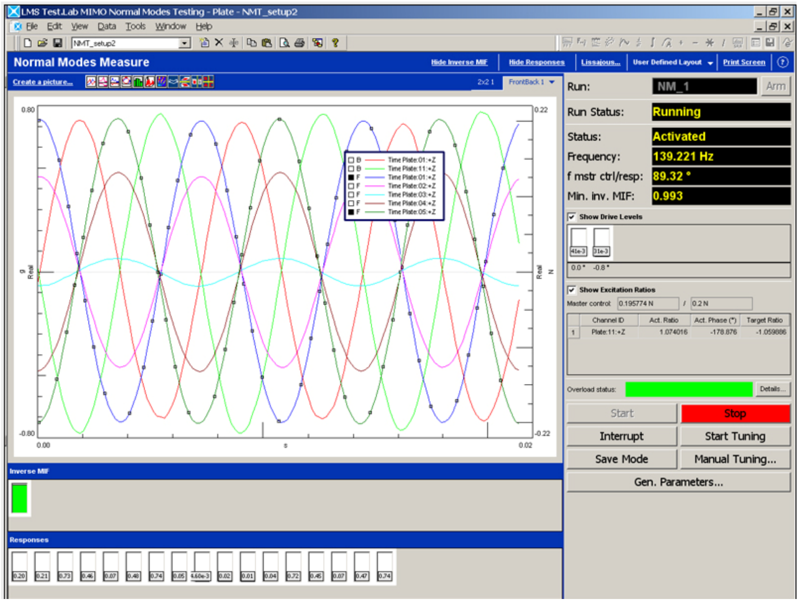
THE CENTER FOR
PROFESSIONAL STUDIES



Experimental Modal Analysis

Modal analysis is an essential technology behind solving today's noise and vibration problems. This course focuses on the practical implementation of experimental modal analysis testing.

- First, the basics of technical concepts and practical hands-on performance of an experimental modal test

- Next, participants will focus on the concepts of theoretical background, digital signal processing, excitation techniques and extraction of modal parameters from measured frequency response functions.

- Lastly, participants will be shown how to run the model and interpret output results on LMS software products. A thorough understanding of what these results mean and how to use them to improve the product design will be discussed.

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Course Syllabus

I IDENTIFYING INFORMATION

Course:	Experimental Modal Analysis
Prerequisite:	Digital Signal Processing in Noise and Vibration Testing
Time Frame:	40 total contact hours
Instructor:	Dr. Peter Avitabile Director of the Modal Analysis and Controls Laboratory BS in Mechanical Engineering MS in Mechanical Engineering PhD in Mechanical Engineering 25 years at UMASS Lowell Professor Mechanical Engineering 10 years industrial experience in structural dynamics, modeling and design
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II REFERENCE MATERIALS

1. The Fundamentals of Signal Analysis (Hewlett Packard App Note 243)
2. Fundamentals of Modal Analysis (Hewlett Packard App Note 243-3)
3. Experimental Modal Analysis - A Simple Non-Mathematical Overview http://sdasl.uml.edu/umlspace/s&v_Jan2001_Modal_Analysis.PDF
4. Modal Space articles originally published in Experimental Techniques, http://sdasl.uml.edu/umlspace/mspace.html

III COURSE GOALS AND OBJECTIVES

1. Understand the basic steps in the development of an experimental model
2. Understand the basic considerations for the test
3. Understand SDOF and MDOF models
4. Understand the concept of modal space
5. Understand the need for windowing and its effects
6. Understand the basic measurements needed for experimental modal analysis
7. Understand and be able to apply impact excitation techniques
8. Understand the shaker excitation techniques employed in modal testing
9. Understand tools used for identification of modes
10. Understand and be able to validate experimental modal models
11. Understand how to calibrate and mount transducers

IV METHODOLOGY

This course is an introduction to experimental modal analysis theory and techniques that are used to characterize the dynamic characteristics of structures. Each module will introduce new material that the student will be allowed to experience for himself with the associated labs.

