ME 690 Hydrodynamic Stability and Transition to Turbulence

Introduction: overview of methods of stability analysis (linear and nonlinear theories), normal mode analysis; Common examples of gravitational, thermal and centrifugal instabilities: Rayleigh-Taylor instability, Rayleigh-Bénard instability, instabilities in Taylor–Couette flow; Instabilities in parallel flows: temporal instability, Rayleigh equation, Orr-Sommerfeld equation and Squire's transformation, numerical technique for solving the Orr-Sommerfeld equation, spatial instability and Gaster's transformation; Spatio-temporal instability: evolution of perturbations in space-time, absolute and convective instabilities, Brigg's method and the pinch point criteria; Stability of non-parallel flows: instabilities in weakly nonparallel flows, parabolised stability equations, bi-global and tri-global stability analysis; Nonlinear stability theory: weak nonlinearity, Landau equation, interaction of linear modes, energy methods; Transition to turbulence: transient growth, pseudo spectra and nonmodal instabilities, receptivity, secondary instability, Morkovin map of roads to wall turbulence, regimes of laminar-turbulent transition in boundary layer flows, routes to chaos and turbulence.