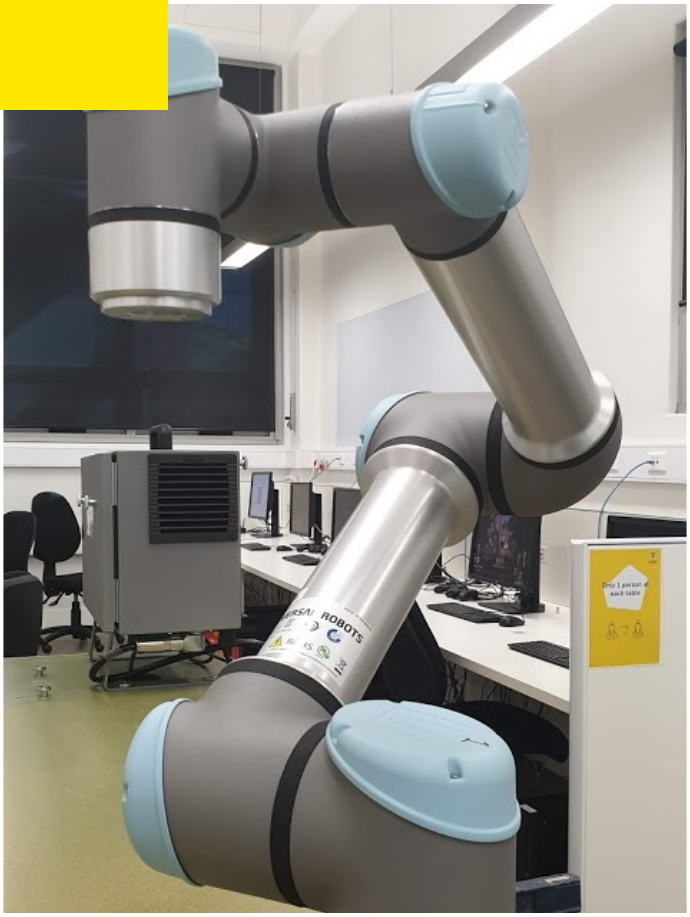

MTRN4230

Robotics

Term Two // 2021

School of Mechanical and Manufacturing Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Mark Whitty	m.whitty@unsw.edu.au	Weekdays, consultation on request	J17-510G	02 9385 4230

Demonstrators

Name	Email	Availability	Location	Phone
Luke Dennis	l.dennis@unsw.edu.au			
Max Kelly	max.kelly@unsw.edu.au			
Timothy Ryan	t.ryan@unsw.edu.au			
Rowan Ramamurthy	r.ramamurthy@unsw.edu.au			

School Contact Information

Location

UNSW Mechanical and Manufacturing Engineering

Ainsworth building J17, Level 1

Above Coffee on Campus

Hours

9:00–5:00pm, Monday–Friday*

*Closed on public holidays, School scheduled events and University Shutdown

Web

School of Mechanical and Manufacturing Engineering

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

(+61 2) 9385 4097 – School Office**

**Please note that the School Office will not know when/if your course convenor is on campus or available

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

School Office – School general office administration enquiries

- NB: the relevant teams listed above must be contacted for all student enquiries. The School will only be able to refer students on to the relevant team if contacted

Course Details

Credit Points 6

Summary 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 term as a foundation for graduate positions.

Course Aims

This course introduces you to the analysis and use of robots in a variety of industrial settings. The course exposes you to the theoretical basis of robotics as well as their practical implementation. A group project involving designing and implementing robot behaviours in a robot cell and in simulation with a robot manipulator places in context much of the content learnt throughout the course.

This is a core course for Mechatronics students and it aims to broaden your understanding of how robotics plays a significant role in achieving many industrial and service roles.

The following are the course objectives:

- O1: Increase awareness of the scope of robot applications, with a focus on industrial applications including past and present trends.
- O2: Provide experience with safely operating and programming an industrial robot manipulator.
- O3: Explain how robot manipulators work and are modelled.
- O4: Demonstrate the advantages of using simulation software for robot system design and integration.
- O5: Highlight the advantages and disadvantages of different robot manipulator designs and provide insight into robot selection.
- O6: Demonstrate how to integrate robot manipulators and vision sensors in order to solve practical problems.
    - Coordinate frames
    - Robot kinematics and dynamics
    - Trajectory design and path planning
    - Computer vision for robotics
    - System integration
- O7: Develop management, systems engineering and teamwork skills through a group project.

