MECH4305

Fundamental and Advanced Vibration Analysis

Term Three // 2020

School of Mechanical and Manufacturing Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Danielle Moreau	d.moreau@unsw.edu.au	Please contact Danielle by email to arrange an appointment outside of scheduled teaching times.	Ainsworth Building (J17), Level 4, Room 408E	(02) 9385 5428

Lecturers

Name	Email	Availability	Location	Phone
Pietro Borghesani	p.borghesani@unsw.edu.au	Please contact Pietro by email to arrange an appointment outside of scheduled teaching times.		

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

Course Details

Credit Points 6

Summary of the Course

This course builds upon the acquired knowledge of an introductory course in vibrations (such as MMAN2300) where you will have studied oscillatory systems under a number of simplifying assumptions – sinusoidal forcing, constant coefficients, simple boundary conditions, etc. In this course, you will examine more complex systems and excitations. As such, you will be exposed to new techniques for seeing, measuring, thinking about, analysing and designing oscillatory systems. These analytical and computational tools will be applied to the challenging and critical application of machine condition monitoring. Vibration-based condition monitoring is a large and expanding field of engineering research and application, which allows massive safety improvements and economic advantages in almost every industry.

Areas of study include: free and forced responses of single degree-of-freedom spring-mass-damper systems; harmonic analysis; linear vibrations of multi-degree-of-freedom systems, normal modes; analysis of continuous systems, longitudinal/torsional vibration of bars and rods, bending vibration of beams; vibration measuring instruments; experimental vibration analysis; typical sources of vibration in machines; modal analysis; vibration testing; typical machine and machine component faults and corresponding vibration signatures; diagnostic procedures and related signal processing techniques.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Model, approximate, analyse and design vibratory systems and their responses.	PE1.1, PE1.2, PE1.3, PE1.5, PE2.1, PE2.2, PE2.3
2. Discern the relevant principles that must be applied to describe or measure the equilibrium or motion of vibratory systems and discriminate between relevant and irrelevant information in the context.	PE1.1, PE1.2, PE1.3
3. Program vibration analysis code to implement vibration signal analysis and extract fault symptoms in rotating machines.	PE1.3, PE2.2, PE2.3
4. Diagnose typical machine faults based on the output of signal processing tools and recommend proper actions.	PE1.3, PE1.6, PE2.1, PE2.2
5. Produce appropriate reports to communicate about technical matters relating to vibration and machine condition monitoring at a professional engineering level.	PE3.1, PE3.2, PE3.4

Teaching Strategies

There are two teaching activities in a typical week which we refer to as the lecture and demonstration class. Lectures will be delivered online using Microsoft Teams. You will enrol in one of two demonstration classes delivered online using Microsoft Teams or face-to-face in the classroom.

The lectures in this course will cover core concepts and background theory in vibration analysis and machine condition monitoring. The lecture material will be available to students electronically before each class via Moodle.

The demonstration classes are designed to provide you with feedback and discussion on worked tutorial-type questions provided on the course Moodle page. Students are required to work through the tutorial exercises during the demonstration class and during their own personal study time.

The teaching activities in this course are organised on the following principles:

1. **Learning:** Student learning is the first priority - teaching and assessment are secondary concerns. Learning here is defined as gaining new ways of understanding the field of vibration analysis; not as simply memorising information. We are trying to transform you into engineers and critical thinkers in the discipline.
2. **Authenticity:** We will have as much authenticity of engineering practice as is possible within the constraints of the course and where it does not restrain your learning.
3. **High standards:** We will have high standards for achievement in the course, and everyone (including staff) will be accountable for putting in the effort to get you to the standard.
4. **Openness:** As much as possible, this course will be conducted in the open where all participants can be aware of it and can comment upon it.
5. **Process:** The focus of the course will be on processes, not outcomes. The right outcomes will be a by-product of following the correct processes.

Additional Course Information

The following assumed knowledge is expected for students undertaking this course: MATH2019 and MMAN2300.

Assessment

Assessment Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
Problem set 1: Fourier analysis and convolution	15%	06/10/2020 05:00 PM	1, 2, 3
Problem set 2: Free and forced response of beams and Hamilton's Principle	15%	26/10/2020 05:00 PM	1, 2, 3
Problem set 3: Measuring vibration and condition monitoring in rotordynamics	30%	20/11/2020 05:00 PM	1, 2, 3, 4, 5
Final Examination	40%	Not Applicable	1, 2, 3, 4

Assessment Details

Assessment 1: Problem set 1: Fourier analysis and convolution

Start date: 14/09/2020 04:00 PM

Length: Approx. 10 pages plus full working

Details:

Individualized feedback on assignment submission.

