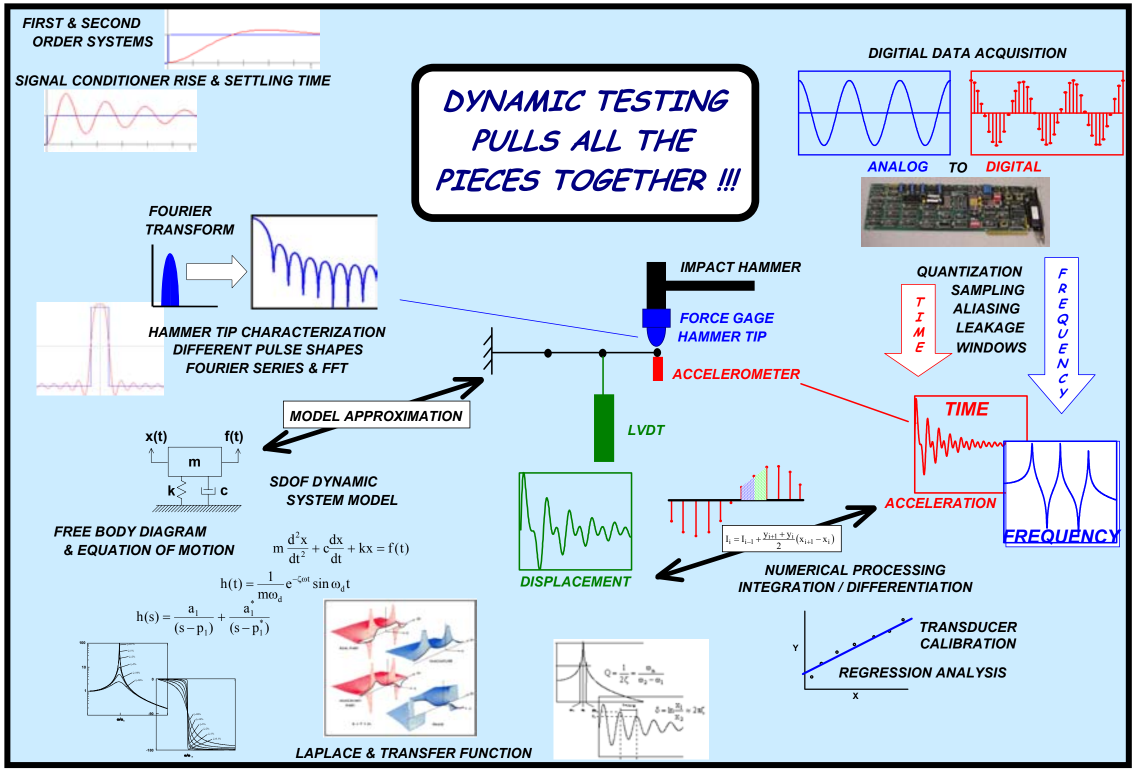
DYNamic SYStems

Developing a Multisemester Interwoven Dynamic Systems Project to Foster Learning and Retention of STEM Material



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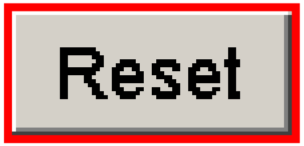
The Problem

Students generally do not understand how basic STEM (Science, Technology, Engineering and Math) material fits into all of their engineering courses

Relationship of basic material to subsequent courses is unclear to the student.

Practical relevance of the material is not clear.

Students hit the "reset button" after each course not realizing the importance of STEM material



The Problem

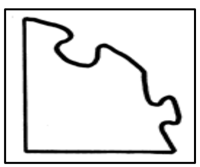
DYNamic SYStems

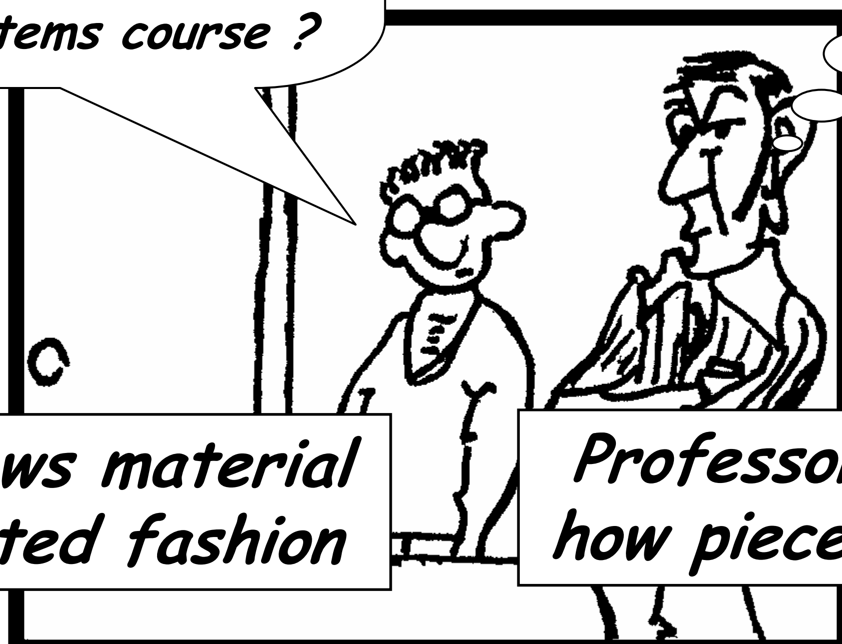
Student Comment:

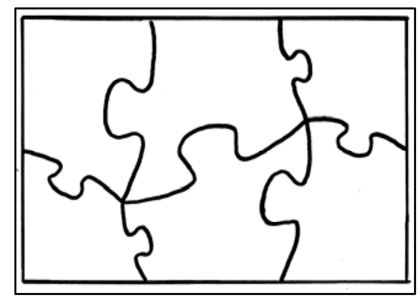
Professor, why didn't you tell us that the material covered in other courses was going to be really important for the work we need to do in this Dynamic Systems course ?

Professor Thoughts:

Hmmmmm...







