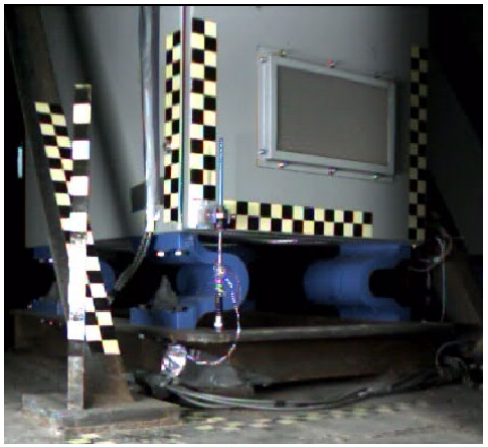
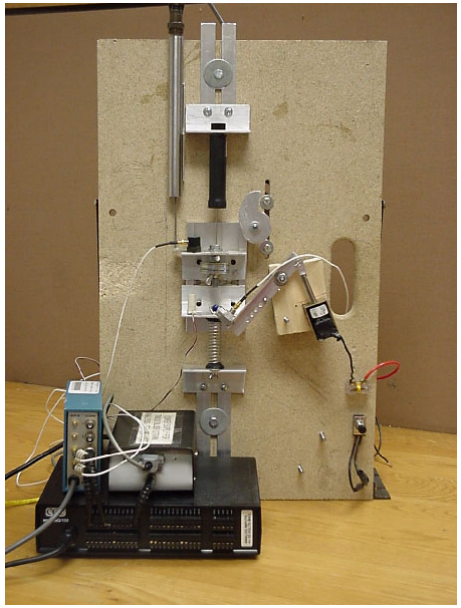
Shock Isolation of Equipment using Acceleration/Displacement Sensors

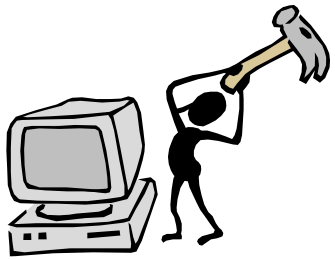




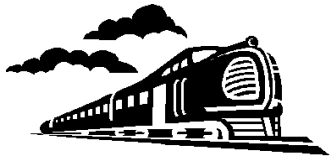
Dr. Peter Avitabile, Assistant Professor
Mechanical Engineering Department

Problem

Mechanical equipment is subjected to a variety of different loading that must be considered in the design process



MISC LOADS



TRANSPORTATION LOADS

OPERATING LOADS

DROP LOADS

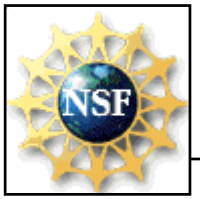
Problem

DYNamic SYStems

Shipboard equipment response due to shock

- Electronic equipment is sensitive to shock loads
- Severe loadings are of concern
- Measurements of response are needed
- How can this be accomplished?

high speed video showing shock response



Dynamic Response Considerations

DYNamic SYStems

Assessing Shock Response from Multiple Sensors

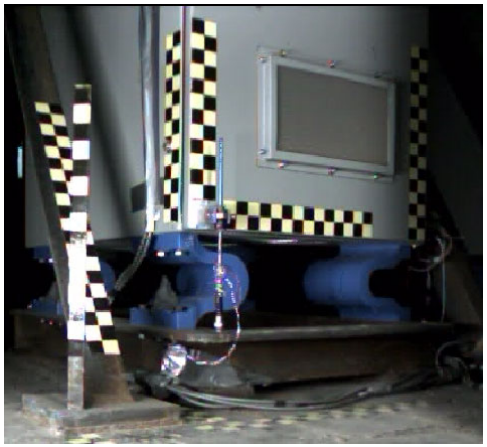
- Measurements of both acceleration and displacement need to be obtained
- Various transducers are available for measurement of response
- Numerical evaluation of data required

