UNSW SYDNEY
Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Term 2 2019

MTRN4230

Robotics

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Dr Mark Whitty
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Moodle: https://moodle.telt.unsw.edu.au/course/view.php?id=41761

Consultation concerning this course should in the first instance be made with your demonstrators, then using the Moodle discussion forums.

Contact details and consultation times for additional lecturers/demonstrators/lab staff

Zhihao Zhang (head demonstrator)	zhihao.zhang1@unsw.edu.au
Mengying (Valerie) Hu	mengying.hu@student.unsw.edu.au
Subhan Khan	subhan.khan@unsw.edu.au
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Xu (Annie) Wang	xu.wang@unsw.edu.au
Rouwei (Kylin) Li	ruowei.li@unsw.edu.au

Please see the course Moodle and begin by communicating through Moodle, either on the discussion forums or via private message.

2. Important links

- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering

3. Course details

Credit points

This is a 6 unit-of-credit (UoC) course and involves 5 hours per week (h/w) of face-to-face contact.

The normal workload expectations of a student are approximately 25 hours per term for each

UOC, including class contact hours, other learning activities, preparation and time spent on all assessable work.

You should aim to spend about 12 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Contact hours

	Day	Time	Location
Lectures	Monday	12noon - 2pm	Colombo Theatre C (K-B16-LG05)
(Web stream)	Any	Any	Moodle
Demonstrations	Monday	4pm – 5pm	Mechatronic Lab 212 (K-J18-212)
	Monday	5pm – 6pm	Mechatronic Lab 212 (K-J18-212)
	Tuesday	10am – 11am	Mechatronic Lab 212 (K-J18-212)
	Tuesday	11am – 12noon	Mechatronic Lab 212 (K-J18-212)
	Tuesday	12noon – 1pm	Mechatronic Lab 212 (K-J18-212)
	Tuesday	3pm – 4pm	Mechatronic Lab 212 (K-J18-212)
	Tuesday	4pm – 5pm	Mechatronic Lab 212 (K-J18-212)
Labs	Monday	6pm – 8pm	Mechatronic Lab 213 (K-J18-213)
	Tuesday	11am – 1pm	Mechatronic Lab 213 (K-J18-213)
	Tuesday	7pm – 9pm	Mechatronic Lab 213 (K-J18-213)
	Wednesday	5pm – 7pm	Mechatronic Lab 213 (K-J18-213)
	Thursday	11am – 1pm	Mechatronic Lab 213 (K-J18-213)
	Thursday	1pm – 3pm	Mechatronic Lab 213 (K-J18-213)
	Thursday	7pm – 9pm	Mechatronic Lab 213 (K-J18-213)
	Friday	9am – 11am	Mechatronic Lab 213 (K-J18-213)
	Friday	11am – 1pm	Mechatronic Lab 213 (K-J18-213)
	Friday	1pm – 3pm	Mechatronic Lab 213 (K-J18-213)
	Friday	3pm – 5pm	Mechatronic Lab 213 (K-J18-213)
	Friday	5pm – 7pm	Mechatronic Lab 213 (K-J18-213)

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

All classes, including demonstrations and labs begin in week 1 of the term. Classes which are held on the Monday which is a public holiday in week 2 will be replaced by a class on Monday week 11.

Summary and Aims of the course

The course introduces students to the analysis and use of robot manipulators, by exposing them to the theoretical basis of robotics as well as their practical implementation. By the end of the course students are expected to understand the ways in which robots are used in industrial and service applications; the key parameters for selecting robots for industrial applications; the main categories of robot frames of reference; and the essentials of robot kinematics, dynamics, control and path planning. Major projects require students to apply the theory to integrate a robot manipulator, simulation software, vision system and safety system to demonstrate the operation of a robot cell. Problem solving, project management and group work skills are developed throughout the semester as a foundation for graduate positions.

This is a final year course in the Mechatronics stream and builds on much content from previous courses including dynamics, robot design, control systems and computing. It seeks to expose students to the whole field of robotics and prepare them for graduate roles in the mechatronics industry.

The following are the course objectives:

- Understand the main categories of robot frames of reference.
- Understand the essentials of robotic kinematics and dynamics and calculate predictive paths.
- Be able to learn and then use the programming environment of a robot to perform a particular task.
- Be able to learn and then use high-level robot simulation software integrating the results with a real robot.
- Enable you to work in groups to improve problem-solving skills using computation.

Student learning outcomes

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

After successfully completing this course, you should be able to:

Learning Outcome		**EA Stage 1 Competencies**
1.	Learn a robot environment and put it to use effectively and efficiently on a given task	2.1, 2.2, 2.4, 3.4, 3.6
2.	Understand robot mechanics and use this knowledge to calculate robot performance	1.3, 1.4, 2.1, 2.2, 3.2, 3.4, 3.5
3.	Implement good safety practices in the use of robots	1.6, 2.2, 3.5
4.	Apply and evaluate image processing techniques in robotics	1.1, 1.2, 1.3, 2.1, 2.2
5.	Apply engineering management and technical tools fluently and systematically	2.2, 2.4, 3.1, 3.2, 3.4, 3.5, 3.6

4. Teaching strategies

The following strategies will be used to teach the subject matter of this course:

- Presentation of the material in lectures and discussions so that the major content is understood.
- Practical assignments in individual and group form with time limits to assist understanding of industrial demands and boundary conditions on the use of robots.

Suggested approaches to learning in the course:

- Be present and attentive at all lectures, tutorials and practical group work.
- Careful reading, discussion and understanding of the material presented in lectures.
- Additional reading on and about the material presented in lectures to broaden the knowledge base.
- Paying attention throughout the tutorials and asking questions when anything is not understood.
- Conscientiously working through the set tutorial exercises and assignments.

