Design projects

M 5740 Math Modeling
Fall 2017

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1 Transformer of vibrations

A simple model of a device (a metamaterial) that transforms the external periodic force $F_e = A\cos(\omega t)$ into electricity is shown in the Figure. It consists of the external massless and rigid plates (two rods), the inclined massless rigid joints that transform vertical vibrations into a horizontal motion $x(t)$ of the central rigid rod with the mass m, a spring with constant C ($F_{spring} = -C\,x$), and the dissipative element (or an electrical generator) with resistance force F is $F = -\gamma\dot{x}(t)$.

Model the motion of the rod. Derive the differential equation for x and solve it. Find optimal value of m and angle α that maximize the average dissipated energy

$$D = \frac{\omega}{2\pi}\int_0^{\frac{2\pi}{\omega}} \dot{x}^2(t)\,dt$$

2 Metamaterials: Negative Poisson's ratio materials

Investigate the mode of deformation of the two structures and compute their Poisson ratio ν in dependence of the angle θ.
http://silver.neep.wisc.edu/ lakes/Poisson.html
http://en.wikipedia.org/wiki/Auxetics

Find other models of Auxetics and discuss their common properties.

Suggest a 3d model of auxetic material. What are natural boundaries for the Poisson ratio?

A natural continuation of the auxetics:
Theory
GW.Milton and A.Cherkaev. Which Elasticity Tensors are Realizable? J. Eng. Mater. Technol 117(4), 483-493 (Oct 01, 1995)
Realization
M.Kadic, T.Bckmann, N.Stenger, M.Thiel, M.Wegener. On the feasibility of pentamode mechanical metamaterials.
https://arxiv.org/abs/1203.1481