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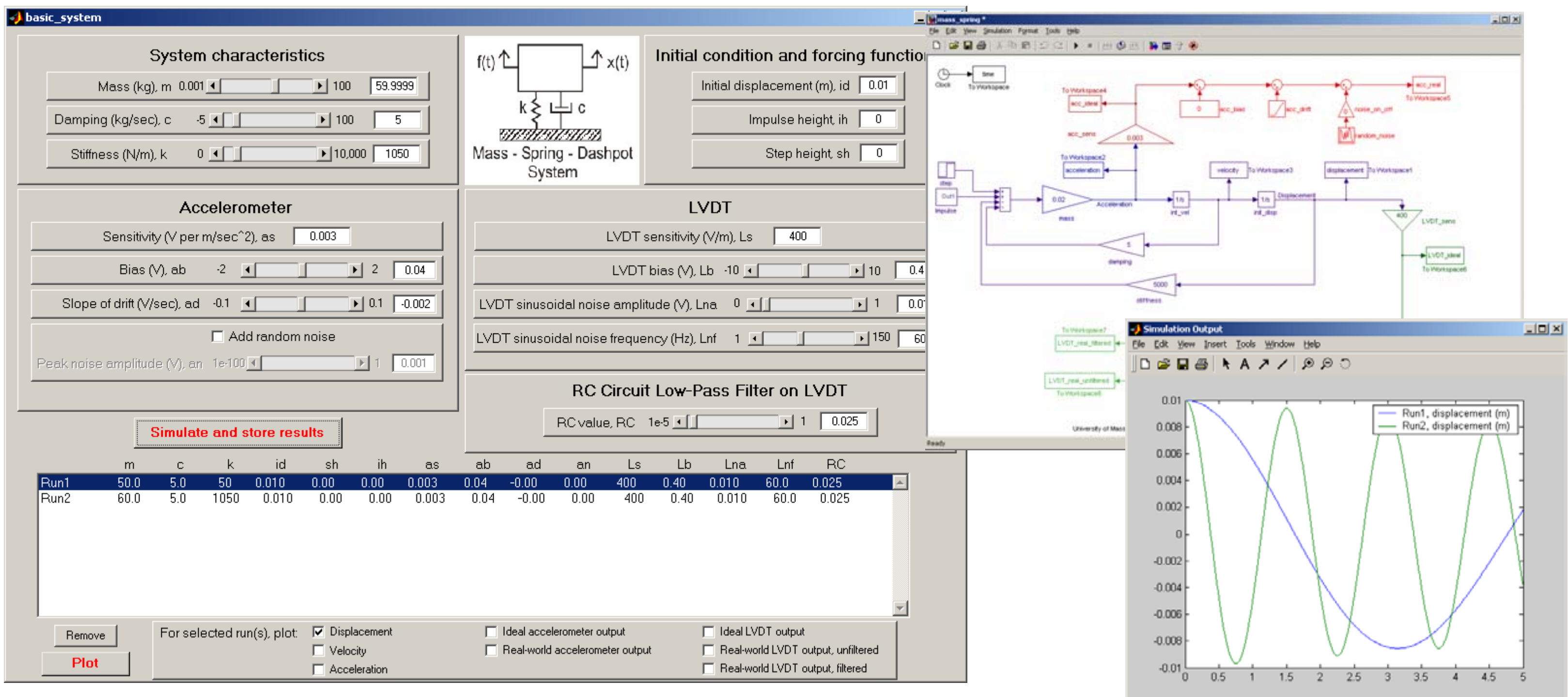
DYNamic SYStems

Developing a Virtual Model of a Second Order System to Simulation Real Laboratory Measurement Problems



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The Problem

Most of the student's educational exposure is to well behaved, deterministic problems with known results.

Most courses expose students to

- material in modules in book chapters

- with exercises/problems at end of the chapter

- majority of the material found in chapter/book

The Problem

Laboratory is the perfect place for students to become exposed to real world problems and solutions to those problems.

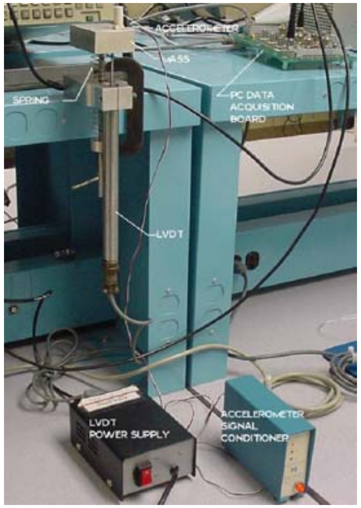
Laboratory is the perfect place to put student's knowledge of basic STEM material to the test.

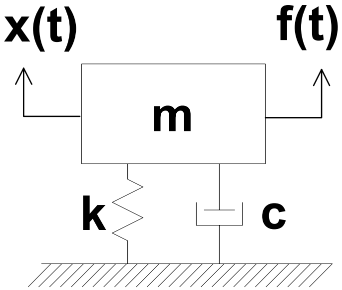
However, many times the real world measurement is much more complicated than the textbook.

