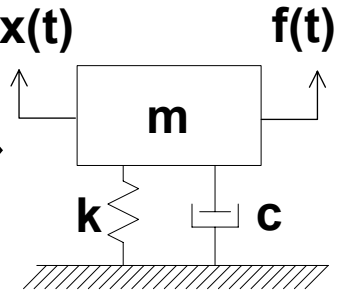
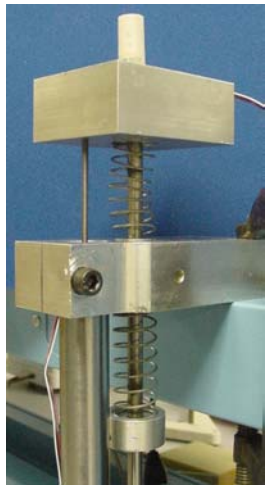
DYNamic SYStems

AN INTERDISCIPLINARY, MULTI-SEMESTER PROJECT RELATING DIFFERENTIAL EQUATIONS AND ENGINEERING

$$m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = f(t)$$





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Outline

- The Problem
- The Project Solution
- UML Mechanical Engineering Curriculum
- Differential Equations Course Content
- Project Modules
- Assessment
- Summary

The Problem

Engineering students often do not understand the relevance of Differential Equations to courses in their major

Therefore, there is low motivation to learn essential skills for later coursework

The Problem

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Student Comment:

Professor, why weren't we told that the material covered in Differential Equations was going to be really important for the work in this course?

Professor Thoughts:

Hmmmmm...

Student views material in a disjointed fashion

Professor clearly sees how pieces fit together

The Problem

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When the time comes for students to recall Differential Equations, they have difficulty doing this because so much time has passed

It can be challenging to teach "engineering" while speaking "mathematics"

The Proposed Solution

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Interdisciplinary, multisemester project designed to lead students to appreciate the relevance and importance of basic STEM (Science, Technology, Engineering and Mathematics) material

Project:

Analysis of 1st- and 2nd-order dynamic systems from various points of view, including mathematical modeling

UML Mechanical Engineering Curriculum

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Courses which will utilize the common project

Sophomore Year	Junior Year	Senior Year
1st Semester	1st Semester Applied Analysis	1st Semester Mechanical Engineering Lab II
2nd Semester Engineering Differential Equations	2nd Semester Mechanical Engineering Lab I	2nd Semester Dynamic Systems

NOTE: The concepts described here can also be applied to other engineering disciplines and other institutions

UML Mechanical Engineering Curriculum

COURSE	FOCUS
Engineering Differential Equations Applied Analysis	Mathematical Modeling & Analytical Techniques
Mechanical Engineering Lab I Mechanical Engineering Lab II	Test & Measurements
Dynamic Systems	Measurements & Other Modeling Methods

Each semester, students will:

1) be reminded of what they already know about the project material

2) apply newly learned techniques from the current course

Differential Equations:

Course Content

Even in applications,

object of interest = differential equation
goal = solution formula

Engineering point of view,

object of interest = system being modeled
goal = understand system response to different classes of inputs

Differential Equations Course

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With the advent of this project, the Engineering Differential Equations course has been modified to reflect more of the engineering point of view.

Two systems:

RC Circuit

Mass-Spring-Dashpot (MCK) System

Students learn how to model these systems using:

RC Circuit: 1st-order linear differential eq.

MCK System: 2nd-order linear differential eq.

Traditionally, the students learn how to model each of these systems by a differential equation, and they learn analytical techniques for finding solutions of the model equations.

Now, they also use the solution formulas to investigate the response of the modeled system to different types of input.

Project Modules

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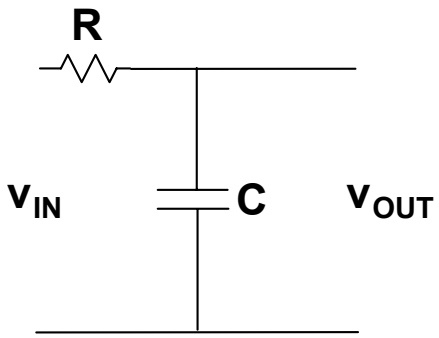
Computer-based tools were developed using the MATLAB, Simulink, and LabVIEW software packages

A graphical user interface (GUI) allows for easy adjustment of system parameters so the student can explore the effects of changing parameter values on system response.