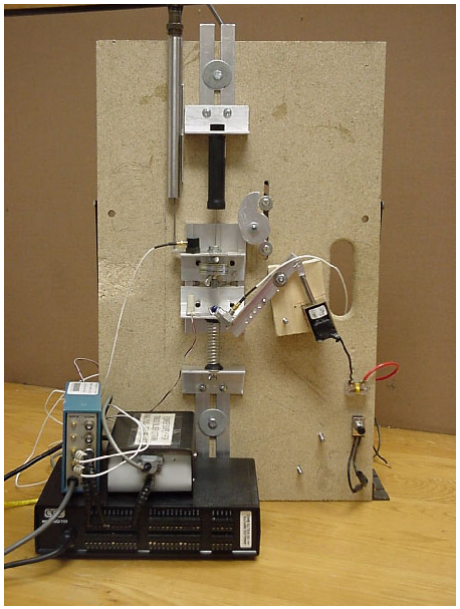
UMASS LOWELL

Measurement Considerations

Assessing Shock Response from Multiple Sensors

- Response due to shock needs to be determined
- Measurements of displacement and acceleration using accelerometers and LVDTs are options for transducer selections

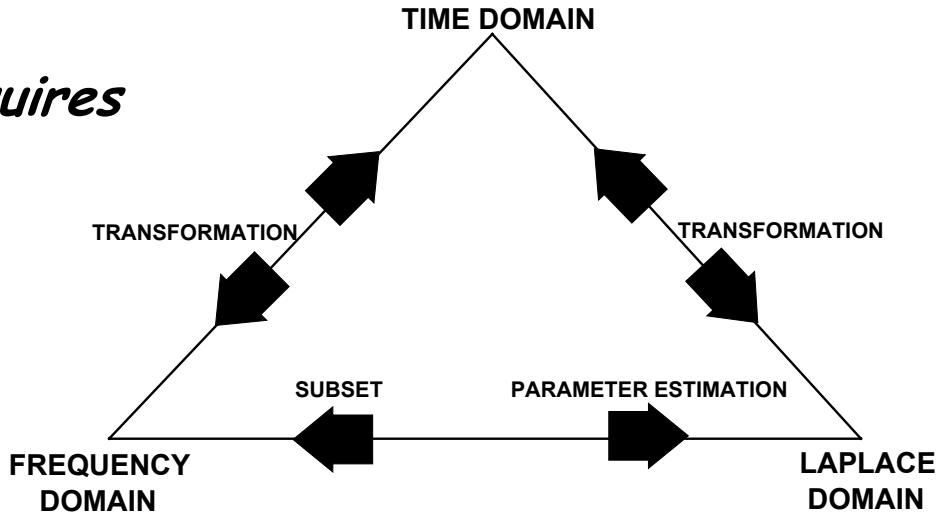




Different Ways to Solve the Same Problem

DYNamic SYStems

Time Domain requires integration and differentiation numerically



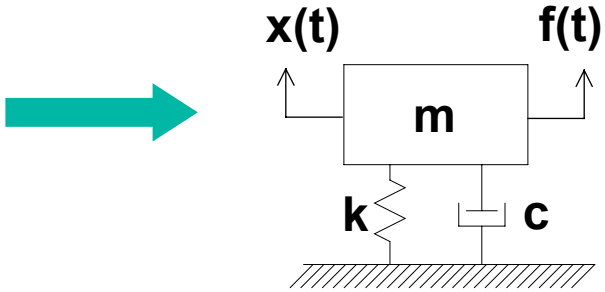
* *Time domain represents the physics of the system*