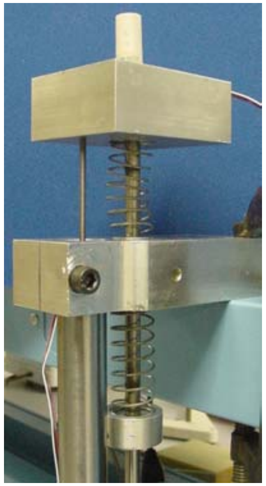
Students often struggle with methods and procedures to solve a real measurement problem (with no answer at the back of the book)

A Typical MCK Measurement System

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







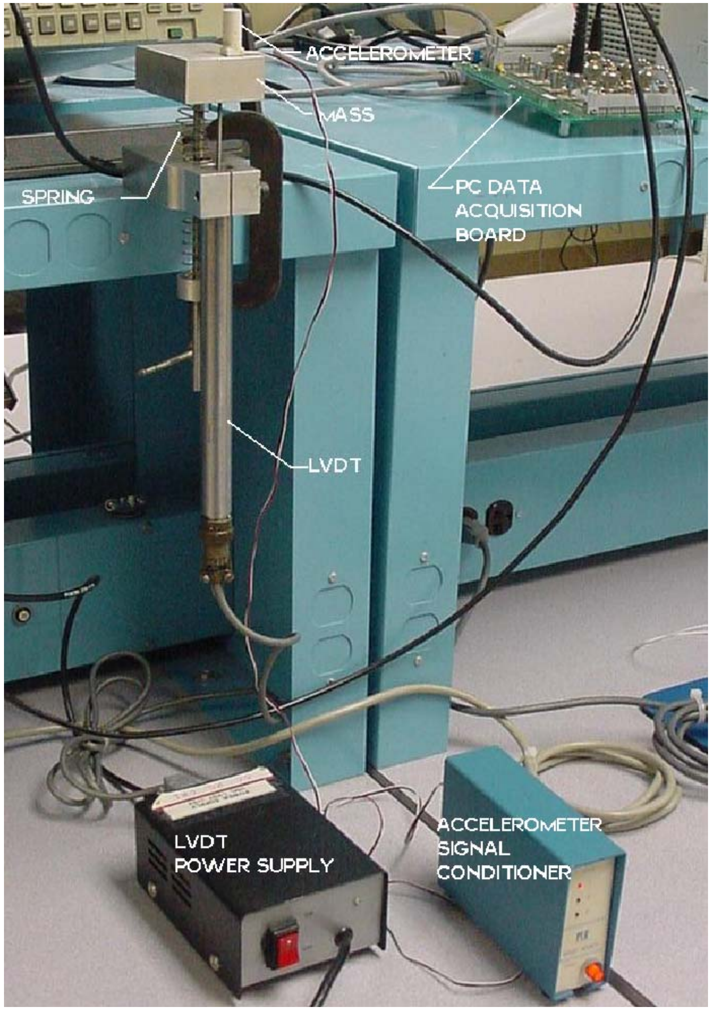
Numerical processing of integration/differential needed to process data

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*



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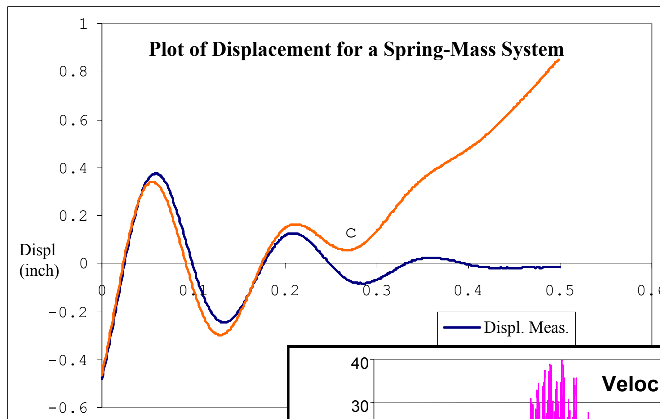
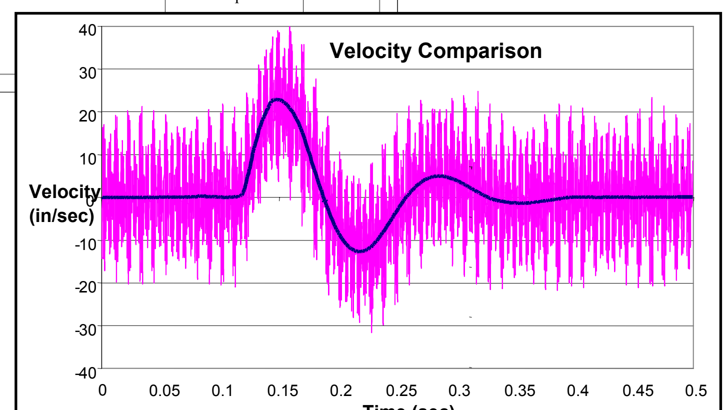
The data acquisition system and transducers are intentionally selected such that the majority of possible errors exist in the data