Student views material in a disjointed fashion

Professor clearly sees how pieces fit together

Dr. Peter Avitabile, Assistant Professor
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How to Solve the Problem

A new multisemester interwoven dynamic systems project has been initiated

This is to better integrate the material from differential equations, mathematical methods, laboratory measurements and dynamic systems

This is done across several semesters/courses to help students better understand the relationship of basic STEM material to an ongoing problem

Goals & Objectives

- *Develop a project which spans across several semesters & courses to interweave related STEM material in a coherent fashion – strongly emphasizing the inter-relationship*

  - *Simple RC Circuit*
  - *Single SDOF System*

Cornerstone of Knowledge

- *Suggested for first evaluations*
- *These are generic to <u>all</u> engineering disciplines in that they exemplify 1st and 2nd order systems*

What Needs to be Addressed

Interwoven, multi-semester problem features:

- ***Differential equations & numerical processing***
- ***Fourier/Laplace transformations***
- ***Instrumentation/signal processing/calibration***
- ***Analog & digital data acquisition systems***
- ***Time & Frequency data***
- ***Impulse response & frequency response***
- ***Rise time & settling time***

Scope of the Complete Project

Phase 1 Develop analytically oriented material to address the problems and techniques for solving dynamic system problems. The intent is to provide analytical tools but also address the anticipated problems encountered in a real measurement environment

Phase 2 Develop experimentally oriented acquired data that extends the application of previously identified analytical techniques and addresses measurement issues associated with collecting real world data

Phase 3 Implement materials generated in another discipline and another institution. Modify and enhance of all materials based on feedback

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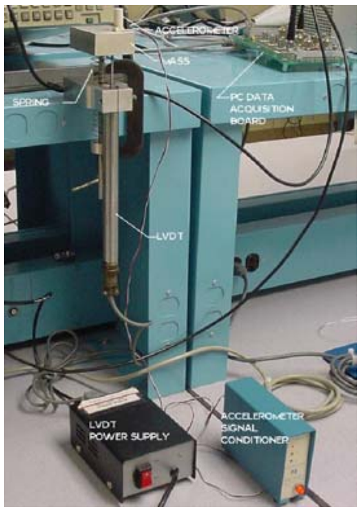
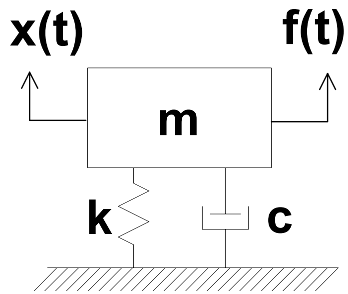
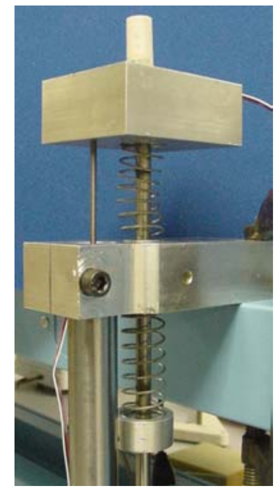
MCK Measurement System

A simple mass, spring, dashpot system is used to measure displacement and acceleration







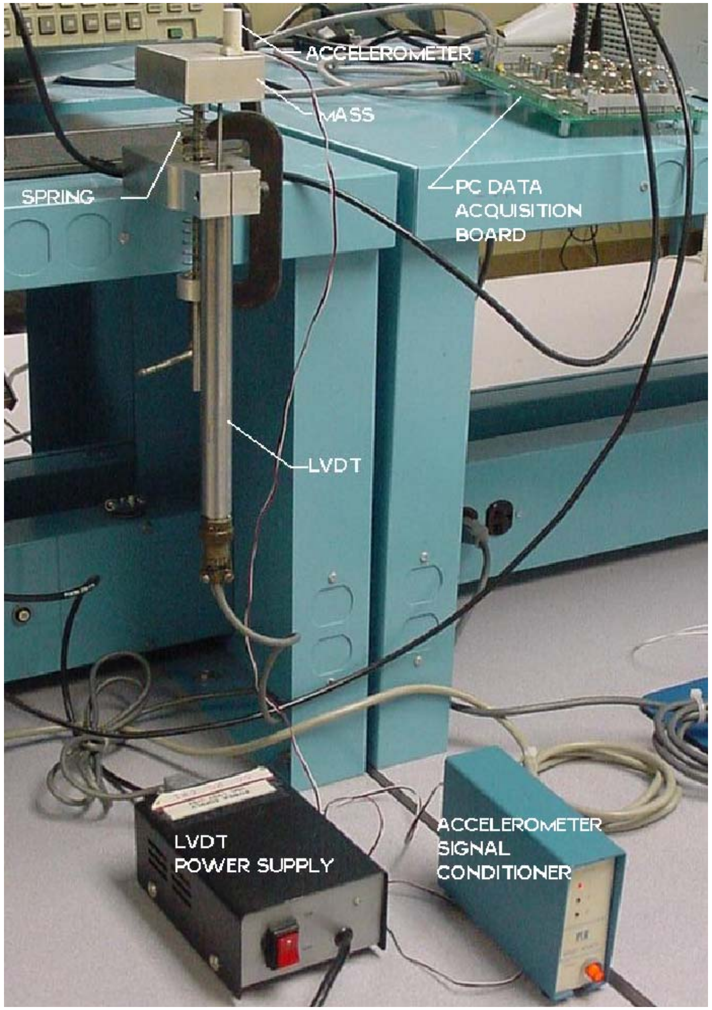
Numerical processing of integration/differential needed to process data

MCK Measurement System

Requires extensive use of a wide variety of different analytical tools.

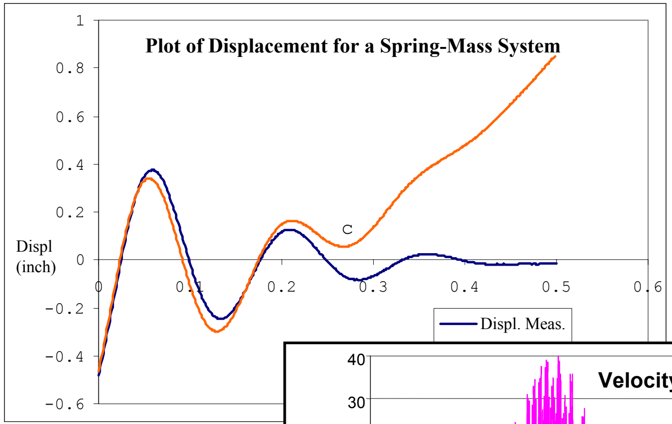
Significant numerical data manipulation needed.

