

Instability and Transition of Fluid Flows - Video course

COURSE DETAIL

Modules	Topic
1	Introduction to Instability and Transition
	<ol style="list-style-type: none"> 1. Introduction 2. What Is Instability? 3. Temporal and Spatial Instability 4. Some Instability Mechanisms <ol style="list-style-type: none"> 1. Dynamic Stability of Still Atmosphere 2. Kelvin–Helmholtz Instability
2	Computing Transitional and Turbulent Flows
	2.1 Fluid Dynamical Equations <ol style="list-style-type: none"> 2.1.1 Equation of Continuity 2.1.2 Momentum Conservation Equation 2.1.3 Energy Conservation Equation 2.1.4 Alternate Forms of the Energy Equation 2.1.5 Equations of Motion in Terms of Derived Variables
	2.2 Some Equilibrium Solutions of the Basic Equation <ol style="list-style-type: none"> 2.2.1 Couette Flow between Parallel Plates 2.2.2 Flow between Concentric Rotating Cylinders 2.2.3 Couette Flow between Parallel Plates, Driven by Pressure 2.2.4 Steady Stagnation Point Flow 2.2.5 Flow Past a Rotating Disc
	2.3 Boundary Layer Theory
	2.4 Control Volume Analysis of Boundary Layers <ol style="list-style-type: none"> 2.4.1 Displacement Thickness 2.4.2 Momentum Thickness 2.4.3 Separation of a Steady Boundary Layer 2.5 Numerical Solution of the Thin Shear Layer (TSL) Equation <ol style="list-style-type: none"> 2.5.1 Falkner–Skan Similarity Profile 2.5.2 Separation Criterion for Wedge Flow 2.5.3 Blasius Profile 2.5.4 Hiemenz or Stagnation Point Flow
	2.6 Laminar Mixing Layer 2.7 Plane Laminar Jet



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	<p>2.8 Issues of Computing Space-Time Dependent Flows 2.8.1 Waves — Building Blocks of a Disturbance Field 2.8.2 Plane Waves</p>
	<p>2.9 Wave Interaction: Group Velocity and Energy Flux 2.9.1 Physical and Computational Implications of Group Velocity 2.9.2 Wave Packets and Their Propagation</p>
	<p>2.10 Issues of Space–Time Scale Resolution of Flows . . . 2.10.1 Spatial Scales in Turbulent Flows 2.10.2 Two- and Three-Dimensional DNS 2.11 Temporal Scales in Turbulent Flows 2.12 Computing Time-Averaged and Unsteady Flows 2.13 Computing Methods for Unsteady Flows: Dispersion Relation Preserving Methods 2.13.1 Spectral or Numerical Amplification Factor 2.13.2 Quantification of Dispersion Error 2.14 DRP Schemes: Parameter Ranges for Creating q-Waves</p>
3	Instability and Transition in Flows
	<p>3.1 Introduction 3.2 Parallel Flow Approximation and Inviscid Instability Theorems 3.2.1 Inviscid Instability Mechanism</p>
	<p>3.3 Viscous Instability of Parallel Flows 3.3.1 Eigenvalue Formulation for Instability of Parallel Flows 3.3.2 Temporal and Spatial Amplification of Disturbances</p>
	<p>3.4 Properties of the Orr–Sommerfeld Equation and Boundary Conditions 3.4.1 Compound Matrix Method 3.5 Instability Analysis from the Solution of the Orr–Sommerfeld Equation 3.5.1 Local and Total Amplification of Disturbances 3.5.2 Effects of the Mean Flow Pressure Gradient 3.5.3 Transition Prediction Based on Stability Calculation 3.5.4 Effects of Free Stream Turbulence</p>
	<p>3.6 Receptivity Analysis of the Shear Layer 3.6.1 Receptivity by Linearized Approach: Connection to Stability Theory 3.6.1.1 A Brief Review of Laplace–Fourier Transforms 3.6.1.2 Fourier and Laplace Transforms 3.6.1.3 Inversion Formula for Laplace Transforms 3.6.1.4 A Short Tutorial on Fourier Integral and Transforms 3.6.1.5 Some Useful Fourier/Laplace Transforms 3.6.2 Receptivity to Wall Excitation and Impulse Response 3.6.2.1 Near-Field Response Created by Localized Excitation 3.6.2.2 Outer Solution 3.6.2.3 Inner Solution 3.6.3 Vibrating Ribbon at the Wall 3.6.4 Receptivity to Free Stream Excitation 3.6.5 General Excitation and Upstream Propagating Modes 3.6.6 Low Frequency Free Stream Excitation and the Klebanoff Mode</p>
	<p>3.7 Direct Simulation of Receptivity to Free Stream Excitation 3.7.1 Coupling between the Wall and Free Stream Modes 3.7.2 Receptivity to a Train of Convected Vortices in the Free Stream</p>