* *Frequency domain represents the system in terms of it's periodicities*

* *Laplace domain represents the system in terms of its poles and residues*

Equivalent System Model Representation

The system can be modeled in an equivalent sense



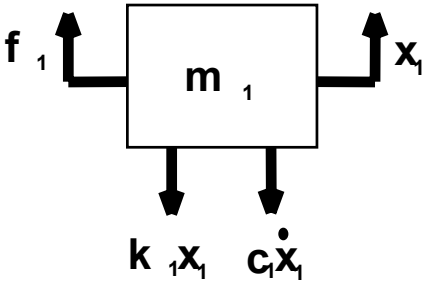
Homogenous equation is

$$m\ddot{x} + c\dot{x} + kx = 0$$

and assuming an exponential solution form gives

$$\left(ms^2 + cs + k\right)e^{st} = 0$$

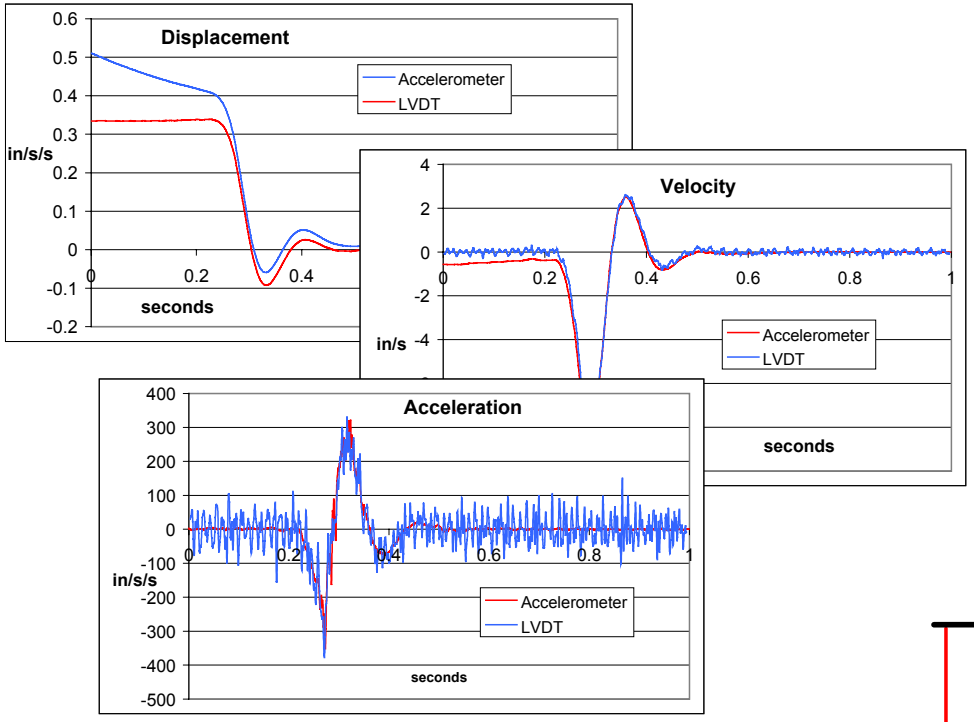
FBD

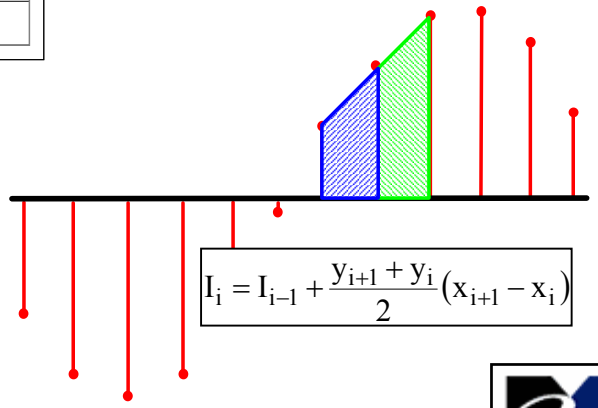


Numerical Integration/Differentiation

DYNamic SYStems

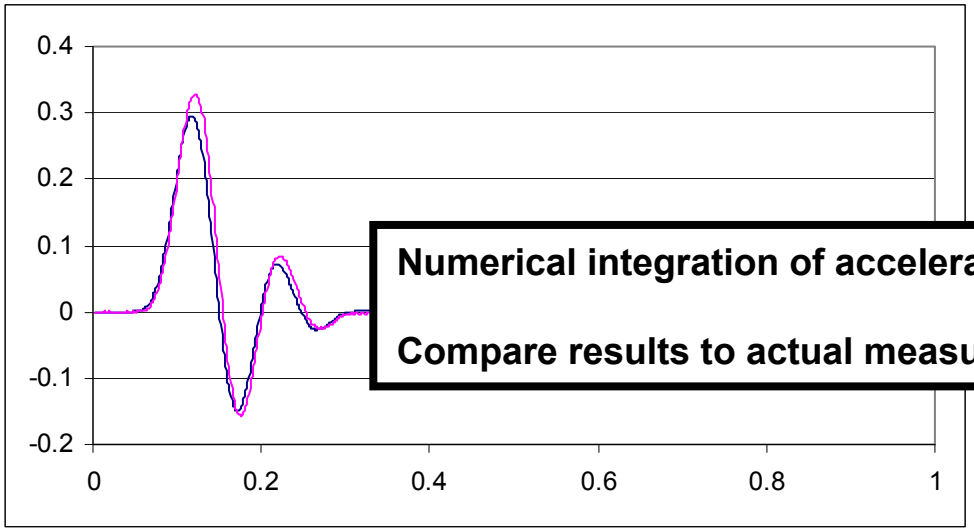
The differential equation could also be processed in the time domain using numerical techniques