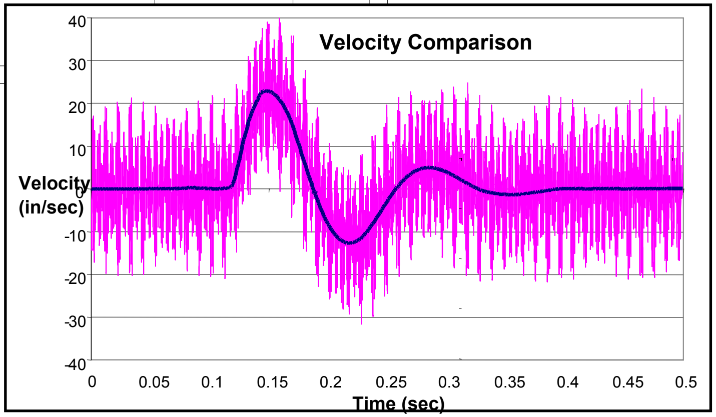
- ***Regression Analysis***
- ***Data Cleansing***
- ***Integration***
- ***Differentiation***



The data acquisition system and transducers are intentionally selected such that the majority of possible errors exist in the data

- ***Drift***
- ***Bias***
- ***Offset***
- ***Quantization***
- ***Noise***

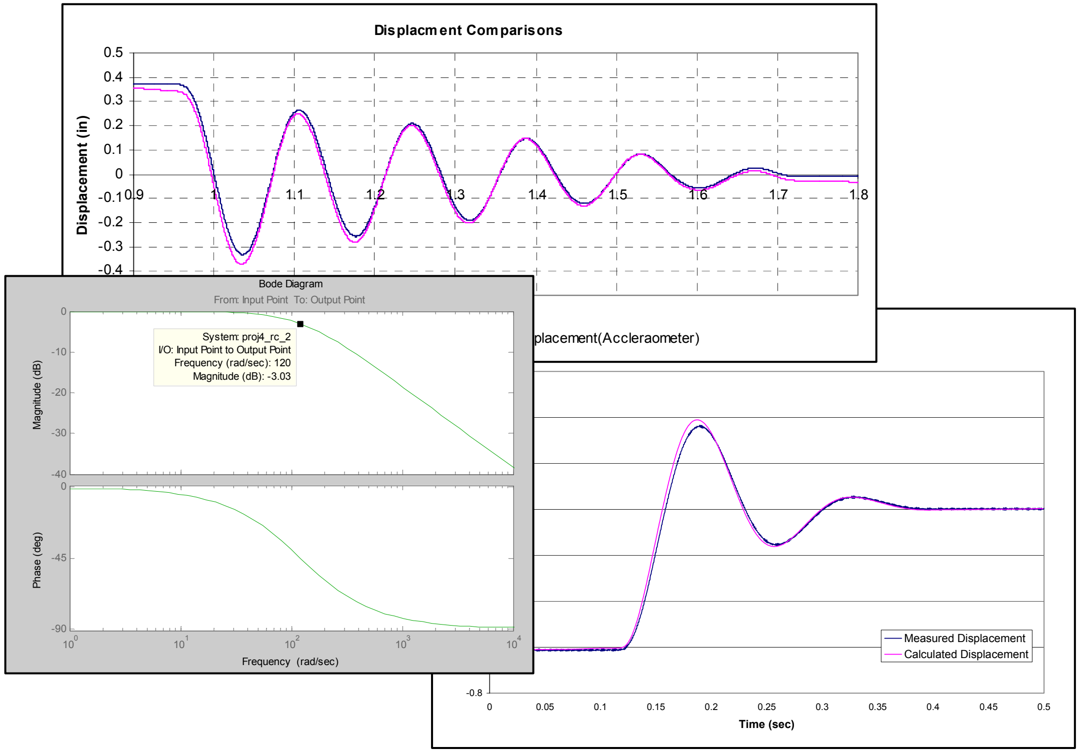




MCK Measurement System

The students are forced to integrate key STEM material and concepts to solve this problem

- ***Numerical processing***
- ***Filtering***
- ***Thinking is required !!!***



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What Has Been Addressed To Date

Several tutorials have been developed related to aspects of dynamic system response evaluation

MATLAB scripts utilizing a simple graphical user interface (GUI) emphasizing the inherent aspects of 1st and 2nd order system response developed

Voice annotated tutorials being developed

LABVIEW modules are also being developed

What Has Been Addressed To Date

Theoretical Aspects of First and Second Order Systems

First Order Systems – Modeling Step Response with ODE and Block Diagram

Second Order Systems – Modeling Step, Impulse, and Initial Condition Responses with ODE and Block Diagrams

