Stability of Nonlinear Oscillations of an Elastic Rod

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I3. Steady-State Whirl of a Long Eccentric Shaft under Variable Tension Rotating in a Viscous Medium. C. D. MICHALOPOULOS AND D. MUSTER, *Department of Mechanical Engineering, University of Houston, Houston, Texas 77004.*—The problem of whipping of an eccentric, long circular shaft under linearly varying tension rotating in a fluid medium is investigated within linear theory. In view of the great lengths under consideration, the bending stiffness is assumed negligible. Internal damping is neglected and the external damping is assumed viscous. The mass eccentricity is assumed to be a deterministic function of the axial coordinate. Only steady-state conditions are considered. The deflection of the shaft is obtained by finite Hankel transforms, and the bending stresses are subsequently determined approximately from the curvature of the deflection curve. Numerical results are given in graphical form for a shaft with a pulse-type eccentricity function in one plane for several values of speed of rotation and tension at the lower end.

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I4. Driven Nonlinear Oscillations of a String. ANTHONY I. ELLER, *Physics Department, Naval Postgraduate School, Monterey, California 93940.*—Because of nonlinearities, the forced oscillations of a string, moving in a single plane, become unstable when the string is driven with sufficient amplitude near resonance. This paper describes the experimental conditions under which forced string oscillations in a vertical plane become unstable. It is found that planar oscillations become unstable in two different ways. One instability is triggered by a spontaneous growth or decrease in the amplitude of the driven vertical motion. The other instability is triggered by a spontaneous growth of a horizontal component of motion, thus leading to a whirling or nonplanar motion of the string. The conditions under which each instability occurs are distinct. These experimental observations agree with the conclusions by Anand [J. Acoust. Soc. Amer. **46**, 667–677 (1969)], based on a theoretical analysis. This paper also describes the response of the nonplanar mode of oscillation. It is found for certain conditions that the vertical amplitude of oscillation decreases as the driving signal is increased.

3:00

I5. Stability of Nonlinear Oscillations of an Elastic Rod. E. C. HAIGHT, *The MITRE Corporation, McLean, Virginia,* AND W. W. KING, *The Georgia Institute of Technology, Atlanta, Georgia.*—The stability of plane steady oscillations of a slender elastic rod subjected to lateral harmonic excitation is investigated. For certain values of excitation amplitudes and frequencies, the planar response is unstable, and nonplanar motions are parametrically excited. Steady nonplanar motions are characterized by each point on the rod centerline tracing an elliptical path perpendicular to the rod axis. The investigation is restricted to cantilevered rods with nearly equal principal moments of inertia of the cross section, and excitation is always in the direction of one of the principal axis of inertia. The effects of damping and of slight variations of the natural frequencies associated with motions in the two principal planes are investigated. Supporting experimental evidence is presented. Finally, the principal features of the transversely driven rod response are compared with the response for the same type rod excited axially.

3:15

I6. Forced Longitudinal Vibrations of Prismatic Slender Bars with Distributed Quadratic and Equivalent Viscous Damping. A. D. WILKINSON, JR., *Manager of Research and Development, The Offshore Company, 3411 Richmond Avenue, Houston, Texas 77006,* AND C. D. MICHALOPOULOS, *Department of Mechanical Engineering, University of Houston, Houston, Texas 77004.*—Forced longitudinal vibrations of a prismatic slender bar with quadratic skin damping and equivalent viscous damping are considered. The bar is assumed to be free at one end and subjected to sinusoidal motion at the other. The differential equation of motion for the case of quadratic damping is solved numerically by the method of characteristics. Frequency-response curves are given for several values of the nonlinear damping coefficient. The equivalent linear system is analyzed by Laplace transforms, and the results are compared with those for the nonlinear system. The equation of motion is linearized by equating the energies dissipated per cycle by quadratic and viscous damping.

3:30

I7. On the Dynamic Behavior of a Cable System in a Recovery Operation. PATRICIO A. LAURA AND JACQUES E. GOELLER, *The Catholic University of America, Washington, D. C. 20017.*—The removal of bodies embedded in the ocean-bottom sediments is a matter of great importance in ocean technology. A common occurrence takes place in the case of salvage recovery of large objects. Another example is the case of civil-engineering-type structures conceived for placement in the ocean floor since some degree of mobility is required for maintenance purposes. The present study deals with an experimental and analytical investigation on the behavior of a cable system in a salvage-type operation. Steady-state and transient vibrations of the system are considered. The possibility of "snap" loads in the system is studied and some conclusions of practical interest are drawn.

3:45

I8. On the Utilization of a Flexible Bar as a Continuous Spatial Filter. R. F. LAMBERT AND F. A. AUPPERLE, *University of Minnesota, Minneapolis, Minnesota 55455.*—In order to determine empirically the wavenumber–frequency spectra of the wall pressure fluctuations beneath a turbulent boundary layer at nonconvective wavenumbers, a spatial filter with high wavenumber resolution is necessary. Such a filter can be realized by using a continuous system such as a flexible bar or by using a discrete array of finite-sized transducers. The bar offers the advantage that high wavenumber resolution can be achieved without the use of the elaborate equipment necessary for the transducer arrays. In order to use the bar as a spatial filter all that is required is a measurement of the modal displacement response at some spatial position. In this paper, the theoretical formulation of the bar as a continuous spatial filter is developed. Calibration procedures and measurement problems such as those associated with vibrational noise are discussed. Finally, measurements of the low-wavenumber (nonconvective) spectra of the wall pressure fluctuations obtained by using the bar as a spatial filter are reported. One important result of this study is that it demonstrates that the primary wavenumbers associated with the pressure fluctuations contributing to the bar response are not the convective wavenumbers. This implies that Corcos's model, which has been empirically verified only for wavenumbers near the convective wavenumbers [D. M. Chase, J. Acoust. Soc. Amer. **46**, 1350–1365 (1969)], may not be adequate for predicting panel response. The measured low-wavenumber (nonconvective) spectra indicate the limitations of Corcos' model in this region. [Work supported by grant from the National Aeronautics and Space Administration.]

4:00

I9. Analysis of Connected Continuous Structures Using Receptances. L. L. FAULKNER AND J. F. HAMILTON, *Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, Lafayette, Indiana, 47907.*—A method for the analysis of connected beam, ring, plate, and shell structures