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

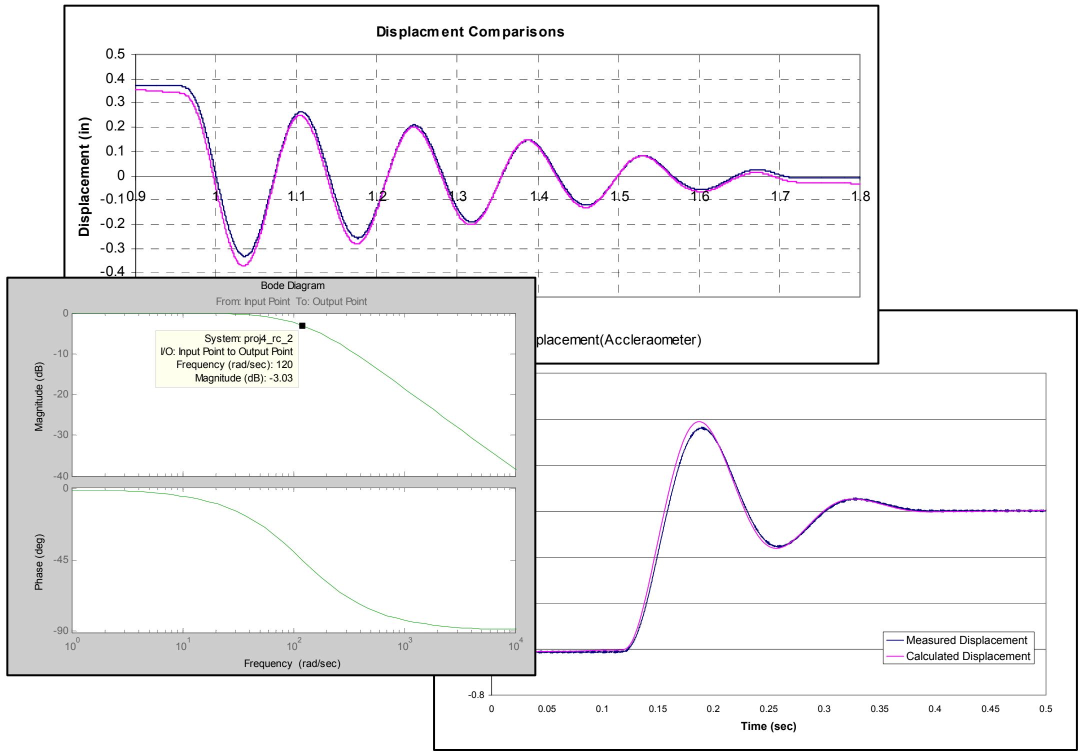




MCK Measurement System

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

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



The real test configuration has many problems that all simultaneously plague the measurement.

Many times students are frustrated with the significant open-ended aspects of this exercise.

This is due to the large number of items that simultaneously plague the measurement.