Mathematical Modeling Considerations

Simulink and MATLAB Primer Materials

Miscellaneous Materials

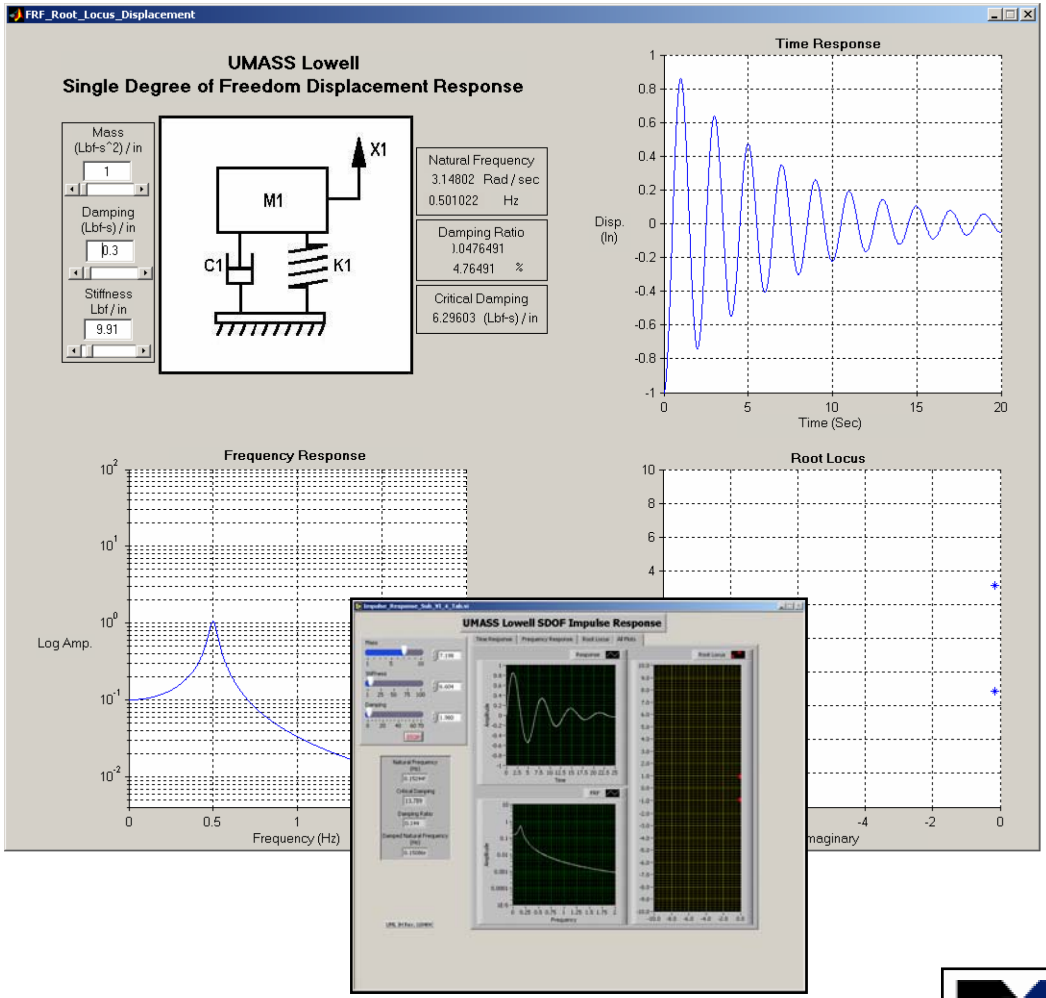
Some examples are illustrated on the following sheets

2nd Order System Initial Condition GUI

User enters M, C, K and natural frequency, critical damping and damping are reported.

User can vary the physical parameters with slide bars.

The frequency response function magnitude is displayed root locus and time response.



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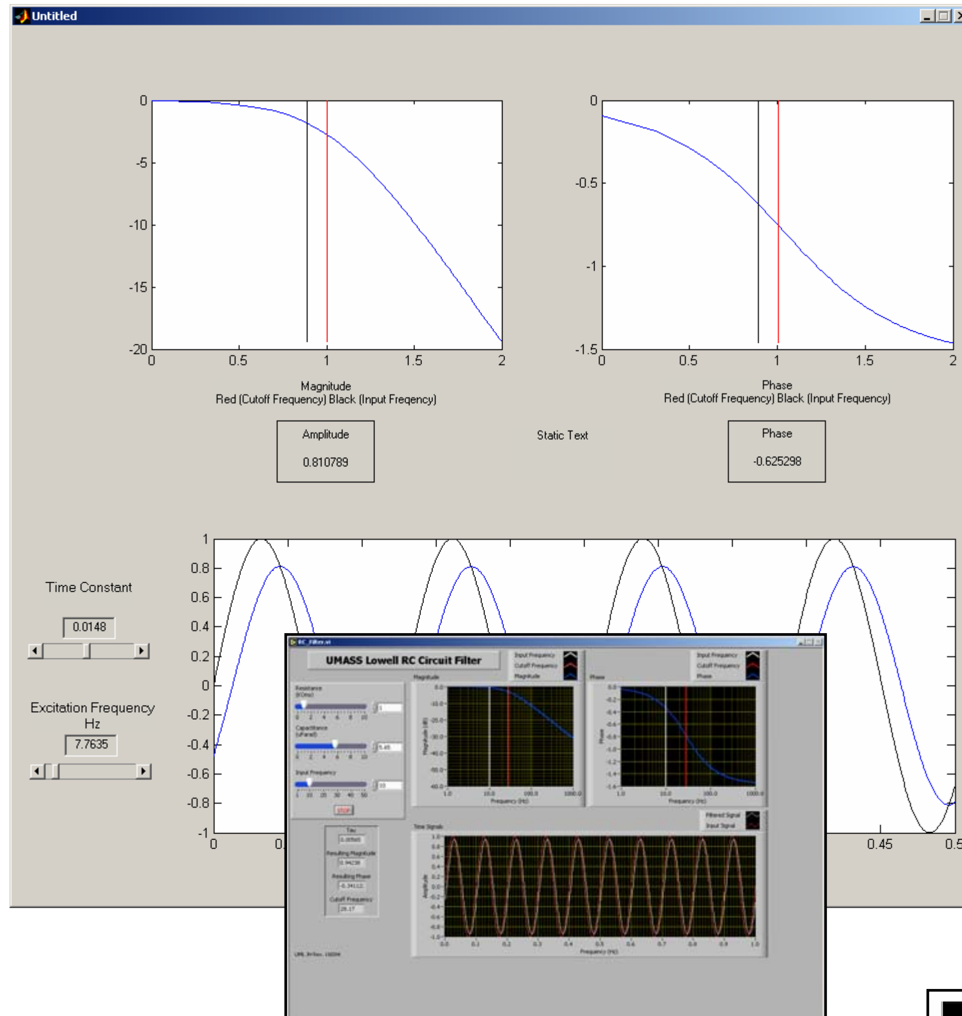
First Order Low Pass Filter GUI

User enters time constant and sinusoidal frequency.

The Bode plot is displayed with the cutoff frequency and the sinusoidal frequency applied.

The initial sinusoidal signal and "filtered" time signal are also displayed.