First Order Systems



First Order Low Pass Filter GUI

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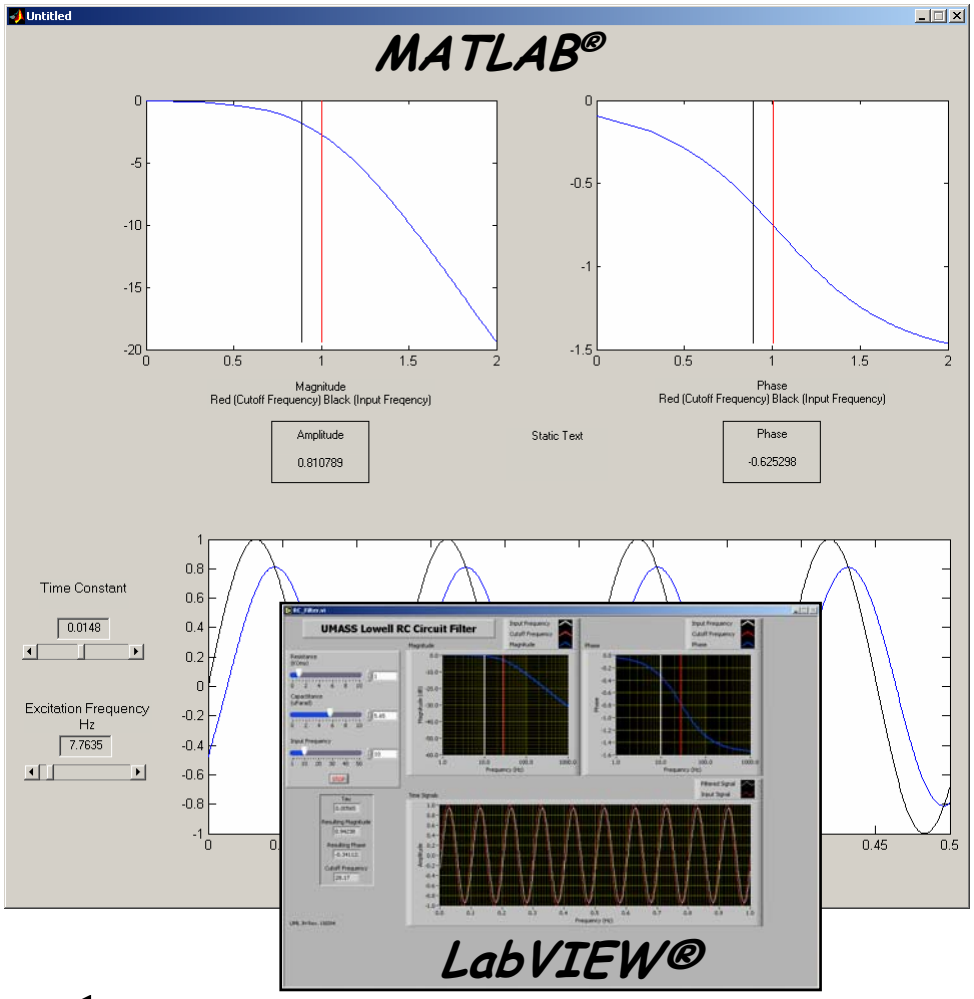
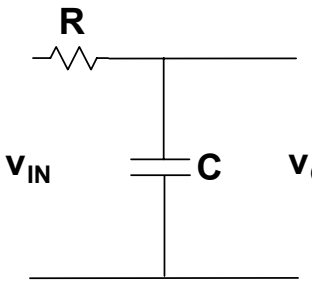
User enters time constant and sinusoidal frequency.