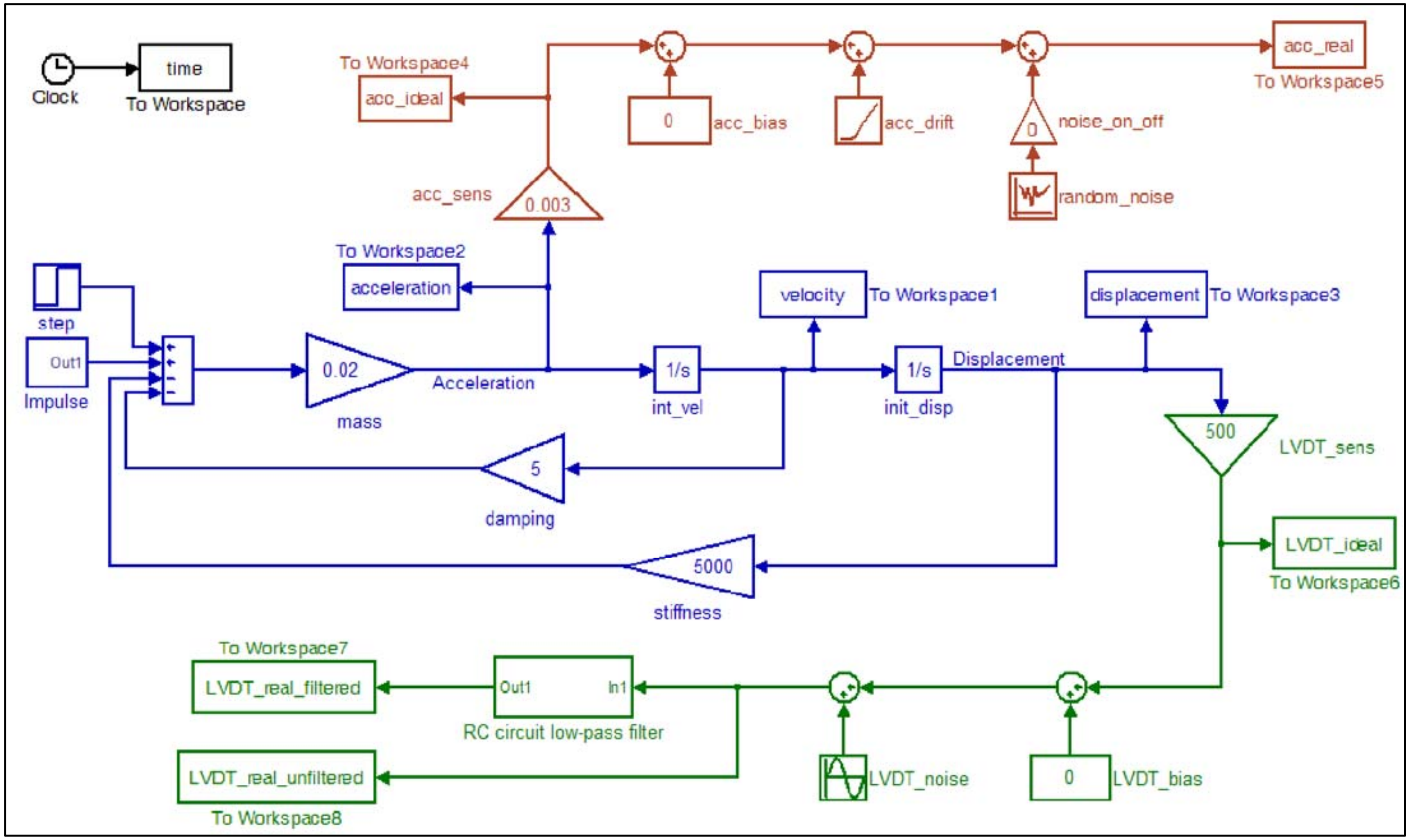
The Virtual Measurement System

In order to assist the student in understanding all of the individual effects, a virtual measurement system was developed.

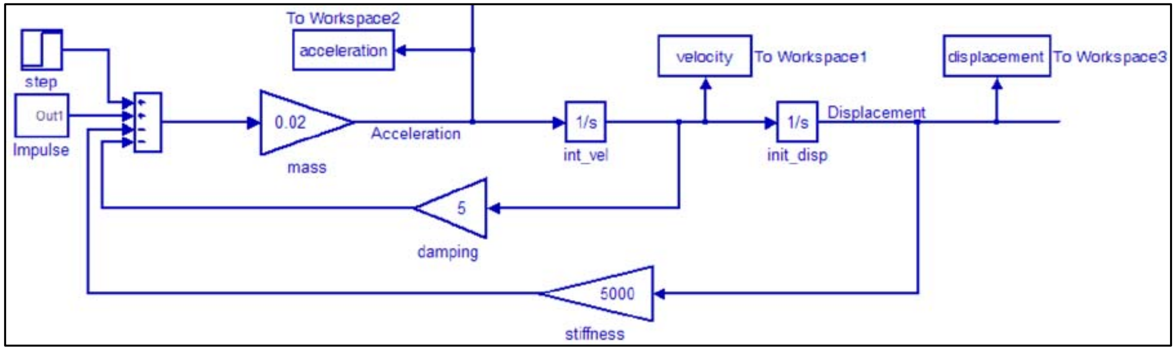
This enables the student to add individual effects and see the result on the measurement made.

The pieces of the Virtual Measurement System are described in the following sections.

