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The Minimal load potential of elastic membranes

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The versatility of elastic membranes as building blocks in mechanical vibration has led to their widespread use in various fields of science and technology, including architecture and construction, medical devices, industrial applications, consumer goods, aerospace and defense, energy applications, and the entertainment industry. Their unique ability to stretch and return to their original shape has made them a crucial material for many applications. To design more efficient membranes, it is essential to study the physical properties of these structures in-depth, gaining further insight into their behavior. This study focuses on a steady state, homogeneous elastic membrane and its optimal load potential under the presence of a vertical load. By assuming a fixed amount of total load energy, we aim to adjust the vertical force to achieve the minimum load potential energy. Our goal is to find a distribution pattern for the force over the membrane that results in the lowest load potential. Mathematically, this leads to an optimization problem with an elliptic partial differential equation as a constraint, resulting in a PDE-constrained optimization problem. It has been established that this problem has a unique solution, and for circular membranes, the optimal load can be derived analytically or in closed form. However, for membranes of general shape, a numerical method has been developed to compute the optimizer. Our numerical approaches have been demonstrated to be robust and efficient through several numerical results for non-circular membrane shapes. These results provide a distribution pattern for vertical forces that optimizes the load potential.

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No

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