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

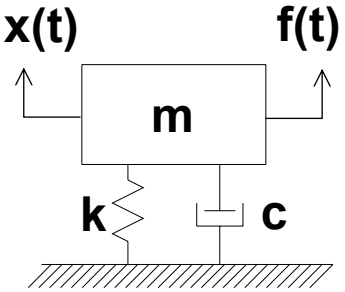
The initial sinusoidal signal and "filtered" time signal are also displayed.





$$\frac{dx}{dt} + \frac{1}{RC}x = f(t)$$

Second Order Systems



2nd Order System Initial Condition GUI

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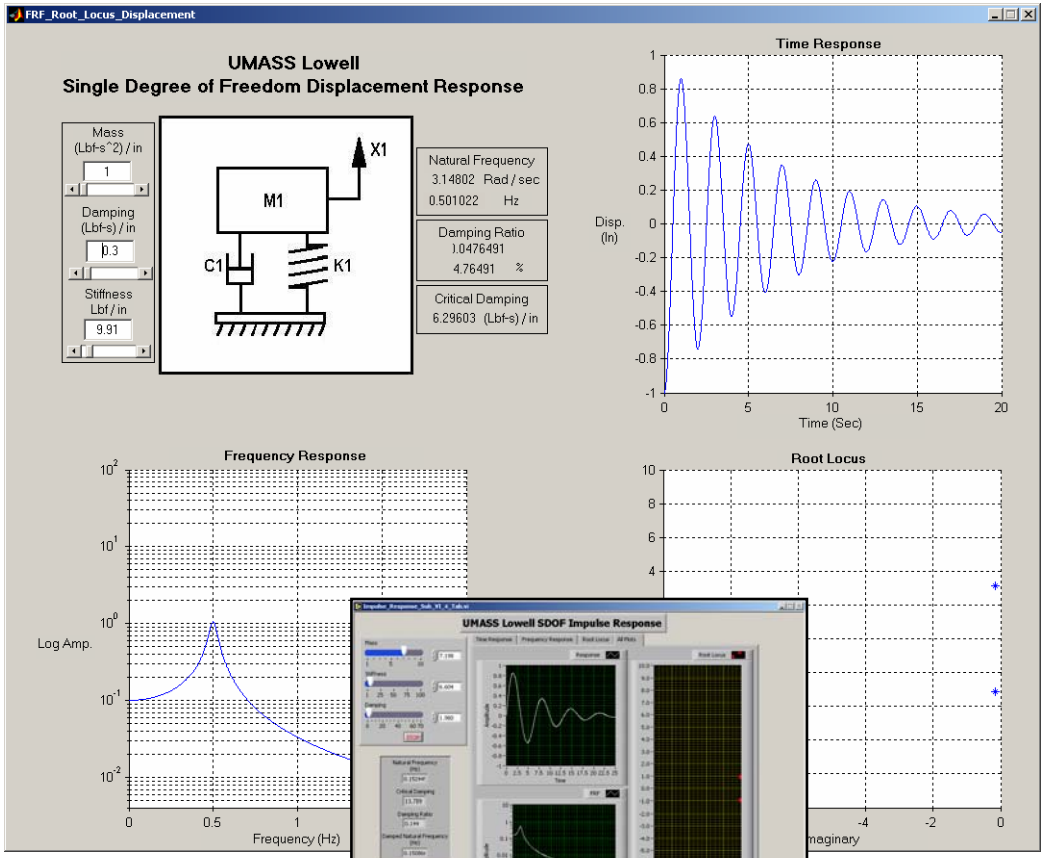
MATLAB®



LabVIEW®

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

User can vary the physical parameters with slide bars.

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

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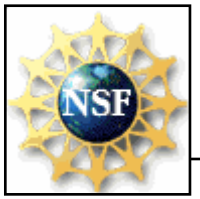

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Preliminary Assessment

Preliminary Assessment

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The project is only in its 2nd year, so complete data on the program's effectiveness are not yet available

However, there are preliminary indications that the project has positive effects on students' learning

Students in the Fall 2004 Engineering Differential Equations course were surveyed before and after this project

Preliminary Assessment

The students were asked to respond to 17 statements, indicating whether they:

1) strongly agreed,

2) somewhat agreed,

3) had no opinion,

4) somewhat disagreed, or

5) strongly disagreed.

