submit individual reports.
- Students will complete assignments/homework to practice and consolidate learning
- Students must keep a log book demonstrating their work on the project

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- Design, numerically-model, implement, and test a digital motion control system for a non-linear problem
- Demonstrate knowledge of MEMS, microfluidics, and manufacturing processes including 3D printing and microfabrication
- Understand and apply deep learning, including convolutional neural networks

Assessment tasks

- Report 1 – System Parameters
- Report 3 - System model
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- Project Demonstration
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- Final Exam

Learning and teaching activities

- Students will conduct practical work in pairs, but will submit individual reports.
- Students will complete assignments/homework to practice and consolidate learning

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcome

- Understand and apply deep learning, including convolutional neural networks

Assessment tasks

- Project Logbook
- Final Exam

Learning and teaching activities

- Students will conduct practical work in pairs, but will submit individual reports.
- Students will complete assignments/homework to practice and consolidate learning
- Students must keep a log book demonstrating their work on the project

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcomes

- Design, numerically-model, implement, and test a digital motion control system for a non-linear problem
- Demonstrate, problem solving, initiative, time management, and record keeping, skills in the completion of a significant project

Assessment tasks

- Report 1 – System Parameters
- Homework / Problem sets
- Report 2 – Circuit diagram
- Report 3 - System model

- Report 4 – System Performance
- Report 5 - Complete Report

Learning and teaching activities

- Students will conduct practical work in pairs, but will submit individual reports.

Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning and teaching activities

- Students will complete assignments/homework to practice and consolidate learning

Changes from Previous Offering

Additional content on neural networks. Removal of basic dynamics and solid mechanics.

Changes in Response to Student Feedback

Incorporation of simulink for modelling, and additional time spent on neural networks.