

# Nonlinear Rolling of a Biased Ship in a Regular Beam Wave under External and Parametric Excitations

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We consider a nonlinear oscillator simultaneously excited by external and parametric functions. The oscillator has a bias parameter that breaks the symmetry of the motion. The example that we use to illustrate the problem is the rolling oscillation of a biased ship in longitudinal waves, but many mechanical systems display similar features. The analysis took into consideration linear, quadratic, cubic, quintic, and seven terms in the polynomial expansion of the relative roll angle. The damping moment consists of the linear term associated with radiation and viscous damping and a cubic term due to frictional resistance and eddies behind bilge keels and hard bilge corners. Two methods (the averaging and the multiple time scales) are used to investigate the first-order approximate analytical solution. The modulation equations of the amplitudes and phases are obtained. These equations are used to obtain the stationary state. The stability of the proposed solution is determined applying Liapunov's first method. Effects of different parameters on the system behaviour are investigated numerically. Results are presented graphically and discussed. The results obtained by two methods are in excellent agreement.

*Key words:* Nonlinear Rolling; External and Parametric Excitations; Stationary State; Stability.