M I N I C U R S O

Bifurcations of Eigenvalues and Stability Problems in Mechanics

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PROGRAM:

Lecture 1 gives general analysis of bifurcations for eigenvalues with geometric interpretation in two- and three-dimensional spaces. Main attention is focused on simple and double eigenvalues, and strong and weak interactions of eigenvalues are distinguished. In Lecture 2 stability and catastrophes in one-parameter circulatory systems with simple mechanical examples are studied. It is proven that in general they are subjected to catastrophes of three types: flutter, divergence, and transition from flutter to divergence and vice versa.

In Lecture 3 properties of two-parameter circulatory systems are studied, and the explicit formulas describing metamorphoses of frequency curves are derived. These formulas use information on the system only at a merging point of the frequencies, and allow qualitative as well as quantitative analysis of behavior of frequency curves near that point with a change of parameters. In particular, development of “a bubble of instability” is analyzed.

In Lecture 4 the Keldysh problem of aeroelastic stability of a wing with bracing struts is discussed, and the effect of disappearance of flutter instability revealed by Keldysh (1938) is explained. It is shown that this effect is connected with the convexity of the flutter domain in the parameter space.

In Lecture 5 we study a problem of maximizing the critical buckling load of an elastic column of given length and volume assuming elastic supports at both ends of the column. This problem was first formulated by J.-L. Lagrange in 1773 for simply supported columns and has been considered by many authors for various boundary conditions. We obtain the bimodal optimal solutions and investigate their post-buckling behavior.

Lecture 6 concerns instability domains for Hill’s equation with damping under assumption of small excitation amplitude and damping coefficient. It is shown that these domains are halves of cones in the three-dimensional parameter space. One of the important applications of Hill’s equation is connected with the stability study of periodic

motions for nonlinear dynamical systems. It is shown how to find stable and unstable regimes for harmonically excited Duffing's equation.
Lecture 7 considers linear vibrational systems with periodic coefficients of arbitrary dimension depending on three independent parameters: frequency and amplitude of periodic excitation, and damping parameter with the assumption that the last two quantities are small. Two important specific cases of excitation matrix are studied: a symmetric matrix and a stationary matrix multiplied by a scalar periodic function. It is shown that in both cases the resonance domains are halves of cones in the three-dimensional space with the boundary surface coefficients depending only on the eigenfrequencies, eigenmodes and system matrices.
In Lecture 8 two mechanical problems are treated and solved: Bolotin's problem of dynamic stability of a beam loaded by periodic bending moments, and parametric resonance of a non-uniform column loaded by periodic longitudinal force.

BIBLIOGRAPHY:

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