Additional details:

Assessment criteria: Course material weeks 1 - 2 inclusive.

Turnitin setting: This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment 2: Problem set 2: Free and forced response of beams and Hamilton's Principle

Start date: 05/10/2020 04:00 PM

Length: Approx. 10 pages plus full working

Details:

Individualized feedback on assignment submission.

Additional details:

Assessment criteria: Course material to week 4 inclusive.

Turnitin setting: This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment 3: Problem set 3: Measuring vibration and condition monitoring in rotordynamics

Start date: 26/10/2020 04:00 PM

Length: Approx. 20 pages

Details:

Individualized feedback on assignment submission.

Additional details:

Assessment criteria: Course material to week 8 inclusive.

Turnitin setting: This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment 4: Final Examination

Start date: Not Applicable

Details: Open book exam.

Additional details:

Assessment criteria: All course material.

Attendance Requirements

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

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 14 September - 18 September	Lecture	L01: Introduction and review of fundamentals L02: Fourier analysis for a SDOF system with a periodic force
	Tut-Lab	T1: Introduction to MATLAB
Week 2: 21 September - 25 September	Lecture	L03: Convolution for a SDOF system with a non-periodic force L04: Free vibration of beams in flexure
	Tut-Lab	T2: Fourier analysis and convolution
Week 3: 28 September - 2 October	Lecture	L05: Forced response of beams L06: Hamilton's Principle and Lagrange's Equations
	Tut-Lab	T3: Free and forced response of beams
Week 4: 5 October - 9 October	Lecture	L06 (continued): Hamilton's Principle worked example L07: Measuring vibration 1 Please note Monday October 5 is a public holiday. The week 4 lectures will be recorded and available on Teams for you to watch in your own time.
	Tut-Lab	T4: Hamilton's Principle
Week 5: 12 October - 16 October	Lecture	L08: Measuring vibration 2 L09: Fourier analysis for condition monitoring
	Tut-Lab	T5: Vibration data analysis
Week 7: 26 October - 30 October	Lecture	L10: Condition monitoring in rotordynamics 1
	Tut-Lab	T6: Condition monitoring in rotordynamics
Week 8: 2 November - 6 November	Lecture	L11: Condition monitoring in rotordynamics 2
	Tut-Lab	T7: Condition monitoring in rotordynamics
Week 9: 9 November - 13 November	Lecture	L12: Condition monitoring of machine components
	Tut-Lab	T8: Condition monitoring of machine components
Week 10: 16 November - 20 November	Lecture	L13: Revision and overflow
	Tut-Lab	T9: Revision

Resources

Prescribed Resources

The textbook for this course is:

- Rao, S.S. Mechanical Vibrations, 6th Edition in SI Units, Pearson

The relevant chapters are stated on the course Moodle page in each week folder and in the lecture notes.

The software used in this course is:

- MATLAB

UNSW has a MATLAB site license that allows currently enrolled UNSW students to download and install MATLAB on their own laptop or home PC. Further details of the license conditions and for download and installation instructions see the UNSW IT > For Student > Software > Matlab page.

Course materials (lecture notes and tutorial exercises) will be provided on the course Moodle page.

Recommended Resources

There are also several recommended books that are closely related to the course content. Many of these books are available through the library:

- Meirovitch, L. Fundamentals of Vibrations, 1st Edition, Waveland Press
- Bendat and Piersol, Random Data: Analysis and Measurement Procedures, 2010, John Wiley and Sons
- Randall, R., Vibration-based Condition Monitoring: Industrial, Aerospace and Automotive Applications, 2010, John Wiley and Sons

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 a complete course restructure and providing more worked examples with full MATLAB code in demonstration classes.

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 in T3.

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. 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 T3 face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. Class rosters will be attached to corresponding rooms and circulated among lab demonstrators. No over-enrolment is allowed in face-to-face class. Students enrolled in online classes can swap their enrolment from online to other additional, **but 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 1.5 metres 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

Other Matters

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
- Health and Safety
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering
- Equitable Learning Services

Image Credit

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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	