Preliminary Assessment

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Percentage of students who strongly agreed or somewhat agreed to the first four statements

	BEFORE	AFTER
I understand the need for ordinary differential equations in course work for my major.	75%	100%
I understand the need for ordinary differential equations in solving practical problems in engineering and science.	79%	100%
The material from this course will be useful to me in courses in my major.	79%	100%
The material from this course will be useful to me in my career.	54%	78%

Preliminary Assessment

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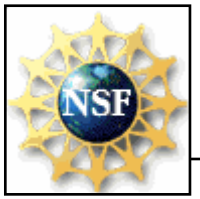
Percentage of students who strongly agreed to the first four statements

	BEFORE	AFTER
I understand the need for ordinary differential equations in course work for my major.	29%	56%
I understand the need for ordinary differential equations in solving practical problems in engineering and science.	38%	56%
The material from this course will be useful to me in courses in my major.	25%	67%
The material from this course will be useful to me in my career.	21%	28%



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Summary

Summary

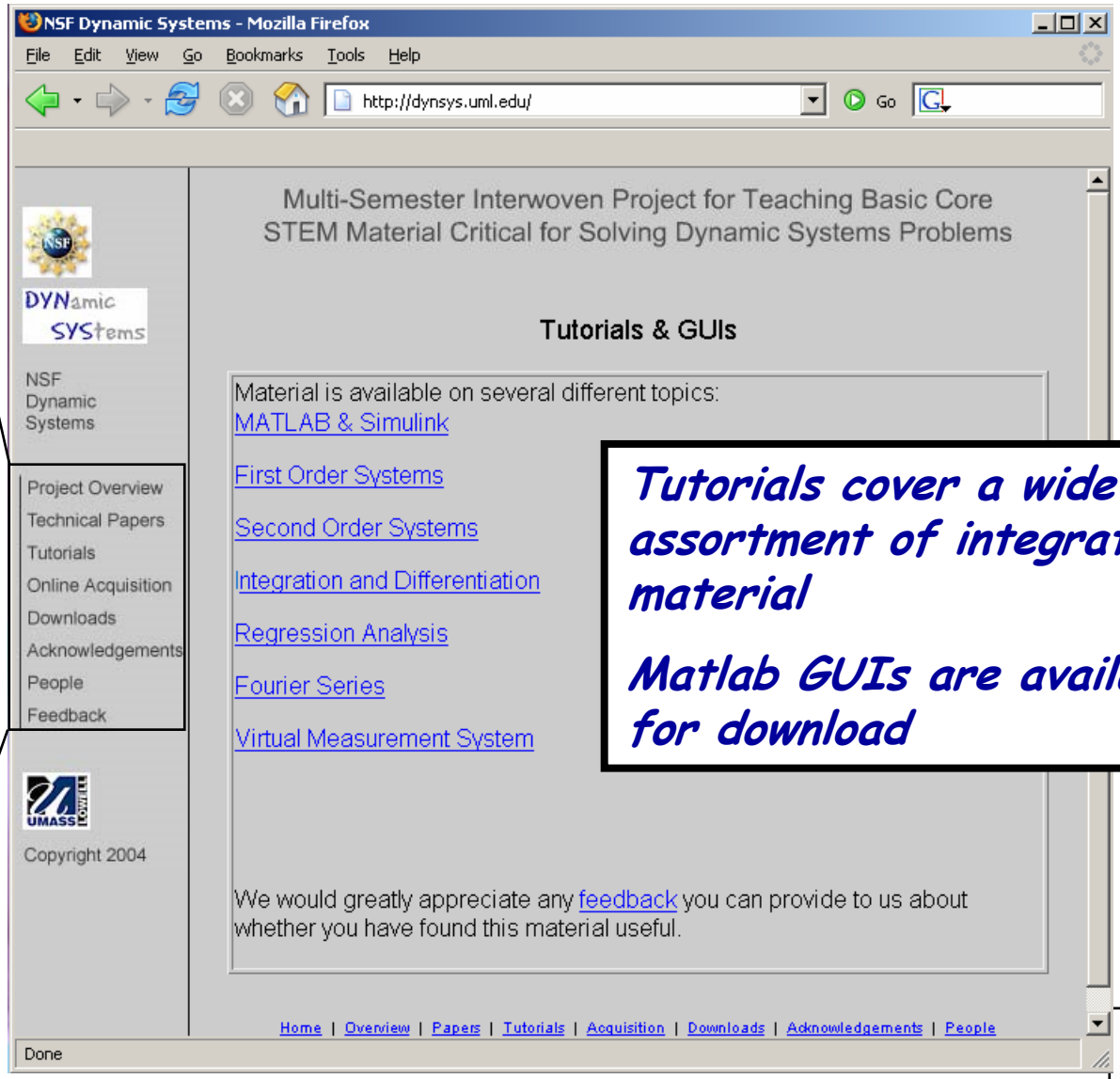
Integration of engineering concepts into Differential Equations course has been accepted favorably by students

The students tend to better understand the material as evidenced from overall capabilities and student comments regarding how they feel with respect to their overall understanding of the material.

