UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Semester 2 2017

MECH9223

MACHINE CONDITION MONITORING

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Phil Howlin
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Moodle: https://moodle.telt.unsw.edu.au/login/index.php

Consultation can be arranged by email. Tuesday afternoon will be a preferred time. Non-private course related matters should be asked on the Moodle forum for the course.

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

Please make arrangements beforehand, via phone or email, if you need to see the following teaching staff outside scheduled class times.

Lecturers

Dr Sangarapillai Kanapathipillai
Room: J17/408J (Ainsworth Lv 4)
Tel: (02) 9385 4251
Email: s.kanapathipillai@unsw.edu.au

Associate Professor Zhongxiao Peng
Room: J17/408B (Ainsworth Lv 4)
Tel: (02) 9385 4142
Email: z.peng@unsw.edu.au

Demonstrators

Dr Danish Haneef
Email: l.deshpande@.unsw.edu.au

Mr Dikang Peng
Email: dikang.peng@student.unsw.edu.au

2. Important links

- Moodle
- UNSW Mechanical and Manufacturing Engineering
- Course Outlines
- Student intranet
- UNSW Mechanical and Manufacturing Engineering Facebook
- UNSW Handbook

3. Course details

Credit Points

This is a 6 unit-of-credit (UoC) course, and involves 3 hours per week (h/w) of face-to-face contact.

The UNSW website states “The normal workload expectations of a student are approximately 25 hours per semester for each UoC, including class contact hours, other learning activities, preparation and time spent on all assessable work. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week.”

This means that you should aim to spend about 9 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**
Lecture	Monday	6pm – ~7:30pm	Ainsworth 202 (K-J17-202)
Demonstration	Monday	~7:30pm – 9pm	Ainsworth 202 (K-J17-202)
Lab	Monday	Held occasionally in 6pm – 9pm slot	Various. Will be advised.

Summary and Aims of the course

This course is intended to provide the necessary tools and basic knowledge in the field of monitoring the health of rotating and reciprocating machines, primarily through vibration analysis.

The course starts with a brief introduction to the broad field of machine condition monitoring (MCM), including methods other than vibration analysis, as applied to the efficient maintenance of operating machines without disturbing their normal operation. Benefits of Condition Based Maintenance (CBM) over run to failure are mentioned. The course then concentrates on the analysis of vibration signals from operating machinery in both normal and faulty condition.

Vibration signals are generated by machines and machine components, such as gears and bearings. Appropriate signal processing techniques that can be used to extract symptoms of individual faults in individual components from the overall vibration signal.

The course applies the dynamic system modelling concepts that you learned in MMAN2300 and MMAN3200 and the Fourier methods introduced in MATH2019 (or their equivalents). A basic knowledge of mechanical vibration, as covered for example in the present MMAN2300 or in former courses MMAN3300 and MECH4305-9305, would be highly beneficial.

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.	List machine condition monitoring techniques and contrast their uses and limitations.	PE1.1, PE1.2, PE1.3
2.	Employ vibration analysis techniques to diagnose faults in rotating and reciprocating machines and recommend proper actions.	PE1.1, PE1.2, PE1.3, PE1.5, PE2.1, PE2.2
3.	Produce appropriate reports to communicate analysis results at a professional engineering level, including executive summary.	PE1.6, PE3.1, PE3.2, PE3.4
4.	Recall the different hardware used to measure and analyse vibration signals	PE1.2, PE1.3, PE2.2

4. Teaching strategies

Material in this course will be presented in Lectures, Demonstrations and Laboratory sessions.

Topics are usually first introduced through PowerPoint® presentations during the lecture time.

Demonstration sessions occur immediately afterward and are designed to investigate concepts in greater depth to ensure that you understand the application. Demonstration sessions have been devised to help you develop your theoretical understanding of the mathematical concepts and theories that you will need to learn. This will be done through several problems that will be provided during the demonstration time, and through MATLAB® examples. Assignment feedback will also be given during this time.

Lab demonstrations will be scheduled to illustrate signal capturing and case studies/histories will be presented.

Material presented in class will generally be available for download using the Moodle LMS.

5. Course schedule

The following course schedule is an indication only, and may be adjusted slightly throughout the Semester.

Wk	Date	Lecturer	Topics covered
1	24 Jul	Phil Howlin	Overview of condition monitoring and vibration analysis maintenance practices. Condition monitoring methods: vibration analysis, oil analysis, performance analysis, thermography etc. Vibration transducers. Permanent vs intermittent monitoring. Signal classification and signals produced by machines and components in healthy and faulty condition. Vibration criteria.
2	31 Jul	Phil Howlin	Basics of mechanical vibrations. Vibration signal measurement and display. Introduction to signal processing. Frequency analysis using filters. Fourier analysis and the Fast Fourier Transform (FFT). *Assignment 1 (15%) given (due Week 6 – 30 August)*
3	7 Aug	Phil Howlin	Convolution and the convolution theorem. Practical FFT analysis; sampling theory, FFT pitfalls, aliasing, leakage, windowing. Scaling. Fault detection using constant percentage bandwidth (CPB) spectra on log frequency scales.
4	14 Aug	Phil Howlin	Advanced signal processing techniques; Hilbert transform, demodulation, cepstrum analysis, time-frequency analysis, cyclostationary analysis.
5	21 Aug	Phil Howlin	Order tracking to compensate for speed fluctuations. Separation of deterministic and random signals.
6	28 Aug	Phil Howlin	Diagnostics of rolling element bearings. Vibrations generated by local and extended faults. Envelope analysis by amplitude demodulation. Spectral correlation. **Assignment 1 (15%) due – 5pm Wednesday 30 August**
7	4 Sep	N/A	**Mid-Semester Exam (15%) – during lecture time** *Assignment 2 (30%) given (due Week 12 – 18 October).*
8	11 Sep	Dr Kana Kanapathi-pillai	Introduction to rotor dynamics. The Jeffcott rotor. More complex rotors. Critical speeds; forward/backward whirl. Unbalance; misalignment.
9	18 Sep	Dr Kana Kanapathi-pillai	Hydrodynamic bearings and their interaction with rotor dynamics. Reynolds equation and solutions.
25 Sep		Mid-semester break	
10	2 Oct	Phil Howlin	Gear diagnostics; time synchronous averaging (TSA), residual analysis, cepstrum analysis, time/frequency analysis.
11	9 Oct	Phil Howlin	Diagnostics of IC engines and other reciprocating machines; torsional vibration, time/frequency analysis.
12	16 Oct	A/Prof Zhongxiao Peng	Condition monitoring by oil analysis and wear debris analysis. **Assignment 2 (30%) due – 5pm Wednesday 18 October**
13	23 Oct	Phil Howlin	Review of course material.

