Experimental nonlinear dynamics is an important area of study in the modern engineering field, with engineering applications in structural dynamics, structural control, and structural health monitoring. As a result, the discipline has experienced a great influx of research efforts and as these projects are conceived and undertaken, each project generally involves physical data collection. Due to a number of logistical challenges, a great obstacle in these studies is the procurement of a device that exhibits the desired nonlinear behavior. As a result, many researchers have longed for a versatile, but accurate, testing methodology that has complete freedom to simulate a wide range of nonlinearities and stochastic behaviors.

The objective of this study is to develop a reconfigurable test setup as a tool to be used in a wide range of nonlinear dynamic studies. The main components include a moving mass whose restoring force can accurately be controlled and reprogrammed (with software) based upon measured displacement and velocity readings at each time step. The device offers control over nonlinear characteristics and the equation of dynamic motion. The advantage of having such an experimental setup is the ability to simulate various types of nonlinearities with the same test setup. As a result, the data collected can be used to help validate nonlinear modeling, system identification, and stochastic analysis studies.

To display potential uses for the reconfigurable approach, examples are presented where the device has been used to create physical data for use in change detection and deterioration studies. Additionally a demonstration is presented of the device's ability to physically simulate a large-scale orifice viscous damper, commonly used in vibration mitigation in bridges and buildings. For a large-scale viscous damper, physical testing is needed to ensure proper working functionality; however it is a very expensive process and few laboratories have the equipment needed to properly test these large devices. Using the reconfigurable test setup, the dynamic signature of the large-scale viscous damper can accurately be simulated with pre-collected data.

The development of a system capable of emulating the restoring force of a nonlinear device with software is a novel approach and requires further calibration for increased reliability and accuracy. A discussion regarding the challenges faced when developing the methodology is presented and possible solutions are recommended.

The methodology introduced by this apparatus is very promising. The device is a valuable experimental tool for researchers and designers, allowing for physical data collection, modeling, analysis, and validation of a wide class of nonlinear phenomena that commonly occur in a wide variety of engineering applications.
The public is welcome to attend.