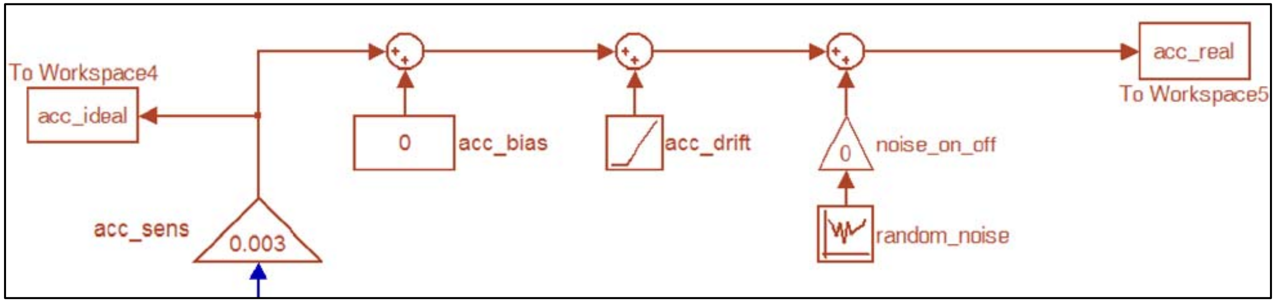
The entire Simulink model



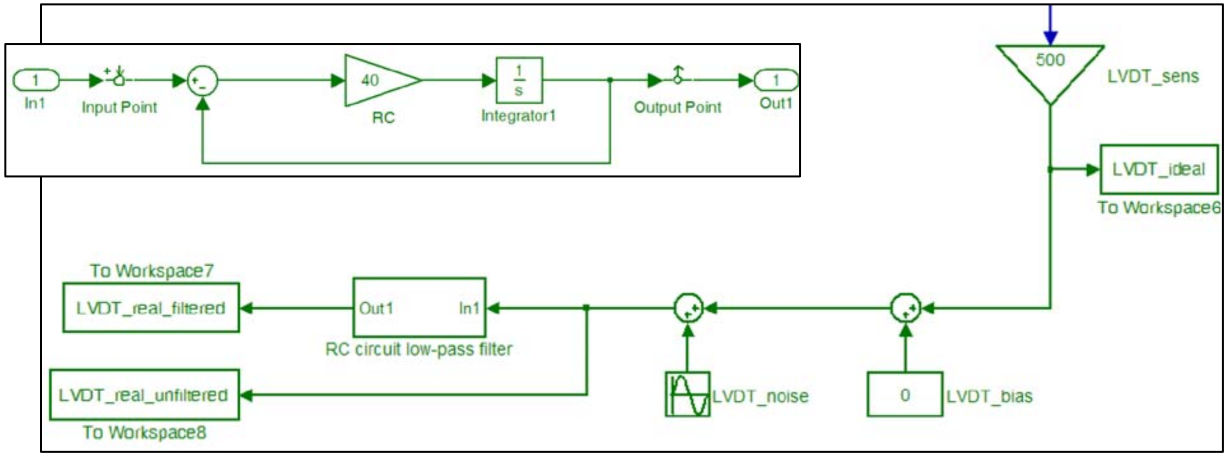
The SDOF system portion



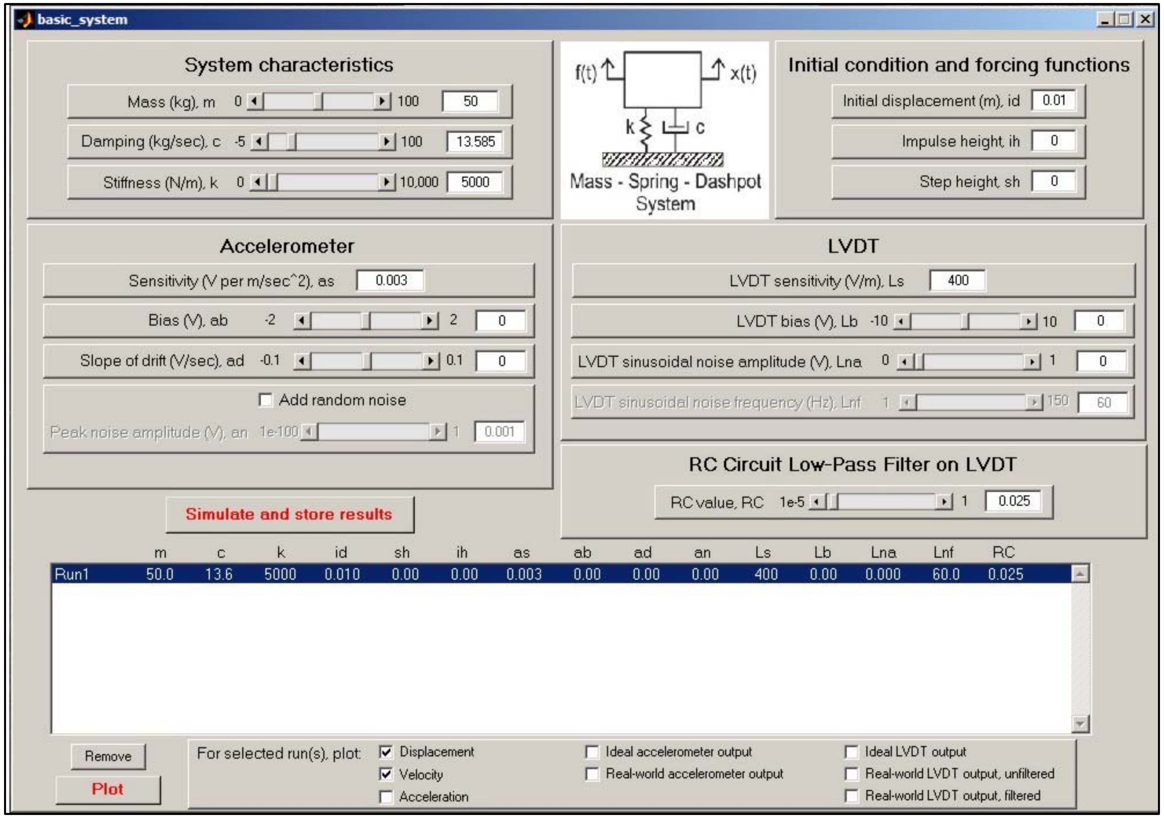
The accelerometer measurement portion



The LVDT & RC filter measurement portion



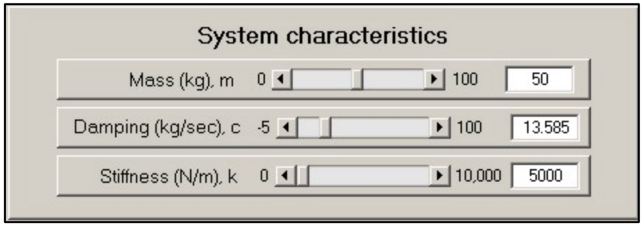
The entire GUI Interface



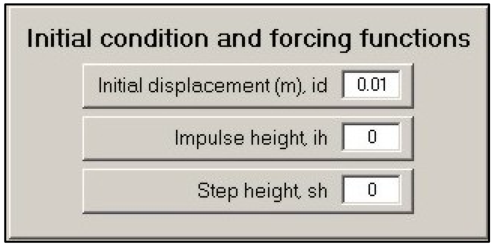
The Virtual Measurement System

The system characteristic definition of

mass,
damping and
stiffness