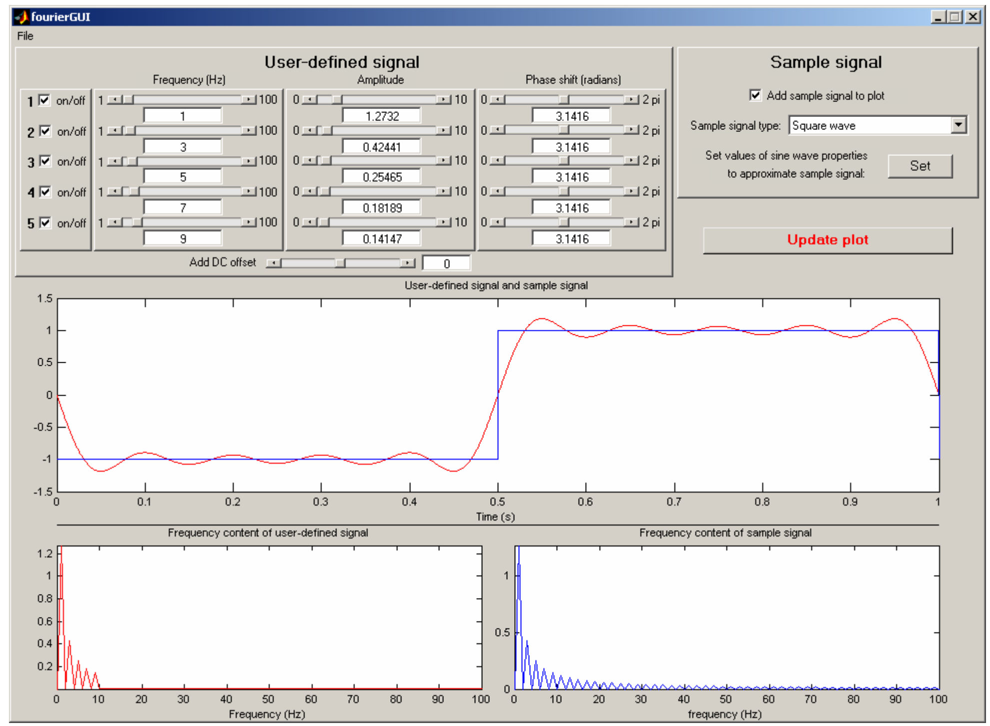


Fourier Series Signal Generation GUI

User enters frequency, amplitude and phase components of a user defined signal to display the resulting signal.

The user can also select sample signals such as square, triangle, etc and the pre-determined fourier coefficients are applied to the user-defined signal.

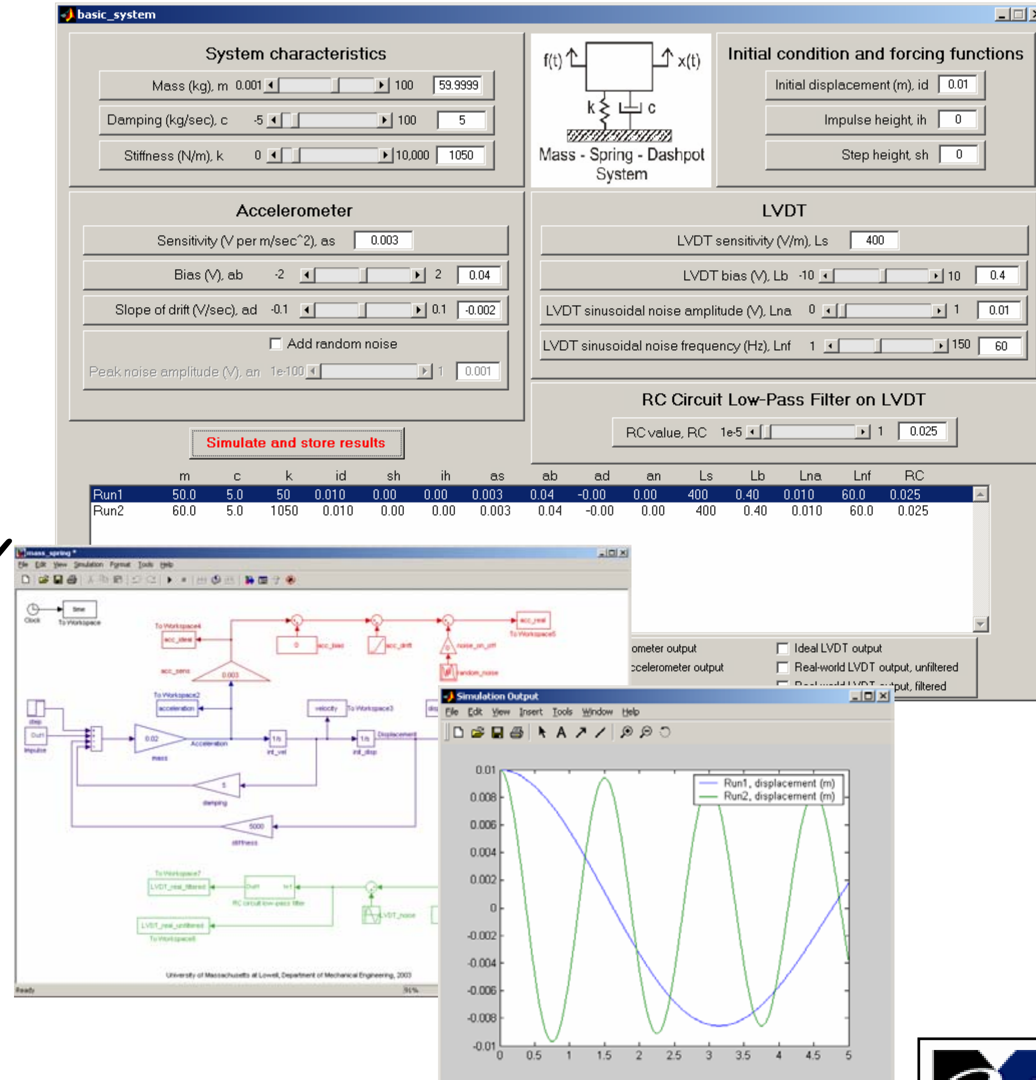
The time signal as well as the corresponding frequency component is displayed.