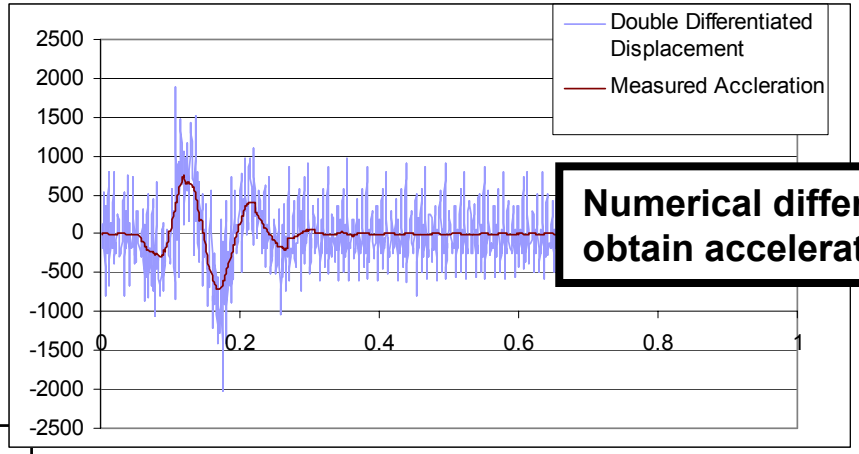
$$I_i = I_{i-1} + \frac{y_{i+1} + y_i}{2}(x_{i+1} - x_i)$$

Numerical Integration & Differentiation



Numerical integration of acceleration data to obtain displacement data

Compare results to actual measured data



Numerical differentiation of displacement data to obtain accelerations and compare to measured data

Evaluation of Measurement Locations

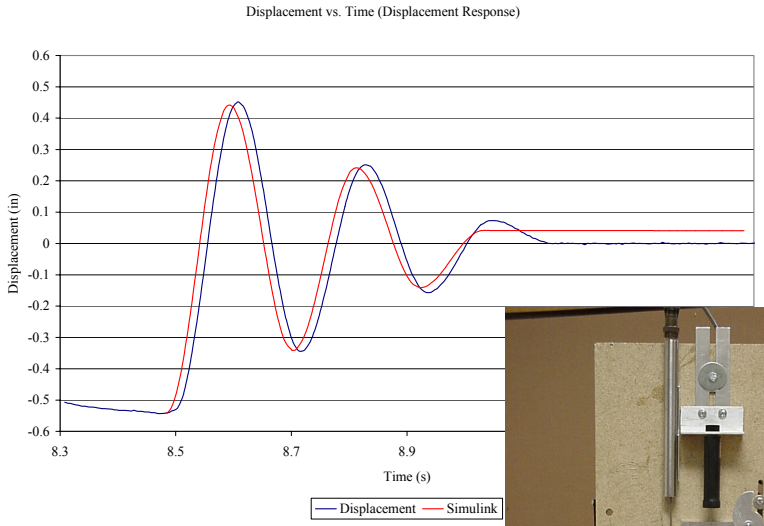
DYNamic SYStems

Need to know ……

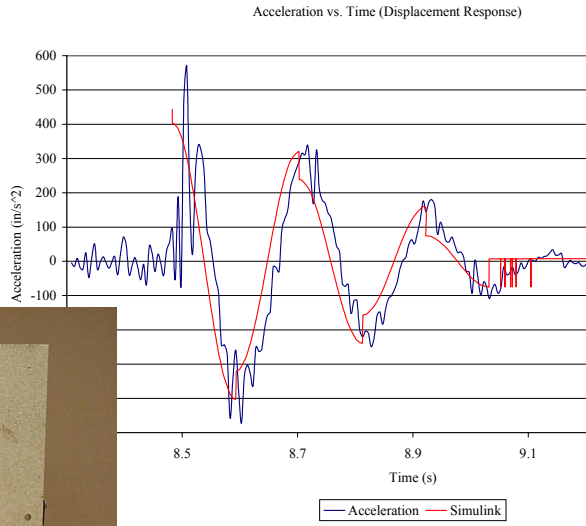
- *Strength of Materials (structural characteristics)*
- *Dynamics (mass, inertia properties)*
- *ME Lab (digital data acquisition)*
- *Numerical Methods (integration, differentiation)*
- *Math (ODE, Laplace, Fourier Series)*

