School of Civil and Environmental

Term 3, 2020

CVEN9840 Structural Health Monitoring Fundamentals

COURSE DETAILS

Units of Credit	6
Contact hours	4 hours per week
Class and Workshop	Friday 12:00 – 16:00 online

Course Coordinator and Lecturer	Dr. Mehrisadat Makki Alamdari email: 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/2020/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	• 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	• Find out what you must learn • Follow worked examples • Hear announcements on course changes
Workshops	• Be guided by lecturer • Practice solving set problems • Ask questions
Assessments **(Final exam and hand-in assignments)**	• 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 3 2020

Date	Topic
18/09/2020 (Week 1)	**Structural Health Monitoring (SHM) Background and Motivation**
25/09/2020 (Week 2)	**Measurement and Sensing**
02/10/2020 (Week 3)	**Structural Dynamics Single Degree of Freedom (SDOF)**
9/10/2020 (Week 4)	**Structural Dynamics Multi Degree of Freedom (MDOF)**
16/10/2020 (Week 5)	**Experimental Modal Analysis (EMA)**
23/10/2020 (Week 6)	***Flexibility week for all courses (non-teaching)***
30/10/2020 (Week 7)	**Vibration Based Damage Identification**
06/11/2020 (Week 8)	**Statistical Learning**
13/11/2020 (Week 9)	**Non-Destructive Testing**
20/11/2020 (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 3 2020 will be held on Monday 11th January – Friday 15th January 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*	*2 October 2020*	*9 October 2020*	*9 October 2020*
2. Assignment 2	Homework	10%	*PE1.1-1.6, PE2.1-2.4, PE3.2-3.5*	*See assignment question uploaded on Moodle*	23 October 2020	30 October 2020	30 October 2020
3. Assignment 3	Homework	15%	*PE1.1-1.6, PE2.1-2.4, PE3.2-3.5*	*See assignment question uploaded on Moodle*	13 November 2020	20 November 2020	20 November 2020
4. Assignment 4	Homework	15%	*PE1.1-1.5, PE2.1-2.4, PE3.2-3.5*	*See assignment question uploaded on Moodle*	27 November 2020	4 December 2020	4 December 2020
5. Final Exam	TBA	50%	*PE1.1-1.6, PE2.1-2.4, PE3.2-3.5*		Final exam period		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 Academic Advice on the School website available at:

https://www.engineering.unsw.edu.au/civil-engineering/student-resources/policies-procedures-and-forms/academic-advice

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