6. Assessment

Assessment Overview

You will be assessed by way of two MATLAB®-based assignments and two examinations, all of which will generally involve a combination of calculations and written descriptive material.

The various assessments contribute towards the overall grade as follows:

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Assignment 1: Fourier Analysis	~ 10 pages	15%	1, 3 and 4	Technical content	Week 6 5pm* Wednesday 30th August Submit on Moodle	5pm Saturday 2nd September	Two weeks after submission
Assignment 2: Diagnostics Project	25 pages	30%	1, 2, 3 and 4	Technical content and report writing skills	Week 12 5pm* Wednesday 18th October Submit on Moodle	5pm Tuesday 24th October	Two weeks after submission
Mid-Semester Exam	2 hours	15%	1 and 4	All course content from weeks 1-5	Week 7 6pm Monday 4th September	N/A	Two weeks after exam
Final exam	2 hours	40%	1, 2 and 4	All course content from weeks 1-12 inclusive	Exam period, date TBC	N/A	Upon release of final results

* Assignments are due at 5pm but may be submitted as late as 11:55pm without penalty. See ‘Submission’ below.

To pass the course, you must achieve an overall mark of at least 50%.

Assignments will be made available on the UNSW Moodle website along with data required to complete the 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

Assignments are due at 5pm on their due date through the TurnItIn submission 'box' on the course Moodle site. If you have trouble with a submission before this time the course convener is available to contact and can assist. You may submit the assignment any time before 11:55pm on the day that the assignment is due without penalty. If there are any problems with the submission process, however, the course convener will not be available to assist.

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Special consideration for assessment tasks must be processed through student.unsw.edu.au/special-consideration. 5:00pm the next day is the time at which the assignment is 'another day' late.

It is always worth submitting late assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

Where there is no special consideration granted, the 'deadline for absolute fail' in the table above indicates the time after which a submitted assignment will not be marked, and will achieve a score of zero for the purpose of determining overall grade in the course.

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 will be one two-hour examination in Week 7 during the normal lecture time covering material from weeks 1 to 5 and one two-hour examination at the end of the semester, covering all material.

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods, which are June for Semester 1 and November for Semester 2.

Provisional Examination timetables are generally published on myUNSW in May for Semester 1 and September for Semester 2.

For further information on exams, please see the Exams section on the intranet.

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 shown 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 School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an "Approved" sticker will not be allowed into the examination room.

Special consideration and supplementary assessment

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

7. Attendance

You are required to attend a minimum of 80% of all classes, including lectures, labs and seminars. It is possible to fail the course if your total absences equal to more than 20% of the required attendance. Please see the School intranet and the UNSW attendance page for more information.

Attendance will be noted periodically.

8. Expected resources for students

All material corresponding to the lectures, demonstrations and their solutions, and assignments will be provided in UNSW Moodle. Extra handouts and further useful material will be posted periodically in UNSW Moodle. You are advised to check it regularly.

All essential material for you to complete the course will be provided; the following references are mentioned in case you would like to investigate certain topics in further detail. The 'recommended text' is very useful for the course.

Recommended text

Randall, R. B., Vibration-based Condition Monitoring: Industrial, Aerospace and Automotive Applications, 1st Edition, Wiley, 2011. (Available in electronic form from the UNSW Library.)

Suggested references

Brandt, A., Noise and Vibration Analysis: Signal Analysis and Experimental Procedures, 1st Edition, Wiley, 2011.

Braun, S., Discover Signal Processing: An Interactive Guide for Engineers, 1st Edition, Wiley, 2008.

Rao, S.S., Mechanical Vibrations, 5th Edition, Prentice Hall, 2011.

Shin, K. and Hammond, J. K., Fundamentals of Signal Processing for Sound and Vibration Engineers, 1st Edition, Wiley, 2008.

Smith, D., Gear Noise and Vibration, 2nd Edition, Marcel Dekker, 2003.

Thomson, W. T., Theory of Vibration with Applications, 4th Edition, Chapman & Hall, 1993.

Other Resources

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

9. 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.

10. 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: 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

Further information on School policy and procedures in the event of plagiarism is available on the intranet.

11. Administrative matters and links

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

- Attendance, Participation and Class Etiquette
- UNSW Email Address
- Computing Facilities
- Assessment Matters (including guidelines for assignments, exams and special consideration)
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Student Support Services

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