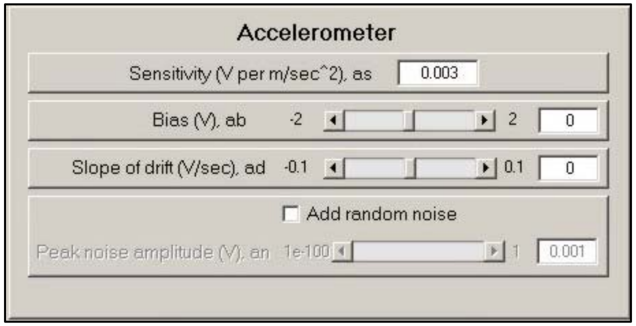


along with IC
and forcing function

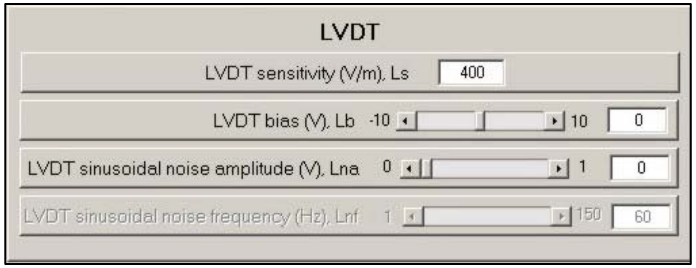


The Virtual Measurement System

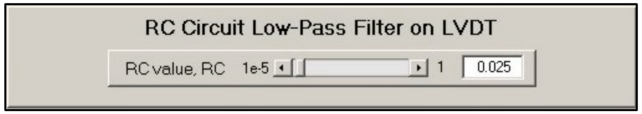
The accelerometer parameters can be entered



along with the LVDT



and RC filter setting



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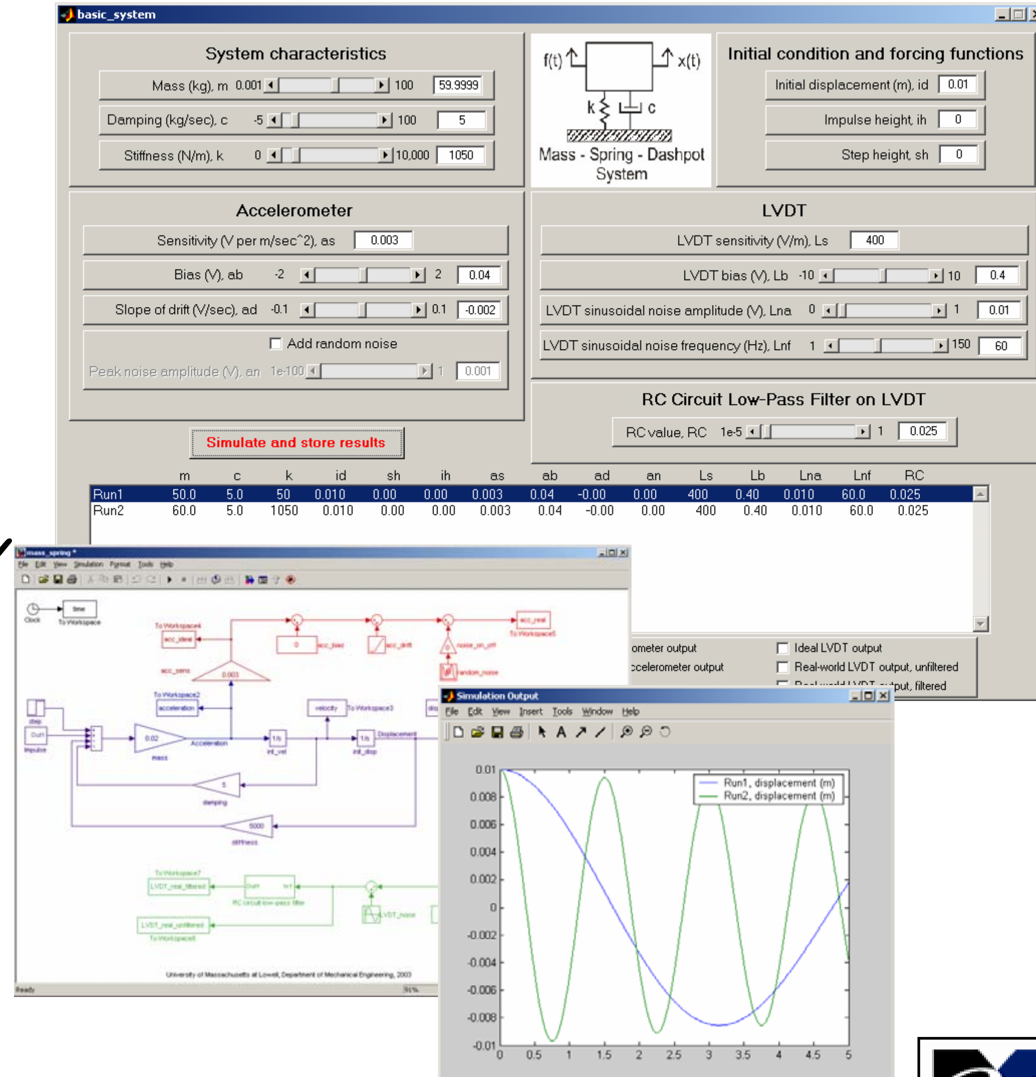
Virtual Measurement System GUI

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.



