AN INTEGRATED UNDERGRADUATE DYNAMIC SYSTEMS
TEACHING METHODOLOGY UTILIZING ANALYTICAL AND
EXPERIMENTAL APPROACHES

DYNAMIC TESTING PULLS ALL THE PIECES TOGETHER !!!

Peter Avitabile
Mechanical Engineering Department
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Integrating Undergraduate Dynamic Systems
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

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
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
Some Key Components of This Work

Analytical Modeling Tools/GUIs
Website and Online Acquisition System
Projects
Integration/Differentiation w/contaminants
Fourier Series using LabVIEW
Design of a Dynamic Measurement System
1\textsuperscript{st} and 2\textsuperscript{nd} Order System Characterization
(many additional smaller projects - see paper)
Tutorials cover a wide assortment of integrated material - both paper tutorials with Matlab and Labview modules with voice annotated multimedia overviews.
## Integrating Undergraduate Dynamic Systems

Dr. Peter Avitabile, Associate Professor  
Mechanical Engineering Department

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**Webpage --- dynsys.uml.edu**

**CLICK HERE FOR ERRATA**

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**Matlab GUI**

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**Complete Imagemap of all materials available**

**SIMULINK**

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Integrating Undergraduate Dynamic Systems  
UMASS  
Dr. Peter Avitabile, Associate Professor  
Mechanical Engineering Department
Analytical Modeling Tools/GUIs

Theoretical Aspects of First and Second Order Systems

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

Second Order Systems
- Step, Impulse, Initial Condition with ODE and Block Diagrams

Mathematical Modeling Considerations
- Fourier Series, Integration/Differentiation, Regression Analysis

Miscellaneous Materials
- Simulink and MATLAB Primer Materials
- LabVIEW Tutorial Materials
- Virtual Measurement Modeling Simulations
- Integration/Differentiation Considerations with Contamination
Analytical Modeling Tools/GUIs

MATLAB & LabVIEW
Online Measurement System

**RUBE**

Response Under Basic Excitation

**System Characteristics**
- Variable Mass
- Variable Damping
- Variable Stiffness

**Excitation**
- Impact Force

**Measurement Devices**
- Accelerometer
- LVDT

**Equation**

\[ k_{eq} = k_{leaf} + k_{coil} \]
Online Measurement System

RUBE
Response Under Basic Excitation

RUBE I

RUBE II
Online Measurement System

"RUBE" Response Under Basic Excitation

To gain control of the VI, right-click and select "Request Control of VI"
Online Measurement System

**RUBE**

- System can be remotely run
- Stiffness is changed for each run
- Sampling rate can be set
- Impact is available
- Initial displacements – three inputs
- LVDT and accelerometers can be turned on and off as desired
- Data saved and captured to browser

URL to download data (copy and paste into a new browser window):
http://dynsys-daq.uml.edu:8999/dynsys_092605_0952AM_46.html
Contaminants Cause Difficulty

Students learn with problems that make them think.
Learn by Doing (not Listening)

Fourier series come to life with LabVIEW
Dr. Peter Avitabile, Associate Professor
Mechanical Engineering Department

Dynamic Measurement System Design

Integration of all material to design system

Comparison of Non-Colocated Accelerometer, Laser and Strain Gage Approximations of Tip Displacement of Cantilever
Dynamic Systems Projects

Projects integrated in with Lecture Material

- Analytical project to force understanding of ODE and Laplace along with MATLAB/Simulink

- RUBE used to strengthen understanding through system identification on less that perfect measurements

- Filtering data through 1st order RC filter in Simulink
Brief Summarizing Statements

Only a brief smattering of material presented here

The 30 page paper has much more material.

The website has a significant amount of material (tutorials, exercises, GUIs, etc) along with the online measurement system.
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

Peter Avitabile, John White, Stephen Pennell
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
Acknowledgements

And to the additional students who have also participated during the final year of the project

Adam Butland, Dana Nicgorski, Aaron Williams, Chris Chipman
Mechanical Engineering Department
University of Massachusetts Lowell

They have also made significant contributions to the overall project

I am very happy for their continued support and dedication
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