

CVEN9840 Structural Health Monitoring Fundamentals and Practices

COURSE DETAILS

Units of Credit	6		
Contact hours	4 hours per week		
Class and Workshop	Wednesday	18:00 – 20:00	online
	Friday	10:00 – 12:00	online

Course Coordinator and Lecturer	Dr. Mehrisadat Makki Alamdari		
	E-mail: m.makkialamdari@unsw.edu.au		
	office: Civil Engineering Building (H20), Level 7, Room CE714		

INFORMATION ABOUT THE COURSE

Structural health monitoring (SHM) refers to the process of design and implementing a condition monitoring and characterization strategy for engineering structures. Needs for optimization of maintenance costs, objective and science-based inspection practices, increase of safety, emergence of new and improved construction materials and methods, new developments in measurement, sensing, processing and monitoring, as well as recent technological developments in various branches of science and engineering led to creation of relatively new, interdisciplinary branch of engineering – Structural Health Monitoring. SHM examines the use of low-cost, long term monitoring systems to keep infrastructure under constant surveillance, ensuring structural integrity. It has received great deal of attention all over the world due to its significant impact on safety and longevity of the structures.

This subject provides an introduction and motivation of SHM with a systematic approach to SHM process. It introduces the topics with basic definitions of measurement and monitoring, various available and emerging monitoring technologies, data acquisition systems and instrumentation, passive and active sensing technologies. The course will cover the principal methods used for local non-destructive evaluation (NDE) and global vibration based SHM techniques. Overview of signal processing basics, feature extraction and a comprehensive list of comparative features will be addressed. Brief overview of structural dynamics will be presented. The students will be provided with hands-on experience in experimental and operational modal analysis, and will learn techniques for structural properties extraction from the measured data. Basics on data interpretation are presented. The subject will also introduce students to the concepts of statistical pattern recognition and machine learning with focus on some well-known supervised and un-supervised learning techniques.

HANDBOOK DESCRIPTION

See link to virtual handbook:

<https://www.handbook.unsw.edu.au/postgraduate/courses/2021/CVEN9840>

OBJECTIVES

The topic of SHM is extremely relevant to the civil engineering profession as there is an ever-increasing demand to ensure the safety, and assess the state of health of existing structures. This subject will provide students with the tools and skills which can be implemented to develop sustainable maintenance and monitoring schemes which is critically important for civil engineering practice.

This subject is intended for postgraduate or senior undergraduate level students in CVEN. This subject cuts across the traditional subjects' boundaries and educate students with advanced problem-solving techniques. The aim is to fill the gap between the theoretical knowledge and its applications to civil engineering by providing enough insights into the relationship between the problems encountered in practice and the associated theory.

TEACHING STRATEGIES

Suggested approaches to learning in the course are tabulated below.

Private Study	<ul style="list-style-type: none">• Review lecture material and textbook• Do set problems and assignments• Join Moodle discussions of problems• Reflect on class problems and assignments• Download materials from Moodle• Keep up with notices and find out marks via Moodle
Lectures	<ul style="list-style-type: none">• Find out what you must learn• Follow worked examples• Hear announcements on course changes
Workshops	<ul style="list-style-type: none">• Be guided by lecturer• Practice solving set problems• Ask questions
Assessments (Final exam and hand-in assignments)	<ul style="list-style-type: none">• Demonstrate your knowledge and skills• Demonstrate higher understanding and problem solving

EXPECTED 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.	Understand and implement fundamental concepts of SHM	PE1.1-PE1.6
2.	Evaluate the state-of-the-art technology and equipment to analyse the integrity of existing civil structures	PE2.1-PE2.4
3.	Design and conduct experiments, as well as analyse and interpret data	PE2.1-PE2.4
4.	Identify, formulate and solve engineering problems under realistic constraints and conditions	PE2.1- PE2.4
5.	Develop analytical and independent critical thinking	PE3.3
6.	Communicate effectively orally and in writing	PE3.2

COURSE PROGRAM**Term 2 2021**

Date	Topic
Lecture & Workshop 1: 02/06/2021 Lecture & Workshop 2: 04/06/2021	(Week 1): Structural Health Monitoring (SHM) Background and Motivation
Lecture & Workshop 1: 09/06/2021 Lecture & Workshop 2: 11/06/2021	(Week 2): Measurement and Sensing
Lecture & Workshop 1: 16/06/2021 Lecture & Workshop 2: 18/06/2021	(Week 3): Structural Dynamics Single Degree of Freedom (SDOF)
Lecture & Workshop 1: 23/06/2021 Lecture & Workshop 2: 25/06/2021	(Week 4): Structural Dynamics Multi Degree of Freedom (MDOF)
Lecture & Workshop 1: 30/06/2021 Lecture & Workshop 2: 02/07/2021	(Week 5): Experimental Modal Analysis (EMA)
---	(Week 6): Flexibility week for all courses (non-teaching)
Lecture & Workshop 1: 14/07/2021 Lecture & Workshop 2: 16/07/2021	(Week 7): Vibration Based Damage Identification
Lecture & Workshop 1: 21/07/2021 Lecture & Workshop 2: 23/07/2021	(Week 8): Statistical Learning
Lecture & Workshop 1: 28/07/2021 Lecture & Workshop 2: 30/07/2021	(Week 9): Non-Destructive Testing
Lecture & Workshop 1: 04/08/2021 Lecture & Workshop 2: 06/08/2021	(Week 10): Industry Guest Lecture

