Abstract of the proposed project for public

Understanding and controlling complicated dynamic behaviors in engineering applications requires studying mechanical systems with parametric and self-excited vibrations, as well as dry friction, in both 1DoF and 2DoF configurations. These systems function as basic models that encompass the main features of more complex structures, enabling a thorough examination of stability, resonance, and nonlinear response phenomena. It is crucial to comprehend the interaction between parametric excitation and self-excited vibrations when dry friction is present. This understanding is necessary for accurately predicting and reducing unwanted oscillations that can result in mechanical failure or subpar performance in machinery, vehicles, and structural components. For example, in the development of vehicle suspension systems, having a thorough understanding of these dynamics helps improve the comfort and stability of the ride by successfully reducing vibrations.

Controlling parametric and self-excited vibrations in aerospace engineering is important for avoiding resonance, which potentially jeopardizes the structural integrity of aircraft. Parametric resonances and friction-excited vibrations are significant phenomena in engineering that have the potential to cause severe damage to structures and mechanical systems. Dangerous parametric resonances include the oscillations seen in suspension bridges, like the famous Tacoma Narrows Bridge collapse, and the instability in rotating machinery, where changes in system parameters on a regular basis can cause resonant situations. Friction-induced vibrations, also known as self-induced vibrations, frequently arise in systems involving sliding contact, such as brake squeals in automobile systems or stick-slip oscillations in drilling operations. When these processes work together, they can make it more destructive because parametric resonances can make friction-induced vibrations stronger, which can lead to a lot of wear and tear and, eventually, the collapse of the structure. Comprehending and reducing these interactions is essential for the reliable and secure design of engineering systems.

Moreover, the ideas obtained from this research play an important role in the advancement of energy-harvesting devices. These devices convert mechanical vibrations into electrical energy by optimizing the conditions in which these vibrations occur. Hence, the research not only enhances theoretical understanding but also offers pragmatic resolutions to real-world engineering obstacles. The rationale for this research arises from the substantial impact that nonlinear vibrations have on the functioning and dependability of mechanical systems. Throughout this study, we will conduct computational, analytical, and experimental investigations on unique experimental stand which briefly explained in detailed description. The system comprises a cart that moves along a linear rolling guide, which is commonly employed in various industries. The stiffness of the system is composed of two elements: a linear time-varying component produced by a rotating rod with a rectangular shape and a nonlinear hardening stiffness resulting from magnetic springs. When dealing with the nonlinear resistance of motion in a rolling bearing, the phenomena are treated as the combination of viscous damping and a second component that is theoretically identical to dry friction, independent of its true nature. Bifurcation analysis also used to examine the stability and dynamic transitions of the systems being studied. The nonlinear differential equations will be solved using analytical techniques such multiple scale method and harmonic balance method to provide approximate solutions. These solutions will, after that, undergo validation and expansion through comprehensive numerical and experimental results. This two-pronged approach guarantees a thorough comprehension of the behavior of the systems in various parameter ranges, resulting in a complete depiction of stability boundaries and dynamic phenomena such as chaos, limit cycles, and bifurcations.

The main objective of this project is to connect theoretical analysis and practical application, thereby providing significant insights into the subject of nonlinear dynamics in mechanical systems. These systems are commonly found in diverse engineering applications where mechanical vibrations must be comprehended, regulated, or exploited.