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Fully Coupled 1D Model for the Response of a Membrane in a Thin Air-Filled Cavity. MAX ROMAN, ARNAUD GOULLET, New Jersey Institute of Technology, NADINE AUBRY, Carnegie Mellon University — A fully coupled 1D model based on a spring-mass system is derived for the response of a membrane subject to a time varying electrostatic charge in a thin air filled cavity. The elasticity of the membrane, the time dependent electric field, and the fluid flow are included in the model. The fluid film of air in the gap between the fixed electrode and deformable membrane is modeled using the linearized compressible Reynolds gas film equation, modified to account for the membrane deformation. From this, a fluid damping and spring coefficient are computed, which are used to calculate the fluid force on the membrane. A stiffness coefficient accounts for both linear and nonlinear membrane deformation. A capacitance-based generalized equation is used for the electrostatic field. Frequency and voltage are the only required inputs. It is found that there are distinct overdamped regimes consistent with spring-mass systems. The response computed from the model is compared to that obtained with a fully coupled 3D finite element solver. Excellent agreement is seen between the model and FEM results, with the model having a great advantage in the time necessary to obtain a solution for the response. The model is deemed a powerful tool in the design of microsystems with moving structures in which fluid damping plays a critical role in the structure's response.

Max Roman
New Jersey Institute of Technology

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