UNSW SYDNEY

Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Term 3 2019

MECH4305

FUNDAMENTAL AND ADVANCED VIBRATION ANALYSIS

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Dr Danielle Moreau
Office location: Ainsworth Building (J17), Level 4, Room 408E
Tel: (02) 9385 5428
Email: d.moreau@unsw.edu.au
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

Please contact Dr Moreau by email to arrange an appointment outside of scheduled teaching times.

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

Course lecturer
Name: Dr Pietro Borghesani
Email: p.borghesani@unsw.edu.au

Please contact Dr Borghesani by email to arrange an appointment outside of scheduled teaching times.

Demonstrators
Please see the course Moodle.

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 4 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	Thursday	1pm – 3pm	Webster Theatre B
Demonstrations	Thursday	4pm – 6pm	Ainsworth 203
	Thursday	4pm – 6pm	Ainsworth 204

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

Summary and Aims 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.

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

Areas of study include: Free and forced responses of single degree-of-freedom spring-mass-damper systems, vibration isolation, transmissibility; Harmonic analysis; Vibration measuring instruments; Linear vibrations of multi-degree-of-freedom systems, normal modes; Analysis of continuous systems, wave equation, longitudinal/torsional vibration of bars and rods, bending vibration of beams. Introduction to experimental vibration analysis using Fast Fourier Transform (FFT) techniques. Typical sources of vibration in machines. Analysis of continuous systems using finite element techniques. Modal analysis. Vibration testing. Typical machine and machine component faults and corresponding vibration signatures. Diagnostic procedures and related signal processing techniques.

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.	Model, approximate, analyse and design vibratory systems and their responses.	1.1, 1.2, 1.3, 1.5, 2.1, 2.2, 2.3
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.	1.1, 1.2, 1.3
3.	Program vibration analysis code to implement vibration signal analysis and extract fault symptoms in rotating machines.	1.3 2.2, 2.3
4.	Diagnose typical machine faults based on the output of signal processing tools and recommend proper actions.	1.3, 1.6 2.1, 2.2
5.	Produce appropriate reports to communicate about technical matters relating to vibration and machine condition monitoring at a professional engineering level.	3.1, 3.2, 3.4

4. Teaching strategies

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, specifically the MECH4305 course at http://moodle.telt.unsw.edu.au/. All official online interactions will take place or be linked clearly and appropriately from this site.

In class: There are two in-class activities in a typical week which we refer to as the Lecture and Demonstration class based on the timetable in Section 3. Both the online and in-class segments of 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.

The lectures in this course will cover core concepts and background theory in Vibration Analysis and Machine Condition Monitoring. The lecture material is available to students electronically before each class via Moodle.

The Demonstration classes are designed to provide you with feedback and discussion on demonstration exercises and the assignments. Students are required to work through the demonstration exercises and assignments during the Demonstration class and also during their own personal study time.

5. Course schedule

Week	Topic	Location	Demonstration Class Content
1	• Introduction and review of fundamentals • Fourier analysis	Webster Theatre B	Introduction to Matlab
2	• Convolution • Free vibration of beams in flexure	Webster Theatre B	Fourier analysis and convolution
3	• Forced response of beams • Hamilton’s Principle and Lagrange’s Equations	Webster Theatre B	Free and forced response of beams
4	• Measuring vibration	Webster Theatre B	Hamilton’s Principle
5	• Measuring vibration	Webster Theatre B	FFT and data analysis
6	• Introduction to vibration-based condition monitoring • Condition monitoring in rotordynamics	Webster Theatre B	Condition monitoring in rotordynamics
7	• Condition monitoring in rotordynamics	Webster Theatre B	Condition monitoring in rotordynamics
8	• Fault detection in machine components	Webster Theatre B	Fault detection in machine components
9	• Fault detection in machine components	Webster Theatre B	Fault detection in machine components
10	• Mock exam	Webster Theatre B	Open Q&A and solutions for mock exam

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
Problem Set 1: Fourier analysis and convolution	No	Approx. 10 pages	15%	1 – 3	Lecture material from weeks 1 – 2 inclusive. Marking rubric provided.	Friday 5pm week 3 via Moodle	5 working days after submission	Two weeks after submission
Problem Set 2: Free and forced response of beams and Hamilton's Principle	No	Approx. 10 pages	15%	1 – 3	Lecture material from weeks 2 – 4 inclusive. Marking rubric provided.	Friday 5pm week 6 via Moodle	5 working days after submission	Two weeks after submission
Problem Set 3: Condition monitoring in rotordynamics	No	Approx. 10 - 15 pages	30%	1 – 5	Lecture material from weeks 4 – 8 inclusive. Marking rubric provided.	Friday 5pm week 10 via Moodle	5 working days after submission	Two weeks after submission
Final exam	No	2 hours	40%	1 – 4	All course content.	Exam period, date TBC	N/A	Upon release of final results

Assignments

The assessment tasks will be placed on the course Moodle homepage, as well as all information regarding assessment. It is your responsibility to read all course requirements on Moodle, attend lectures (in person or via webcast) and understand the assessment requirements.

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

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:

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

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

You must be available for all tests and examinations. Final examinations for each course 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.

Calculators

You will need to provide your own calculator of a make and model approved by UNSW for the examinations. The list of approved calculators is available at student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an "Approved" sticker for it from the Engineering Student Supper Services Centre prior to the examination. Calculators not bearing an "Approved" sticker will not be allowed into the examination room.

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

Recommended textbooks:

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

Other suggested textbooks:

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 materials will be provided on Moodle.

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 a complete course restructure, providing more worked examples and practice problems during Demonstration classes.

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
- Disability Support Services
- 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