Virtual Measurement System GUI

User enters M, C, K system. User enters the amount of experimental distortion on the accel. (sensitivity, bias, drift) and displacement LVDT (sensitivity, bias, noise) and the low pass filter characteristics to virtually "simulate" the measurement environment.

Data can be exported with ability to select which outputs and what effects are included on the measurement.



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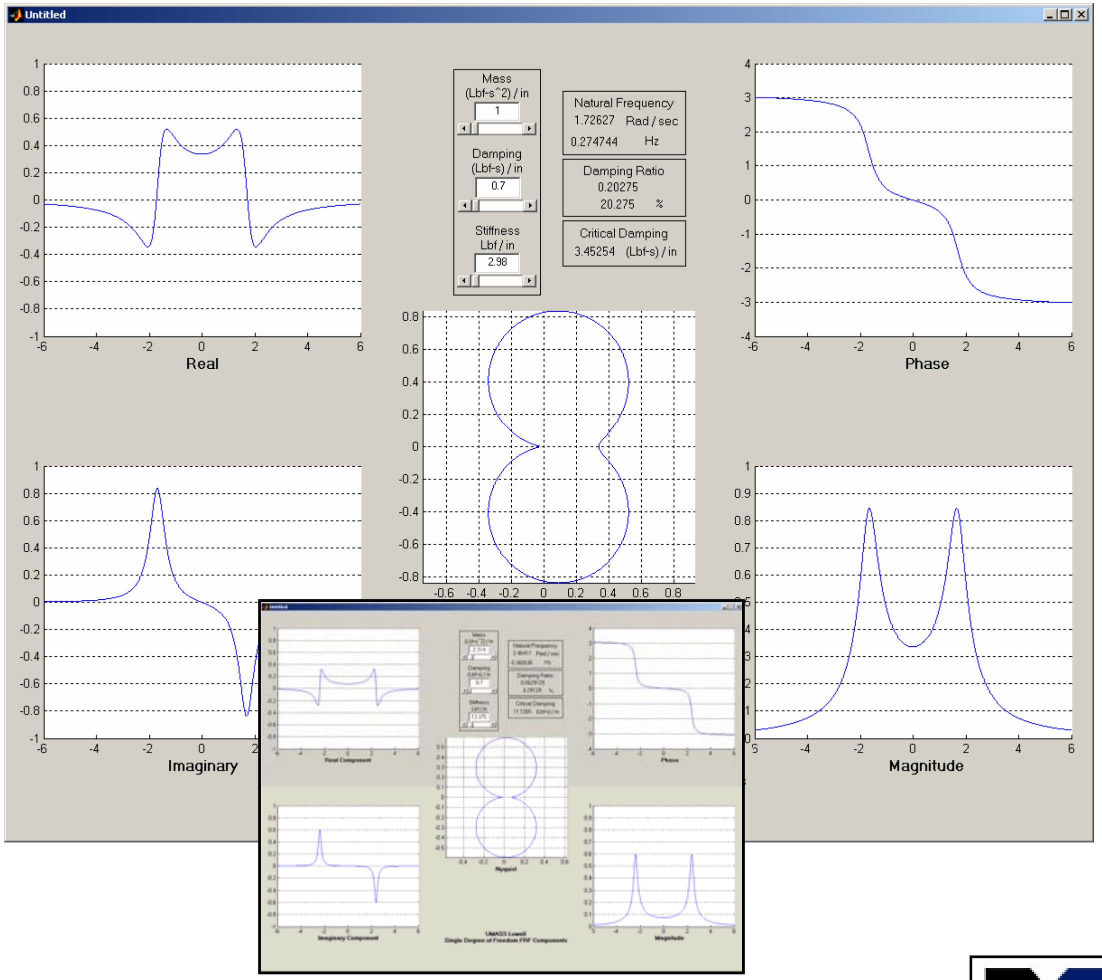
Single DOF Complex FRF Plot GUI

User enters M, C, K and natural frequency, critical damping and damping are reported.

User can vary the physical parameters with slide bars.

The complex frequency response function is displayed simultaneously as real, imaginary, magnitude, phase and nyquist plots.