	3.7.3 Further Explanation of Free Stream Periodic Excitation
	3.8 Nonparallel and Nonlinear Effects on Instability and Receptivity 3.8.1 Time Varying Receptivity Problem vis-a-vis the Signal Problem 3.8.2 Evidence of Nonparallel and Nonlinear Effects 3.8.3 Limitations of Linearized Nonparallel Theories
4	Bypass Transition: Theory, Computations, and Experiments
	4.1 Introduction 4.2 Transition via Growing Waves and Bypass Transition 4.3 Visualization Study of Vortex-Induced Instability as Bypass Transition . . . 179 4.4 Computations of Vortex-Induced Instability as a Precursor to Bypass Transition 4.5 Instability Mechanism in Vortex-Induced Instability 4.6 Instability at the Attachment Line of Swept Wings
5	Spatio-Temporal Wave Front and Transition
	5.1 Introduction 5.2 Transient Energy Growth 5.3 Bromwich Contour Integral Method and Energy-Based Receptivity Analysis 5.4 Spatio-Temporal Wave Front Obtained by the Bromwich Contour Integral Method 5.5 Nonlinear Analysis: Transition by the Spatio-Temporal Front and Bypass Route 5.5.1 Governing Equations and Boundary Condition 5.5.2 Nonlinear Receptivity to Vortical Wall Excitation 5.5.3 Low Amplitude, Moderate Frequency Excitation 5.5.4 High Amplitude Cases and Spot Regeneration Mechanism 5.5.5 Low Frequency Excitation Cases: Different Route of Transition 5.6 Calculation of the N Factor
6	Nonlinear Effects: Multiple Hopf Bifurcations and Proper Orthogonal Decomposition
	6.1 Introduction 6.2 Receptivity of Bluff-Body Flows to Background Disturbances 6.2.1 Numerical Simulation of Flow Past a Cylinder 6.3 Multiple Hopf Bifurcations, Landau Equation and Flow Instability 6.4 Instability of Flow Past a Cylinder 6.5 Role of FST on Critical Reynolds Number for a Cylinder 6.6 POD Modes and Nonlinear Stability 6.7 Landau–Stuart–Eckhaus Equation 6.8 Universality of POD Modes
7	Stability and Transition of Mixed Convection Flows
	7.1 Introduction 7.2 Governing Equations 7.3 Equilibrium Boundary Layer Flow Equations 7.3.1 Schneider's Similarity Solution 7.4 Linear Spatial Stability Analysis of the Boundary Layer over a Heated Plate

	<p>7.4.1 Fundamental Solutions of the OSE 7.4.2 Compound Matrix Method for the Sixth Order OSE 7.4.3 Initial Conditions for an Auxiliary System of Equations 7.4.4 Dispersion Relation 7.4.5 Grid Search Method and Newton–Raphson Technique for Eigenspectrum 7.4.6 Neutral Curve and Wavenumber Contours 7.4.7 Precision in Computing 7.4.8 Results of the Linear Spatial Stability Theory 7.5 Nonlinear Receptivity of Mixed Convection Flow over a Heated Plate 7.5.1 Boundary and Initial Conditions 7.5.2 Eigenfunction Structure and DNS of the Mixed Convection Problem</p>
8	Instabilities of Three-Dimensional Flows
	<p>8.1 Introduction 8.2 Three-Dimensional Flows 8.3 Infinite Swept Wing Flow 8.4 Attachment Line Flow 8.5 Boundary Layer Equations in the Transformed Plane 8.6 Simplification of Boundary Layer Equations in the Transformed Plane 8.7 Instability of Three-Dimensional Flows 8.7.1 Effects of Sweep Back and Cross Flow Instability 8.8 Linear Stability Theory for Three-Dimensional Flows 8.8.1 Temporal Instability of Three-Dimensional Flows 8.8.2 Spatial Instability of Three-Dimensional Flows 8.9 Experimental Evidence of Instability on Swept Wings 8.10 Infinite Swept Wing Boundary Layer 8.11 Stability of the Falkner–Skan–Cooke Profile 8.12 Stationary Waves over Swept Geometries 8.13 Traveling Waves over Swept Geometries 8.14 Attachment Line Problem 8.15 Empirical Transition Prediction Method for Three-Dimensional Flows 8.15.1 Streamwise Transition Criterion 8.15.2 Cross Flow Transition Criteria . 8.15.3 Leading Edge Contamination Criterion</p>
9	Analysis and Design of Natural Laminar Flow Airfoils
	<p>9.1 Introduction 9.2 Airfoil Nomenclature and Basic Aerodynamic Properties 9.3 Pressure Distribution and Pressure Recovery of Some Low Drag Airfoils 9.4 Flapping of Airfoils 9.5 Effects of Roughness and Fixing Transition 9.6 Effects of Vortex Generator or Boundary Layer Re-Energizer 9.7 Section Characteristics of Various Profiles</p>