This course will be delivered both in the classroom and online. Full participation in the class means that you will participate fully in both arenas. That is, you will be held accountable for all content, instructions, information, etc. that is delivered either in class or online.

Online: The online forum for participation in this class is the Moodle Platform, linked above. All official online interactions will take place or be linked from this site.

5. Course schedule

Week	Lecture Topic	Tutorial Content	Lab content
1	Introduction to robotics, definitions, classification, parallel robots, safety	Induction and software setup	Training on robots
2	*Public Holiday*	PSE2 introduction	In-person safety assessment + robot training + PSE1 introduction
3	Computer vision for robotics applications	PSE2 working	PSE1 assessment + group project introduction
4	Kinematics: coordinate frames, homogeneous transforms	PSE2 assessment	PSE3 introduction + group project time
5	Kinematics: Denavit Hartenberg method	Asst1 introduction	PSE3 assessment + group project time
6	Kinematics: the Jacobian	Asst1 working	PSE4 introduction + group project time

Week	Lecture Topic	Tutorial Content	Lab content
7	Kinematics: Robot trajectory design, path planning 1	Asst1 working	PSE4 assessment + group project time
8	Path planning 2 and joint dynamics and control	Asst1 working	Group project time
9	Dynamics: Rigid-body equations of motion	Asst1 assessment	Group project time
10	Dynamics: manipulator control	Group project assistance	Group project time (demonstrator not present)
11 Stuvac	Mobile robots	-	Group project time (demonstrator not present)
12 Exams	-	-	Group project time (demonstrator not present)
13 Exams	-	-	Group project assessment

All lectures, lab classes and tutorials on Monday following week 2 are deferred by a week for the students enrolled in Monday classes. The exception is the final lab demonstration which will still be held on Monday week 13 – a make-up lab session will be arranged.

6. Assessment

Assessment overview

Assessment	Group Project? (# Students per group)	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Safety	No	N/A	5%	3	Demonstrate ability to use robot cell	Moodle quiz, 5pm Friday week 2, In-person safety test, end of week 2 lab	N/A	Immediately
Problem Solving Exercises (PSEs)	No	N/A	25%	1, 2, 4	Demonstrate solution to demonstrator	PSE1: end of your week 3 lab, PSE2: End of your week 4 tutorial, PSE3: End of your week 5 lab, PSE4: End of your week 7 lab	N/A	1 week after submission
Individual assignment	No	N/A	40%	2 and 4	Complete image processing task and robot mechanics analysis	Report: 5pm Friday week 8, Demo: End of your week 9 tutorial	N/A	2 weeks after submission
Group assignment	Yes (up to 12)	N/A	30%	1, 3, 4 and 5	Demonstrate a robot system's operation	Portfolio: End of week 12 (during exam period), Demo: End of your week 13 lab time (during exam period)	N/A	1 week after submission

All details of assessment tasks will be found on Moodle. Team evaluation will be used to evaluate the contributions of peers to the group assignment.

Assignments

Presentation

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Submission

Late submissions are **not permitted** in this course. An extension may only be granted by means of special consideration (see below).

Marking

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

Examinations

There is no final examination for this course, but the final assignment is due during the exam period as specified above.

Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to submitting an assessment or sitting an exam.

Please note that UNSW now has a Fit to Sit / Submit rule, which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

7. Expected resources for students

The prescribed textbook for the course presents a very wide range of background material in an accessible manner with extensive Matlab examples:

Corke, P., **Robotics, Vision and Control: Fundamental Algorithms in Matlab**, 2017, Springer. This book is available in the UNSW Bookshop.

The full book is also available online for download through the UNSW library:
https://primoa.library.unsw.edu.au/primo-explore/fulldisplay?docid=UNSW_ALMA51228764990001731&context=L&vid=UNSWS&lang=en_US
The first edition (2011) of this textbook is also appropriate.

Lecture slides and supporting course notes will be available on Moodle.

Additional References

Spong, M., Hutchinson, S. and Vidyasagar, M., Robot Modeling and Control, 2006, John Wiley & Sons.
This text is a classic in robotics and contains well-presented derivations of the theoretical concepts covered in the course.

Spong, M. and Vidyasagar, M., Robot Dynamics and Control, 1989, John Wiley & Sons.

Craig, J. J., Introduction to Robotics (3rd Ed), 2005, Pearson Prentice Hall.

A source of comparable material from around the world is:
http://www.roboticscourseware.org/courses.html

In this course, students are expected to take initiative for their own learning and these sites are a good place to start:

UNSW Library website: https://www.library.unsw.edu.au/
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

8. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, informal discussion in the final class for the course, and the School's Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

In this course, recent improvements resulting from student feedback include adjusting the total number of assessments and structuring of team evaluation for group assignments. Lecture slides have been updated to reflect more modern content, clarify notation and streamline content. Laboratory timeslots are now enrolled through myUNSW, so are fully timetabled. Additional timeslots have been added to allow for increasing enrolment. Two new robots arms have been purchased and set up for use in this course to introduce students to collaborative robotics as well as provide clearer demonstration of the kinematic principles.

9. Academic honesty and plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism, visit: [student.unsw.edu.au/plagiarism.](student.unsw.edu.au/plagiarism) The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis) even suspension from the university. The Student Misconduct Procedures are available here:
www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

10. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and polices. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address
- Computing Facilities
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Lab Access

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving
	PE2.2 Fluent application of engineering techniques, tools and resources
	PE2.3 Application of systematic engineering synthesis and design processes
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (professional and lay domains)
	PE3.3 Creative, innovative and pro-active demeanour
	PE3.4 Professional use and management of information
	PE3.5 Orderly management of self, and professional conduct
	PE3.6 Effective team membership and team leadership