ASSESSMENT

The final grade for this course will be based on the sum of the scores from each of the assessment tasks. *The assessment of this course will be based on four assignments, and a final exam. A mark of at least 40% in the final examination is required before the assignments' mark is included in the final mark.*

Note: The lecturer reserves the right to adjust the final scores by scaling.

1. Assignment (Homework) – 50%

- Assignment 1 (10%)
- Assignment 2 (10%)
- Assignment 3 (15%)
- Assignment 4 (15%)

2. Final Exam: 50%

Supplementary Examinations for Term 2 2021 will be held on Monday 6th September – Friday 10th September 2021 (inclusive) should you be required to sit one. You are required to be available during these dates. Please do not to make any personal or travel arrangements during this period.

PENALTIES

A penalty of 10% will apply for each day of late submission for assignments.

ASSESSMENT OVERVIEW

Item	Length	Weighting	Learning outcomes assessed	Assessment Criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
1. Assignment 1	Homework	10%	PE1.1-1.6, PE2.1-2.4, PE3.2-3.5	See assignment question uploaded on Moodle	18 June 2021	25 June 2021	25 June 2021
2. Assignment 2	Homework	10%	PE1.1-1.6, PE2.1-2.4, PE3.2-3.5	See assignment question uploaded on Moodle	9 July 2021	16 July 2021	16 July 2021
3. Assignment 3	Homework	15%	PE1.1-1.6, PE2.1-2.4, PE3.2-3.5	See assignment question uploaded on Moodle	30 July 2021	6 August 2021	6 August 2021
4. Assignment 4	Homework	15%	PE1.1-1.5, PE2.1-2.4, PE3.2-3.5	See assignment question uploaded on Moodle	13 August 2021	20 August 2021	20 August 2021
5. Final Exam	TBA	50%	PE1.1-1.6, PE2.1-2.4, PE3.2-3.5		Final exam period 13 August- 26 August		Official release of results

RELEVANT RESOURCES

- Farrar, C.R. and Worden, K., 2012. *Structural health monitoring: a machine learning perspective*. John Wiley & Sons.
- Chen, H.P. and Ni, Y.Q., 2018. *Structural health monitoring of large civil engineering structures*. Hoboken, NJ: Wiley Blackwell.
- Placko, D. ed., 2013. *Fundamentals of instrumentation and measurement*. John Wiley & Sons.
- Morris, A.S. and Langari, R., 2012. *Measurement and instrumentation: theory and application*. Academic Press.
- Géradin, M. and Rixen, D.J., 2014. *Mechanical vibrations: theory and application to structural dynamics*. John Wiley & Sons.
- Chopra, A.K., 2017. *Dynamics of structures. theory and applications to. Earthquake Engineering*.
- Graham, K.S., 2000. *Fundamentals of Mechanical Vibrations*.
- Ewins, D.J., 2009. *Modal testing: theory, practice and application*. John Wiley & Sons.
- Fu, Z.F. and He, J., 2001. *Modal analysis*. Elsevier.
- Duda, R.O., Hart, P.E. and Stork, D.G., 2012. *Pattern classification*. John Wiley & Sons.
- Bishop, C.M., 2006. *Pattern recognition and machine learning*. Springer.
- Murphy, K.P., 2012. *Machine learning: a probabilistic perspective*. MIT press.
- Mix, P.E., 2005. *Introduction to nondestructive testing: a training guide*. John Wiley & Sons.

DATES TO NOTE

Refer to MyUNSW for Important Dates available at:

<https://student.unsw.edu.au/dates>

PLAGIARISM

Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise are also liable to disciplinary action, including exclusion from enrolment.

Plagiarism is the use of another person's work or ideas as if they were your own. When it is necessary or desirable to use other people's material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at:

<https://student.unsw.edu.au/plagiarism>

ACADEMIC ADVICE

For information about:

- Notes on assessments and plagiarism;
- Special Considerations: student.unsw.edu.au/special-consideration;
- General and Program-specific questions: [The Nucleus: Student Hub](#)
- Year Managers and Grievance Officer of Teaching and Learning Committee, and
- CEVSOC/SURVSOC/CEPCA

Refer to Key Contacts on the Faculty website available at:

<https://www.unsw.edu.au/engineering/student-life/student-resources/key-contacts>

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