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# Dynamic features of mechanical systems: A Review

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***Abstract***— **In this paper, a concise review of different types of mechanical systems with potential applications in industry is presented from modeling view point. Among several types of models, beams, rods, shafts, plates, shells, membranes are highly enforceable. Based on the technical papers, it is perceptible that mathematical-mechanical modeling is of great importance. Besides to the mechanical model, incorporation of material properties both in mechanical and thermal domains helps the designer get a better maneuverability.**

***Keywords—mechanical and mathematical modeling, dynamic and static response***

## I. INTRODUCTION

In this paper, applications of diverse mechanical systems with interdisciplinary courses in mechanical, electrical, chemical, civil, biomedical engineering is proposed. As one of the most important steps in presenting a decent product, modeling is a vital step. Modeling an electro-mechanical system, or even a purely mechanical system is of great importance and requires in-depth knowledge of mechanical concepts along with great and robust technics in mathematics. On the other hand there is a great improvement in nano and micro-technologies. Such new-born technologies lead to the incorporating and merging mechanical techniques. In other words, with introduction and implementation of micro/nano-electro-mechanical-systems in past decades, various researchers from all over the world, showed a tendency towards micro and nano-technology research and case studies. This technology is comprised of a big range of industrial appliances such as micro-sensors/actuators/resonators. All types of research aligned with the micro/nano-technology requires a suitable mechanical and mathematical model of the system to get a better and more accurate final product. Among the mostly-used models, rods, plates, beams, shells, membranes with different boundary conditions have been adopted. Based on the dimensions of the system, the appropriate theory should be taken. In other words, it has proved that the classical continuum mechanics theory is not capable of capturing the size-dependency of the system. However, for the systems of mezoscale, classical mechanics is still useable. In order to compensate the deficiency of the continuum mechanics theory, several non-classical theories have been introduced. Such non-classical theories consider the size effects upon the static and dynamic analysis of the system [1-4]. Nonlocal elasticity theory [5], is one of the mostly-used non-classical theories so far. Moreover, modified couple stress theory, strain gradient theory, surface effect theory are all valid and highly-applicable theories (Babaei et al. (2015), Ghanbari et al. (2015)).

In recent years, several researchers have shown the static, buckling, and vibration analyses of micro-beams using size-dependent theories (Ghanbari and Babaei (2015)). Sheikh-Ahmadi also investigated dynamic response of mechanical system (2019). Moreover, Demir et al. (2020) studied dynamic analysis of curved systems using differential quadrature element method. Babaei et al. (2019) reported dynamic response of a system modeled based on beam theories with length scale parameter mutations and tolerating thermal stresses induced to the system. Faroughi et al. (2019) modeled a cantilever beam to simulate the response of a system usable in bio-mechanical and biology studies regarding human health care. Roque et al. (2013) did research on bending of a Timoshenko micro-beam using a meshless method upon collocation with radial basis functions. MEMS-type gyroscope was modeled and studied by Babaei (2019). He investigated chaotic and discernable responses of a system representing a small-scaled gyroscope. Babaei and Ahmadi (2017) investigated vibration analysis of micro-beams based on the modified couple stress theory. They considered a system of pinned-pinned or simply-supported system for the boundary conditions. Salamat-talab et al. (2012) proposed the same parabolic beam model for functionally graded beams and they compounded the dynamic analysis to the static one. Buckling of a functionally graded micro-beam was studied by Nateghi et al. (2012). Dynamic response of a Timoshenko beam based on mutable length scale parameter is carried out by Babaei and Rahmani (2018). A comprehensive study of vibrations, statics and buckling of a micro-structure using higher order beam theory was reported by Şimşek and Reddy (2013). Size-dependent dynamic analysis of MEMS elements under mechanical shock is perused by Askari and Tahani (2014). Babaei and Rahmani (2020) carried out a research regarding simulations and dynamic responses of a gyroscope undergoing thermal stresses. Rokni et al. (2014) optimized a reinforced micro-cantilever beam by polymers to reach the desired frequency domain. Babaei and Yang (2018) investigated a research about vibration analysis a rod-shape gyroscope using nonlocal elasticity theory. Jung et al. (2014) carried out a research on the buckling and vibration analyses of micro-plates embedded in elastic medium. Fathalilou et al. (2014) studied the micro-inertia effects on dynamic characteristics of a micro-beam.

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