Course Learning Outcomes

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	PE2.1, PE2.2, PE2.4, PE3.4
2. Apply robot mechanics to calculate robot performance	PE1.3, PE1.4, PE2.1, PE2.2, PE3.4
3. Implement good safety practices in the use of robots	PE1.6, PE2.2, PE3.5
4. Apply and evaluate image processing techniques in robotics	PE1.1, PE1.2, PE1.3, PE2.1, PE2.2
5. Apply engineering management and technical tools fluently and systematically	PE2.2, PE2.4, PE3.1, PE3.2, PE3.4, PE3.5, PE3.6

Teaching Strategies

This course is included to give you the skills to design robot applications and solutions that will fulfil industry requirements, and to be able to analyse and understand the principal factors that contribute to successful outcomes.

Effective learning is supported when you are actively engaged in the learning process and by a climate of enquiry, and these are both an integral part of the lectures.

You become more engaged in the learning process if you can see the relevance of your studies to professional, disciplinary and/or personal contexts, and the relevance is shown in the lectures and assessments by way of examples drawn from industry.

Dialogue is encouraged between you, others in the class and the lecturers. Diversity of experiences is acknowledged, as some students in each class have prior knowledge and experience. Your experiences are drawn on to illustrate various aspects, and this helps to increase motivation and engagement.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 categories of robots are understood

· Practical assignments in individual and group form with time limits to assist understanding of demands on the use of robots.

Suggested approaches to learning in the course:

· Be present and attentive at all lectures and laboratory sessions.

· 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 laboratory sessions, and asking questions when anything is not understood.

· Conscientiously working through the set assessments and example problems.

Assessment

To reflect professional practice, late submission of all assessments in this course is not permitted without applying for and being granted special consideration through the special consideration procedures outlined below. Note that in lieu of a final exam, the major project assessment will be due in week 12 or week 13, exact timing will be confirmed closer to that date.

Assessment Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
ROBOT-1 and ROBOT-2: Safety and robot demonstrations	15%	See below	1, 3
ASST: Assignment	10%	See below	1, 2
MP-I: Major Project - Individual components	45%	See below	1, 4, 5
MP-G: Major Project - Group components	30%	See below	1, 2, 3, 4, 5

Assessment Details

Assessment 1: ROBOT-1 and ROBOT-2: Safety and robot demonstrations

Length: -

Details:

Demonstrate ability to use robot system safely and effectively (in two parts - ROBOT-1 and ROBOT-2).

ROBOT-1 (5%): due in your week 2 lab class.

ROBOT-2 (10%): due in your week 4 lab class.

Late submission is not permitted without approval through the special consideration process outlined below.

Assessment criteria will be detailed in the assessment description.

Marks will be returned within 1 week of the due date.

Submission notes: In person in your lab class timeslot

Turnitin setting: This is not a Turnitin assignment

Assessment 2: ASST: Assignment

Length: ~20 pages

Details:

Individual robot design and analysis assignment, submitted as a report, due 5pm Friday week 10.

Late submission is not permitted without approval through the special consideration process outlined below.

Assessment criteria will be detailed in the assessment description.

Marks will be returned within 2 weeks of the due date.

Turnitin setting: This assignment is submitted through Turnitin and students can see Turnitin similarity reports.

Assessment 3: MP-I: Major Project - Individual components

Length: See assessment description

Details:

Complete individual components of a major project involving a robot manipulator and vision system. Multiple parts: MP-I1, MP-I3, MP-I4.

MP-I1 (5%): Management report, due Friday 5pm week 3.

MP-I3 (15%): Progress demonstration, due in week 8 lab class.

MP-I4 (25%): Final system component demonstration, due week 12/13 (timeslot to be confirmed).

Late submission is not permitted without approval through the special consideration process outlined below.

Assessment criteria will be detailed in the assessment description.

Marks will be returned within 1 week of the due date.

Assessment 4: MP-G: Major Project - Group components

Length: See assessment description

Details:

Group components of major project in two parts:

MP-G2 (10%): Requirements, due by the start of your lab class in week 5.

MP-G5 (20%): Final system demonstration, due in week 12/13 (timeslot to be confirmed).

Late submission is not permitted without approval through the special consideration process outlined below.

Assessment criteria will be detailed in the assessment description.

Marks will be returned within 1 week of the due date.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