Data indicate an increase in student awareness of the need for differential equations during the course of the semester.

Webpage http://dynsys.uml.edu

- Project Overview
- Technical Papers
- Tutorials
- Online Acquisition
- Downloads
- Acknowledgements
- People
- Feedback



- Tutorials cover a wide assortment of integrated material
- Matlab GUIs are available for download

Acknowledgements

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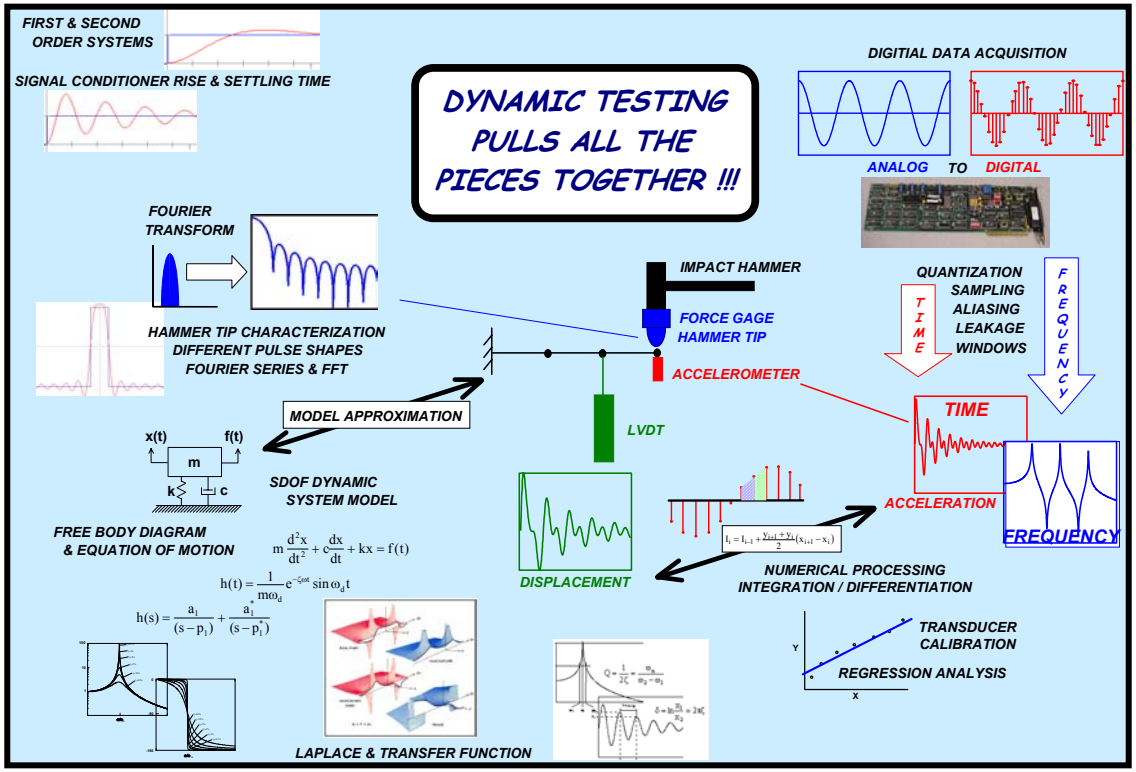
NSF Engineering Education Division Grant EEC-0314875

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



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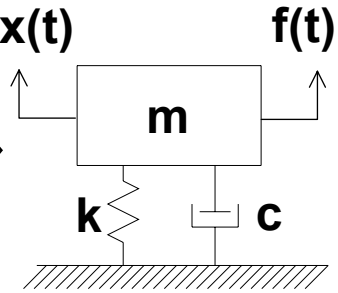

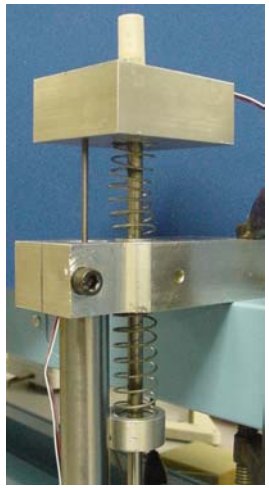

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