

REGULAR AND COMPOUND BEHAVIOR OF A PENDULUM SYSTEM IN A MAGNETIC FIELD

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This paper considers the dynamics of an oscillatory dissipative system of two coupled pendulums in a magnetic field. The pendulums are coupled via an elastic element. The inertial components of the pendulums vary over a wide range, and in the analytical study the mass ratio is chosen as a small parameter. The magnetic forces are calculated using the Padé approximation, which best agrees with the experiment. This approximation describes the magnetic excitation to good accuracy. The presence of external inputs in the form of magnetic forces and various types of loads that exist in many engineering systems significantly complicates the mode shape analysis of nonlinear system. Nonlinear normal modes of this system are studied, one mode being coupled and the other being local. The modes are constructed by the multiple-scale method. Both regular and compound behavior is studied as a function of the system parameters: the pendulum mass ratio, the coupling coefficient, the magnetic intensity coefficient, and the distance between the axis of rotation and the center of gravity. The effect of these parameters is studied both at small and at sizeable initial pendulum inclination angles. The analytical solution is compared with the results of a numerical simulation based on the fourth-order Runge–Kutta method where the modes are calculated using the initial values of the variables found in the analytical solution. The numerical simulation, which includes the construction of phase diagrams and trajectories in the configuration space, allows one to assess the dynamics of the system, which may be both regular and compound. The stability of the coupled mode is studied using a numerical-analytical test, which is an implementation of the Lyapunov stability criterion. In doing so, the stability of a mode is determined by assessing the vertical off-trajectory deviation of the mode in the configuration space.

Keywords: coupled pendulums, magnetic forces, nonlinear normal modes, multiple-scale method.

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