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Negative stiffness as a unified model of solitary wave propagation and friction force oscillations produced by rotation of non-spherical particles

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Rotation of non-spherical particles in the presence of compression leads to the effect of apparent negative stiffness. We show that the dynamics of a rotating non-spherical particle is equivalent to that of inverted pendulum where the gravity force acting on the mass of the pendulum substitutes the effect of compression. We investigated analytically and experimentally the eigenfrequency and the stability of the inverted pendulum under changing mass. We demonstrated that increase of the mass leads to the decrease of eigenfrequency of the system beyond that of an ordinary pendulum. Furthermore, there exists a value of the mass at which the eigenfrequency becomes zero. At this point the system loses its stability. This corresponds to the results obtained for a pair of coupled linear oscillators with one negative stiffness spring. Thus the concept of negative stiffness allows formulation of a simple and accurate model of inverted pendulum and rotating non-spherical particle. A chain of coupled inverted pendulums (or rotating particles) shows propagation of a solitary wave. Furthermore, randomly located rotating non-spherical particles under compressive force create fluctuations in the friction force. The concept of negative stiffness provides a unified description of the above phenomena.