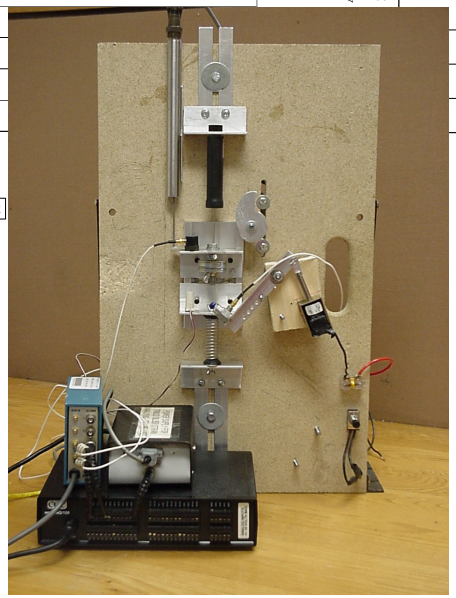
Senior Project Results

Displacement



Acceleration





Skill Sets Needed

DYNamic SYStems

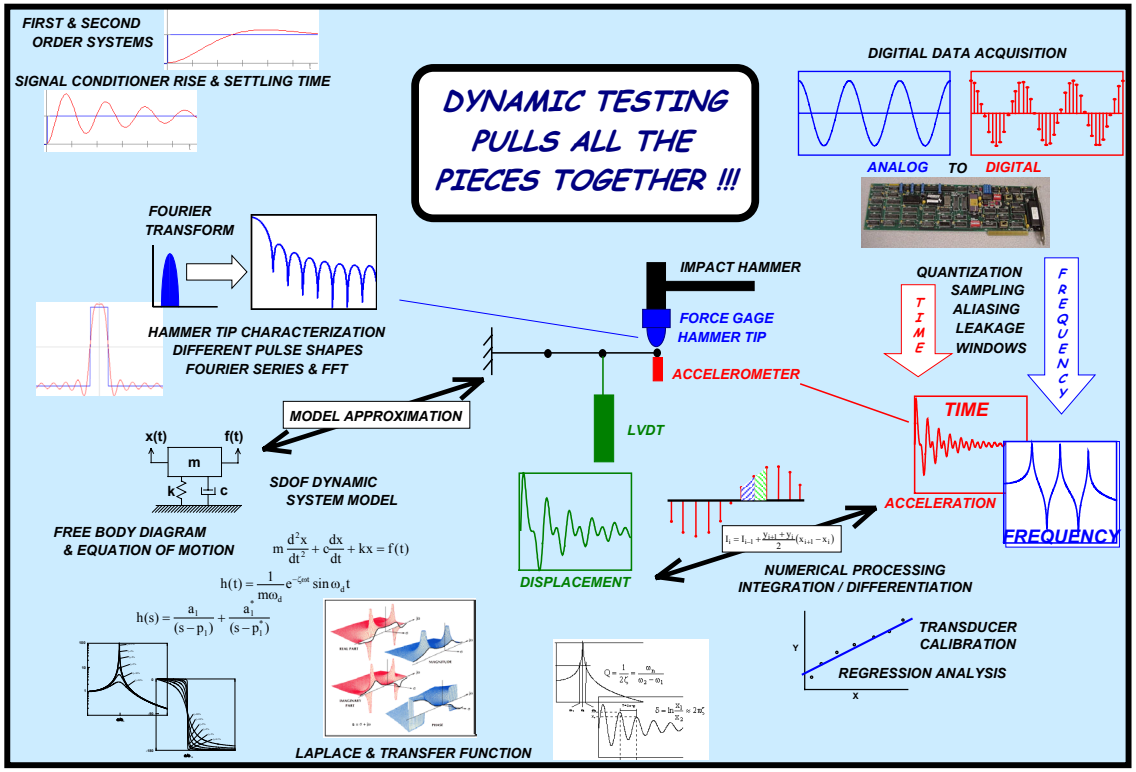
Numerical methods used in problem evaluation

- Must have a firm understanding of underlying math related to problem
- Computer software helps provide solution to underlying mathematical formulation
- Upper level students are expected to have a firm understanding of basics to solve the problem
- Engineers utilizing tools to solve critical problems clearly must understand the basic underlying mathematical principles involved

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



Peter Avitabile, John White, Stephen Pennell