View class timetable

Timetable

Date	Type	Content
O Week: 25 May - 28 May	Online Activity	Online induction, to be completed at your leisure (before week 1 labs).
Week 1: 31 May - 4 June	Lecture	Introduction to Robotics, Definitions and Classification, Safety.
	Workshop	Training on UR5e robots, Polyscope, software setup.
Week 2: 7 June - 11 June	Lecture	Kinematics 1: Coordinate Frames & Homogeneous Transformations
	Workshop	Advanced Polyscope programming, marking of ROBOT-1 assessment.
Week 3: 14 June - 18 June	Lecture	Kinematics 2: Forward kinematics
	Workshop	Git, issue management, systems engineering and project management procedures.
Week 4: 21 June - 25 June	Lecture	Kinematics 3: The Jacobian and Inverse Kinematics
	Workshop	Introduction to ROS, basic joint control, marking of ROBOT-2 assessment.
Week 5: 28 June - 2 July	Lecture	Kinematics 4: Robot Trajectories
	Workshop	ROS + UR control + MoveIt introduction for moving the UR5e programmatically, marking of MP-G2 assessment.
Week 6: 5 July - 9 July	Online Activity	Optional lecture: Skills and Careers in Robotics
Week 7: 12 July - 16 July	Lecture	Computer Vision for Robotics
	Workshop	Computer vision exercises, camera calibration.
Week 8: 19 July - 23 July	Lecture	Path Planning for Robot Manipulators
	Workshop	Computer vision exercises continued, marking of MP-I3 assessment.
Week 9: 26 July - 30 July	Lecture	Joint Dynamics and Control, Euler-Lagrange Equations
	Workshop	Modelling a robot manipulator, group reflection.
Week 10: 2 August - 6 August	Lecture	Automated Work Cells and Industrial Applications
	Workshop	Multi-robot simulation.

Resources

Prescribed Resources

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

Recommended Resources

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

ROS: https://www.ros.org/ is the homepage for the Robot Operation System which will be used in this course - note that we will be using ROS 1 (not ROS 2), specifically the Melodic version.

For ROS resources, theconstructsim.com is a great place to start learning and there are many tutorials on YouTube.

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:

The use of a fully featured professional simulation environment was a positive outcome when the course was run in T2 2020. With the addition of 4 new physical UR5e robot arms in the lab, the simulation environment has been expanded and is intended to allow students to switch seamlessly to the physical robots. All assessments have been completely rewritten and the course content has been adapted in response to the mechatronic program review to best prepare students for graduate roles. This include improve sequencing of content between the lectures and assessments. Previous negative feedback around response times and unclear instructions has been tackled through a dynamic group of demonstrators who are well versed in the course content. Lectures will be held synchronously and audience participation welcomed. We look forward to your feedback on this new and improved course.

Laboratory Workshop Information

Enclosed footwear is required to enter the labs.

Submission of Assessment Tasks

Assessment submission and marking criteria

Should the course have any non-electronic assessment submission, these should have a standard School cover sheet.

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.

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.

Late policy

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 20 percent (20%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day.

Work submitted after the 'deadline for absolute fail' is not accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by the specified date. Examples include:

1. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
2. Online quizzes where answers are released to students on completion, or
3. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
4. Pass/Fail assessment tasks.

Examinations

You must be available for all quizzes, tests and examinations. For courses that have final examinations, these are held during the University examination periods: February for Summer Term, May for T1, August for T2, and November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates. For further information on exams, please see the Exams webpage.

Special Consideration

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.

UNSW now has a Fit to Sit / Submit rule, which means that if you attempt 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.

Please note that students will **not** be required to provide **any** documentary evidence to support absences from any classes missed **because of COVID-19 public health measures such as isolation**. UNSW will **not** be insisting on medical certificates from anyone deemed to be a positive case, or when they have recovered. Such certificates are difficult to obtain and put an unnecessary strain on students and medical staff.

Applications for special consideration **will** be required for assessment and participation absences – but no documentary evidence **for COVID 19 illness or isolation** will be required.

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. 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

Academic Information

Credit points

Course credit is calculated in Units-Of-Credit (UOC). The normal workload expectation for one UOC is approximately 25 hours per term. This includes class contact hours, private study, other learning activities, preparation and time spent on all assessable work.

Most coursework courses at UNSW are 6 UOC and involve an estimated 150 hours to complete, for both regular and intensive terms. Each course includes a prescribed number of hours per week (h/w) of scheduled face-to-face and/or online contact. Any additional time beyond the prescribed contact hours should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

On-campus class attendance

Public distancing conditions must be followed for all face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. No over-enrolment is allowed in face-to-face classes. Students enrolled in online classes can swap their enrolment from online to a **limited** number of on-campus classes by Sunday, Week 1. Please refer to your course's Microsoft Teams and Moodle sites for more information about class attendance for in-person and online class sections/activities.

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate.** We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed. Further information is available on any course Moodle or Teams site.

In certain classroom and laboratory situations where physical distancing cannot be maintained or there is a high risk that it cannot be maintained, face masks will be considered **mandatory PPE** for students and staff.

For more information, please refer to the
FAQs: https://www.covid-19.unsw.edu.au/safe-return-campus-faqs

Guidelines

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
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism

Important Links

- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Faculty Transitional Arrangements for COVID-19
- Makerspace
- UNSW Timetable
- UNSW Handbook
- Equitable Learning Services

Image Credit

Mark Whitty

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	✓
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	✓
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	✓
PE3.2 Effective oral and written communication in 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	✓