DEPARTMENT OF ENGINEERING

UNIVERSITY OF CAMBRIDGE

Module 5R13:

Experimental Methods in Mechanics

Leader: Professor J Woodhouse (jw12@cam.ac.uk)

Timing: The module can run in both Michaelmas and Lent terms, and can also run by arrangement at other times of year if needed. Contact Prof Woodhouse to arrange an initial briefing session.

Prerequisites: Dependent on the assignments taken; discuss with Prof Woodhouse.

Structure: A series of coursework exercises, each undertaken after a preliminary demonstration session.

Mode of Assessment: Coursework

AIMS

The module provides training in a range of laboratory techniques for mechanical testing and analysis. Many are based around in-house Matlab software for data acquisition and analysis. Candidates must complete a minimum of four from the following list of assignments. Each assignment comprises a guided laboratory exercise on which a report should be written and submitted for assessment. This will be followed by a feedback session.

ASSIGNMENTS

(1) *Introduction to digital vibration measurement.*
The coursework associated with third-year module 3C6.This experiment introduces a range of ways to measure vibration transfer functions using a digital datalogger. It provides essential background information for several other assignments, including an introduction to the CUED data-logging software package. For those who have not already taken the third-year undergraduate module 3C6, this unit is strongly advised.

(2) *Experimental modal analysis.*
The coursework associated with fourth-year module 4C6.For those who have not taken this module, this exercise gives an introduction and demonstration of the technique of experimental modal analysis, using impact-hammer testing on a grid of points covering the test object to give quantitative measurements of the normalised mode shapes.

(3) *Wave propagation, group velocity and time-frequency analysis.*
This experiment involves measuring the vibration response of a long bending beam and the acoustic response of a circular duct. The signals can be analysed using time-frequency (or sonogram) analysis to give an experimental comparison with theoretical predictions of the group velocity. Some Matlab programming is involved in this experiment.

(4) *The scanning laser vibrometer.*
Structured learning exercise in the use of the scanning laser vibrometer to measure response at a grid of points on a test structure, and obtain 3D animations of the vibration at resonance peaks.

(5) *Calibration of vibration measurements.*
An exercise which illustrates and compares calibration methods for vibration transfer functions and for the various individual components such as hammers, shakers and accelerometers.

(6) *Measurement of elastic and damping properties of sheet material by vibration testing.*
Vibration methods often give the simplest and most accurate way to measure the elastic properties of materials. This experiment works through a systematic procedure to determine the relevant elastic constants for an isotropic or orthotropic sheet material. The associated vibration damping properties are also measured.

(7) *Introduction to the Hysitron nanoindenter*.
Mechanical properties of many materials can be characterised by nanoindentation. In this exercise you will learn to use the Hysitron machine to conduct standard tests on three different materials, and to interpret the results and assess their significance.

(8) *Introduction to driving simulator rig.*
Exercise to observe how a driver controls a vehicle via the steering wheel under the circumstance that the AFS (Active Front-wheel Steering) controller holds different target path from the driver, using a driving simulator. The second stage of the experiment is to identify and validate a driver-AFS non-cooperative game model which has been built to predict the driver's steering behaviour, using recorded experimental data.

(9) *Introduction to FTIR.*
The chemical composition of many materials can be analysed using infrared spectroscopy. This exercise introduces the background concepts, and takes you through a learning exercise on the Perkin-Elmer Spectrum 100 ATR-FTIR in the Metrology Wet Lab. You will learn to make good measurements that are repeatable and can be compared between materials, and also how to treat mixtures by taking advantage of superposition in absorbance mode.

(10) *Microscopy and image analysis.*
This exercise introduces several types of microscopy available in CUED, including associated image analysis software. It covers light microscopy, scanning electron microscopy and scanning probe microscopy.

(11) *Arm muscle analysis with electromyography*
An exercise to introduce the use of electromyography for measuring the activation of arm muscles. The exercise involves lifting and pulling weights, and gives an understanding of the key muscles of the arm when performing such tasks.

(12) *Introduction to the Dynamic Mechanical Analyser*
The viscoelastic behaviour of many materials can be analysed using a dynamical mechanical analyser (DMA). This exercise introduces the background concepts, and takes you through a learning exercise on the Triton Technologies DMA in the Inglis Materials teaching laboratory, testing polymer samples.

ASSESSMENT

Candidates will submit 4 reports, each carrying equal credit. The submission dates will be by arrangement.

JW/RWDC – Sep 2014