Start MATLAB GUI

Webpage --- dynsys.uml.edu

Project Overview

Technical Papers

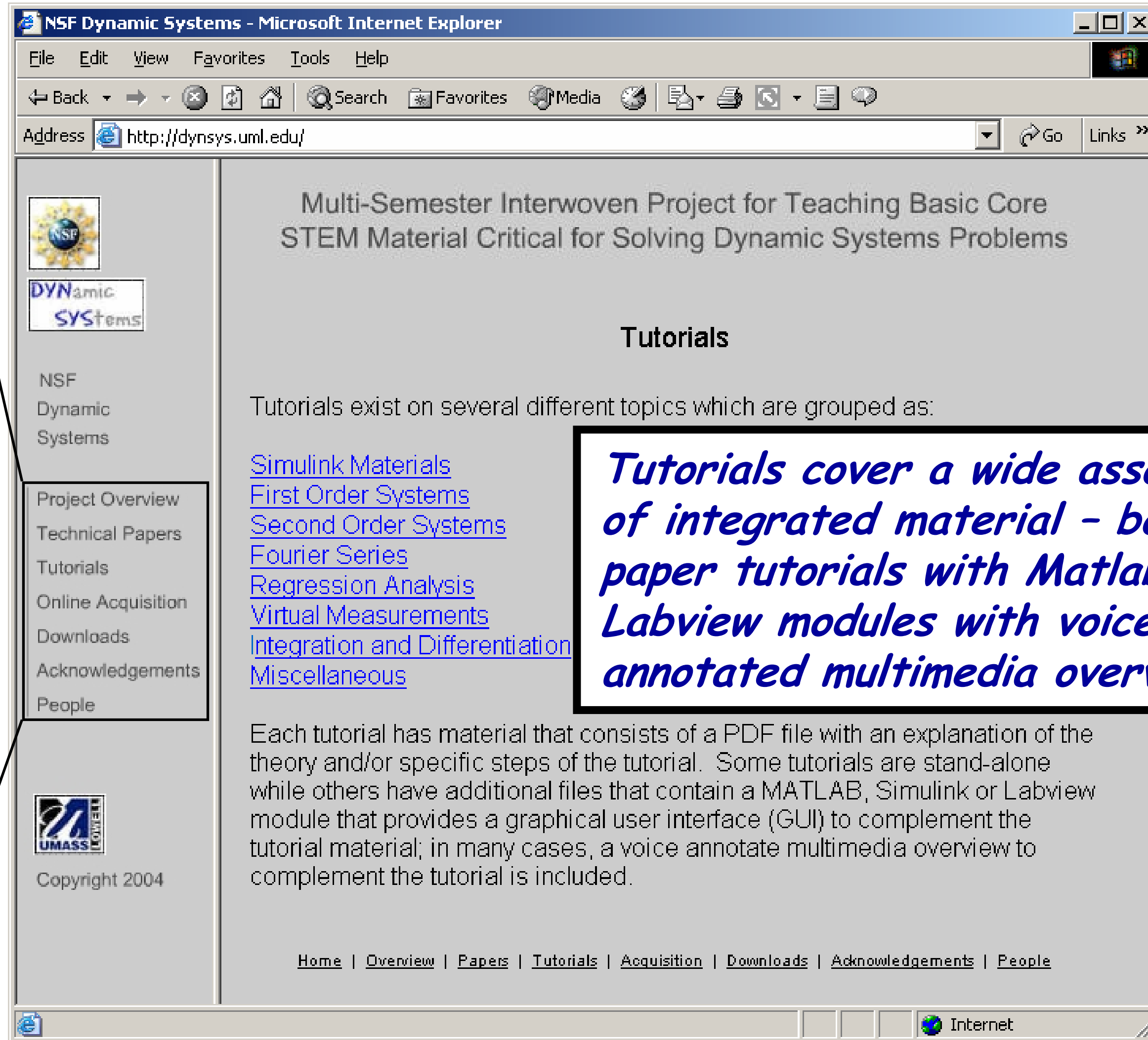
Tutorials

Online Acquisition

Downloads

Acknowledgements

People

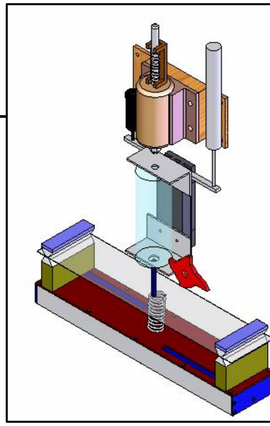


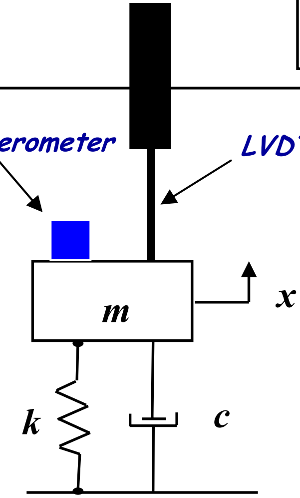
Tutorials cover a wide assortment of integrated material – both paper tutorials with Matlab and Labview modules with voice annotated multimedia overviews

Online Measurement System

RUBE

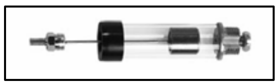
Response Under Basic Excitation





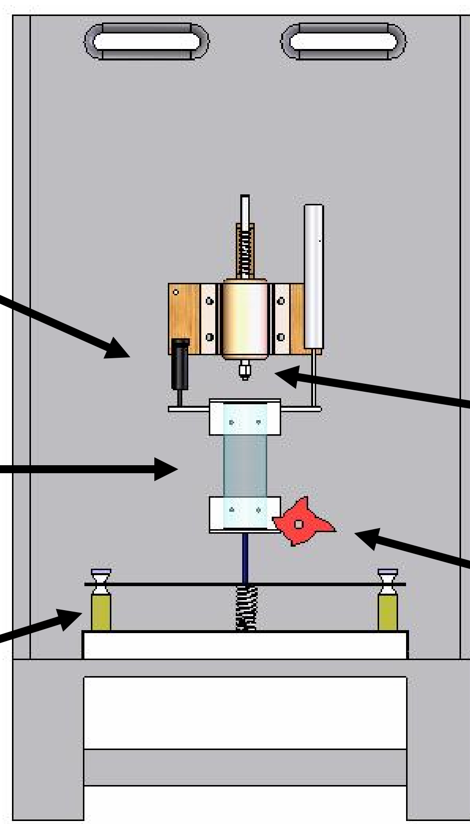
Measurement Devices

Variable Damping

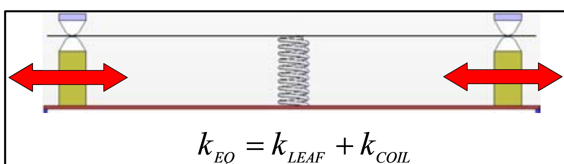


Variable Mass

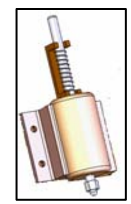
System Characteristics



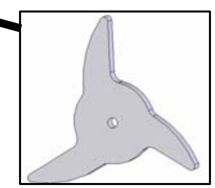
Variable Stiffness



Excitation



Impact Force



Initial Displacement

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Summary

DYNamic SYStems

A new multisemester interwoven dynamic systems project was described.

Several tutorials and modules developed were presented.