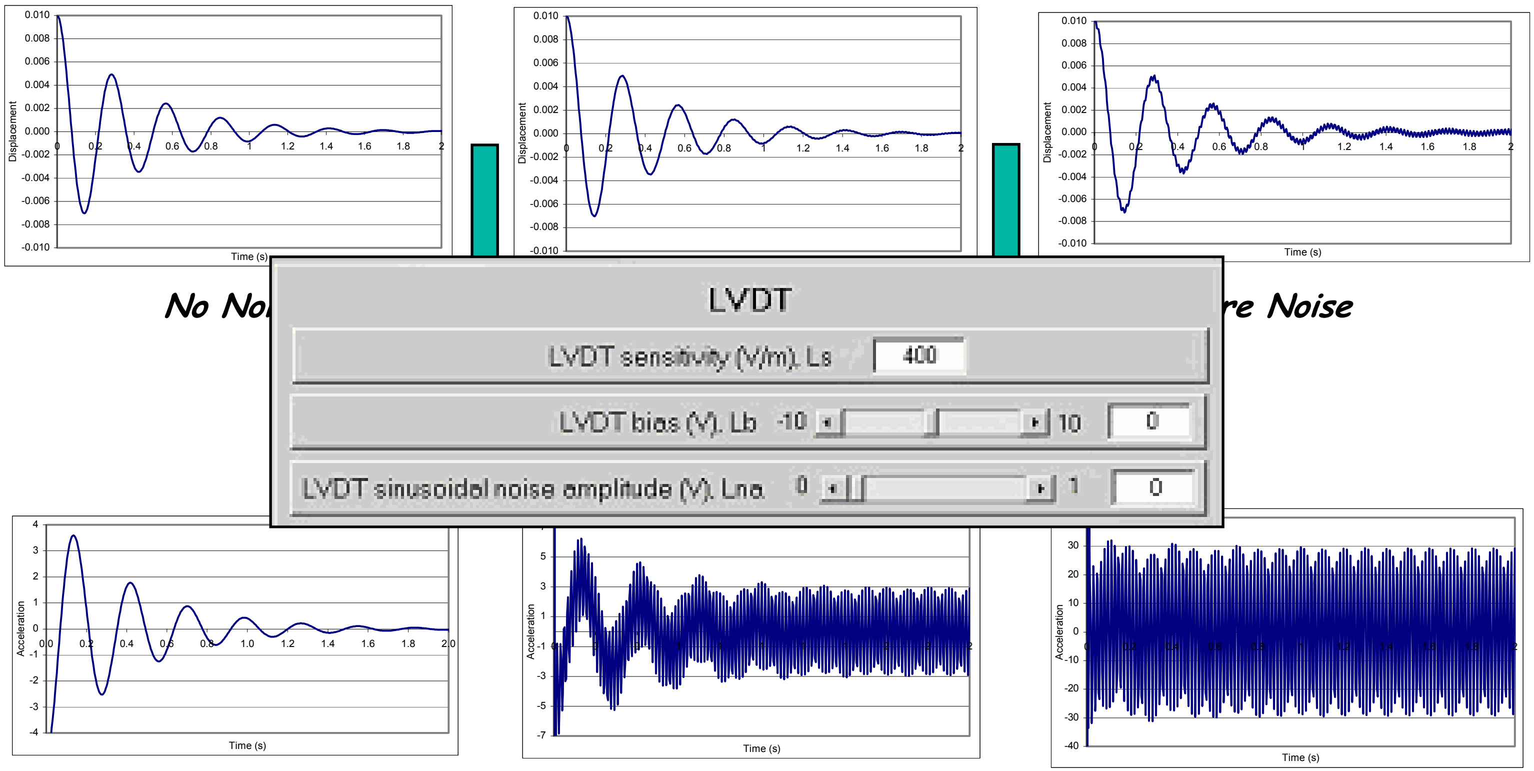
Virtual Measurement Simulation

The student can quickly study the measurement issues associated with drift, bias and offset.

