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Interdisciplinary collaboration between engineering, mathematics and science

SEMS Research Highlights

This newsletter presents the research conducted within the School of Engineering, Mathematics and Science (SEMS) at Robert Morris University (RMU). It covers various relevant topics including: interdisciplinary efforts, successful research grants, student research, posters and papers, journal publications, presentations at national and international conferences, contribution to professional societies, STEM educational research, industrial consulting collaborations and applied research.

Vibration of Discrete and Continuous Systems

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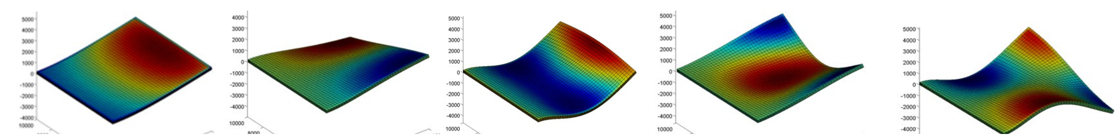
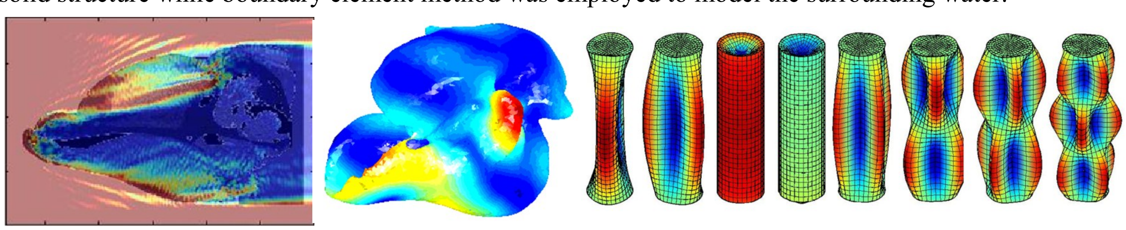
In mechanical engineering design, it is important to check that the system doesn't work at one of its natural frequencies to avoid catastrophic failure such as the Tacoma-Narrows bridge collapse. However, there may be some situations where a system needs to work at one of its natural frequencies such as an energy harvester. Natural frequencies and their corresponding modes of vibration are usually computed from a generalized eigenvalue problem defined by the following equation:

$$[K]\{X\} - \lambda P[K']\{X\} = \{0\}$$

Natural frequencies of continuum systems may be computed using Rayleigh-Ritz method. The Rayleigh-Ritz method consists of carrying out the minimization of the potential and kinetic energy of the system, modelling the amplitude of the displacement of the structure with a set of admissible functions. The figure below shows the first five modes of vibration of a cantilever plate.



Natural frequencies of the submerged structures are also important. The application of this research was made to study the hearing systems of marine mammals. Species closer in evolution appear to have a similar hearing. This research was carried out with Dr. Petr Krysl. Figures below show the hearing path of a dolphin with a signal at 120 kHz (left), and modes of vibration of two different structures submerged in water: (a) an ear bone of a marine mammal (center), and (b) a closed cylinder (right). Natural frequencies and modes of vibration of submerged structures were computed using finite element method to model the solid structure while boundary element method was employed to model the surrounding water.



Ground resonance in helicopters can be attributed to the coupling between a natural frequency of the fuselage with the regressing lead-lag mode of the rotor. When this happens the helicopter starts to shake severely and it can turn over. The regions of instability of the rotor can be computed from an eigenvalue problem. The instability of the helicopter can be avoided with an appropriate landing gear design.

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