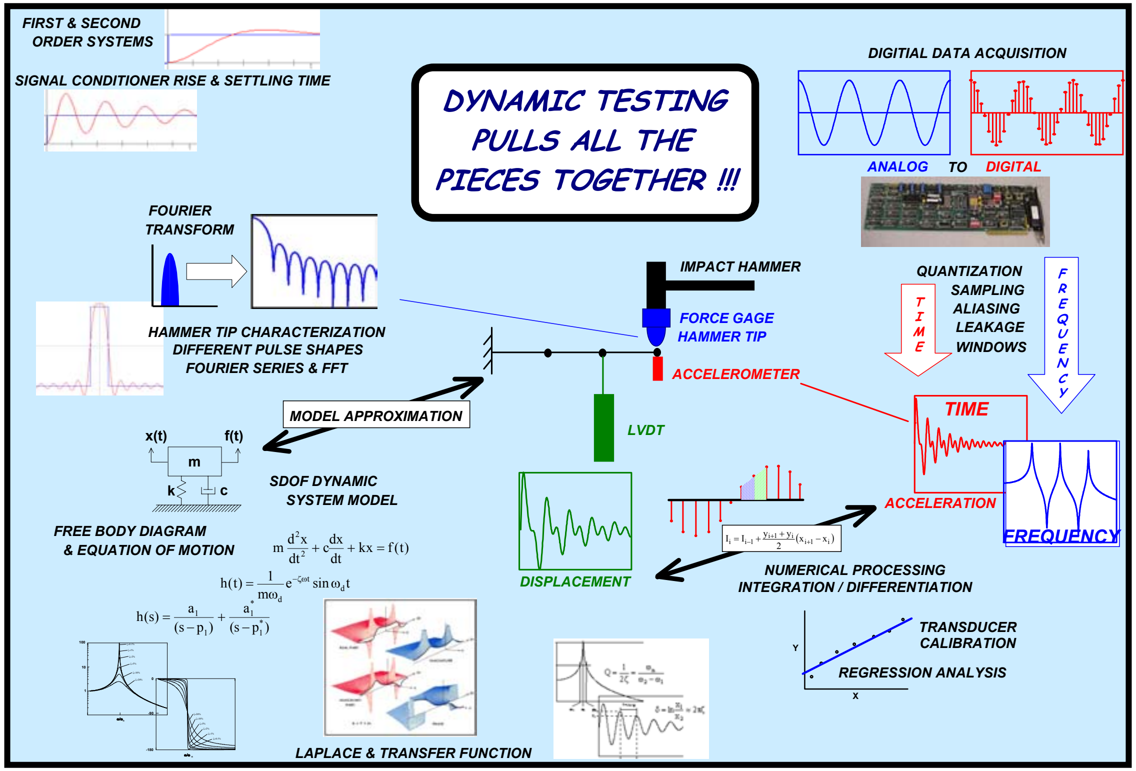
Summary

The salient feature of the project is that material from various courses such as differential equations, mathematical methods, laboratory measurements and dynamic systems is integrated in a fashion that helps the students understand the need for basic STEM (Science, Technology, Engineering and Mathematics) material.

Acknowledgements

This project is partially supported by NSF Engineering Education Division Grant EEC-0314875

Multi-Semester Interwoven Project for Teaching Basic Core STEM Material Critical for Solving Dynamic Systems Problems



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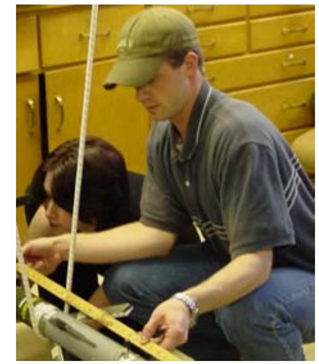
Acknowledgements

A special thanks to the students who have really been the driving force in making all this happen

Tracy Van Zandt, Nels Wirkkala,
Wes Goodman and Jeffrey Hodgkins
Mechanical Engineering Department
University of Massachusetts Lowell



I could not have done any of this without their dedication and devotion to making this all happen

I have the pleasure of working with them and having them contribute to this effort

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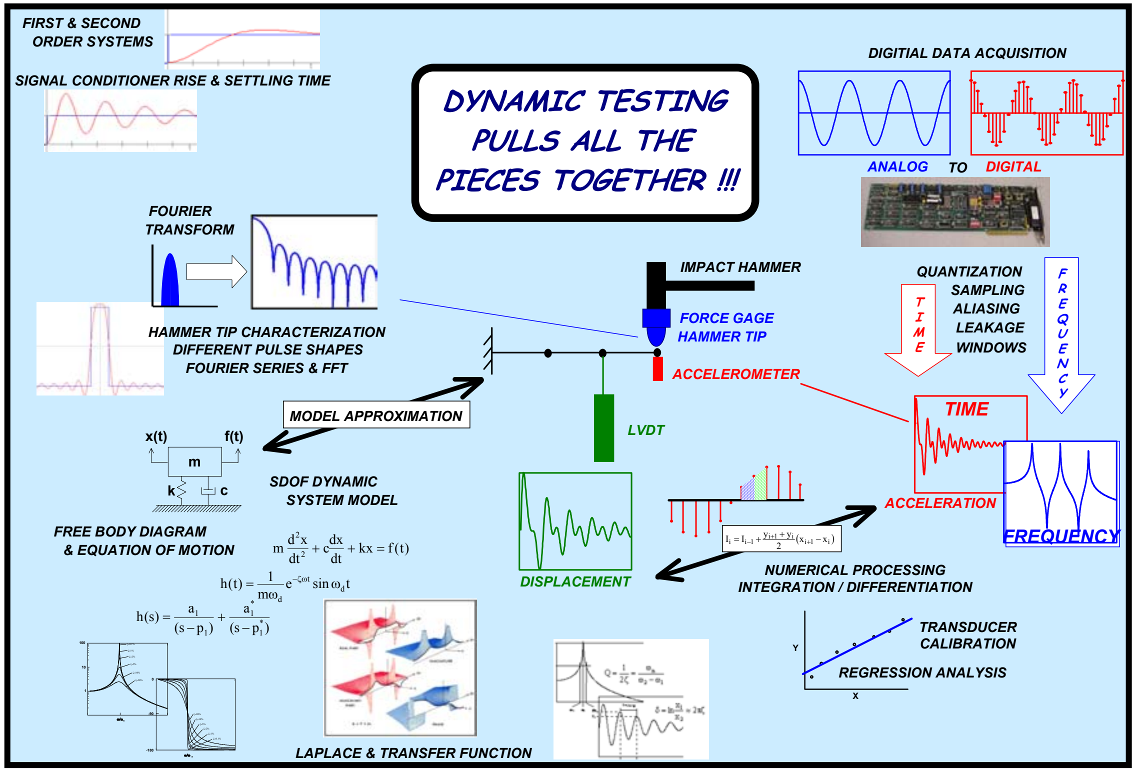

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