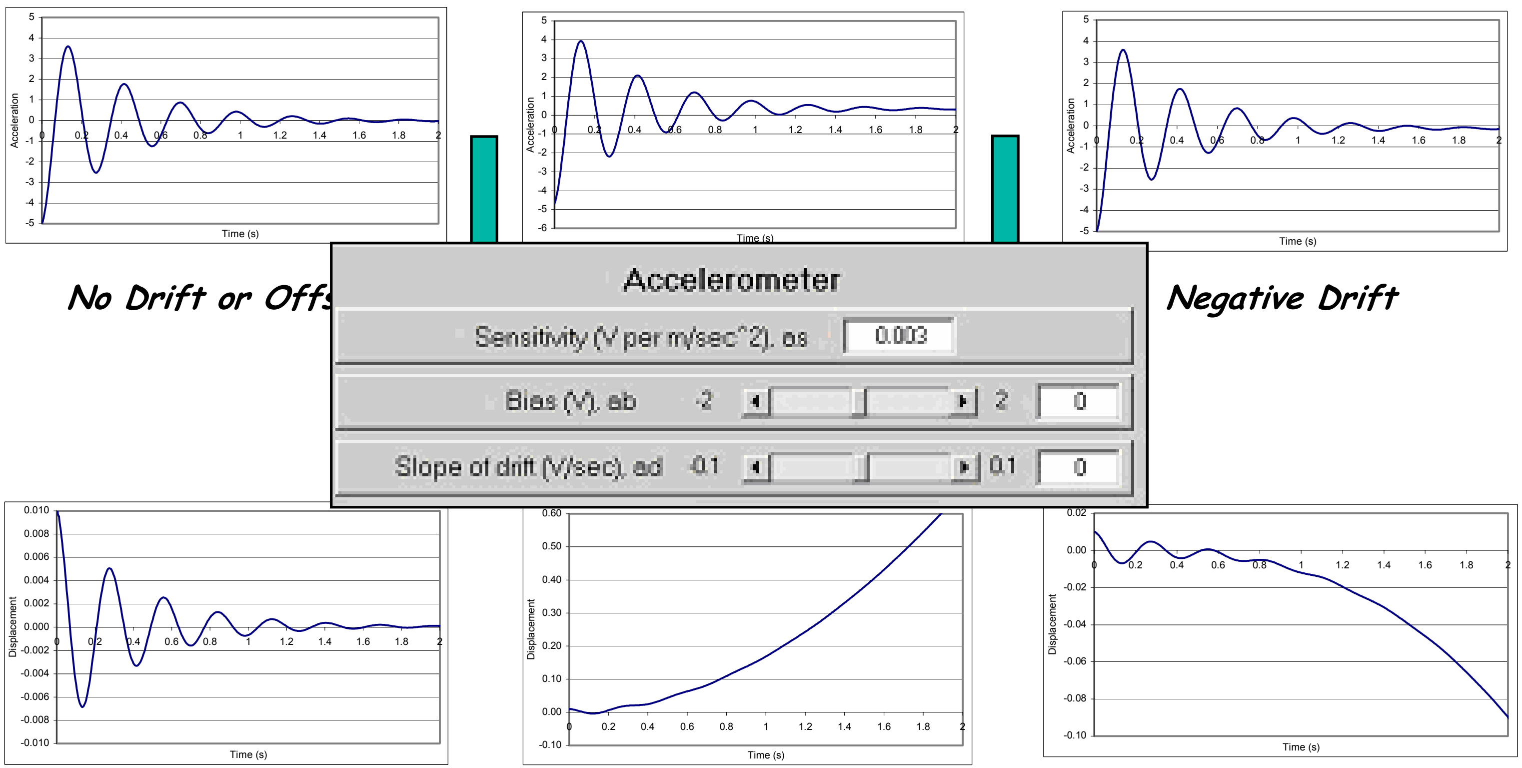
These effects are significant when numerically processing the data to perform differentiation and integration.

Several cases are shown to illustrate the usefulness of the Virtual Measurement System.

Differentiation of LVDT measurement and noise



Integration of the accelerometer measurement



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Summary

Students tend to struggle when trying to process real world measurements.

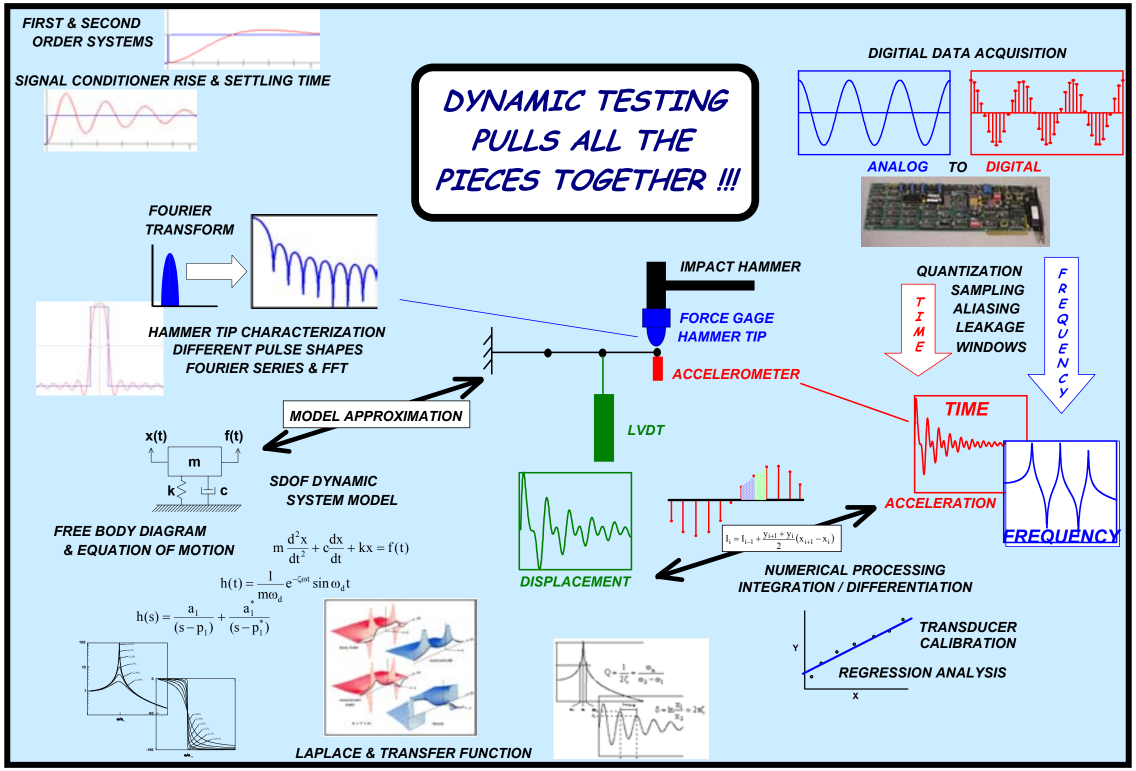
All of their STEM knowledge must come to bear to solve these types of problems.

A Virtual Measurement System was developed to assist students in breaking down the measurement problem into pieces which all contribute to the distortion of the real measurement.

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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