Lectures

Each detailed subject will be presented in a lecture format outlining the theory and standardized accepted methodology. A printed copy of the lecture material will be provided for the student's personal in-class use and as a reference material.

Specific Industry Examples

Real life examples will be covered that explain the application of the theory to various industries such as automotive, aerospace, home appliance. This will give the students a clear understanding of how and why these techniques are utilized in different industries and the value they add to noise and vibration refinement.

In-Class Assignments

The student will conduct several hands-on labs to reinforce the theoretical concepts and to conduct an experimental modal analysis. These labs will increase in complexity as the students further develop their skills in understanding modal theory and practice. The students will present their work to the group for review and discussion.

V COURSE OUTLINE & ASSIGNMENTS

Module 1 – Overview of Structural Dynamic Modeling Techniques

- Modal Analysis and Structural Dynamics
- Analytical Modal Analysis
- Finite Element Models
- Experimental Modal Analysis
- Experimental Modal Reduction
- Frequency Response Functions (FRFs)
- Shaker vs. Impact
- Mode Shapes from FRFs
- Operating Data
- Uses of Modal Analysis

Module 2 – Introduction to Modal Analysis

- What is Modal Analysis?
- What is Finite Element Analysis?
- What is Experimental Modal Analysis?
- Analytical and Experimental Modal Correlation

Module 3 – Modal Test Considerations

- Why???
- Test Setup
- Acquire FRF Measurements
- Identify Modes
- Estimate Residues / Mode Shapes
- Validate Model

Module 4 – Basic Modal Analysis Theory and Related Topics

- Different Mathematical Model Formulations
- SDOF Theoretical Overview
- MDOF Theoretical Overview
- Frequency Response Functions
- Linear Algebra Concepts

Module 5 – Digitization, Quantization, Aliasing, Leakage

Digitization of Time Signals
Quantization & Quantization Error
Sampling
Time vs. Frequency
Aliasing & Anti-Aliasing Filters
Fourier Transform
Leakage

Module 6 - Windows

Rectangular / Hanning / Flat Top
Window Effects
Force / Exponential for Impact Testing

Module 7 – Measurement Definitions

Linear Spectra
Power Spectra
Derived Relationships
Effects of Noise
Auto Power Spectrum
Cross Power Spectrum
Frequency Response Function
Coherence

Module 8 – Impact Excitation

Hammer Tip Selection
Pre-trigger Delay
Double Impact
Right Hammer for the Test
Exponential Window
Impact Excitation – Examples
Multiple Reference Impact Test

Module 9 – Shaker Excitation

Excitation Configuration
Signal Types
Signal Characteristics
General Excitation Characteristics
Swept Sine Excitation
Random Excitation
Pseudo Random Excitation
Periodic Random Excitation
Burst Random Excitation
Sine Chirp Excitation
Digital Stepped Sine Excitation
Comparisons

Module 10 – Mode Indicator Techniques

Identification of Indication Functions Typically Employed
(such as Mode Indicator Function, Multivariate Mode Indicator Function,
Complex Mode Indicator Function, Stability Diagram,)PolyMAX

Module 11 – Basic Modal Parameter Estimation

Parameter Estimation Concepts and Parameter Extraction Considerations
Classification of Modes; Time and Frequency Domain Representations
Different Forms of the Same Equation; Why Have Different Methods
Modal Parameter Estimation Concepts and Extraction Considerations
Mode Determination Tools; Model Order; Stability Diagram
Modal Extraction Methods
SDOF Modal Parameter Estimation
MDOF Modal Parameter Estimation
Modal Parameter Estimation Considerations

Module 12 – Modal Parameter Estimation Guidelines

Basic Curve Fitting; Considering Complicated Structures; Curve Fitting Guidelines

Module 13 – Model Validation

Animation
Modal Assurance Criteria
FRF Synthesis

Module 14 – Transducers

Transducer Calibration
Transducer Mounting Methods

Labs –

LMS Test.Lab Setup
Plexiplate Instrumentation Setup
Plexiplate Geometry Setup
Modal Impact Data Acquisition Setup
Shaker / Spectral Data Acquisition Setup
Modal Parameter Estimation