

CONTENTS

	<i>page</i>
<i>Foreword by John Miles</i>	xiii
<i>Preface</i>	xix
1 INTRODUCTION	
1 Introduction	1
2 Mechanisms of instability	4
3 Fundamental concepts of hydrodynamic stability	8
4 Kelvin-Helmholtz instability	14
5 Break-up of a liquid jet in air	22
Problems for chapter 1	27
2 THERMAL INSTABILITY	
6 Introduction	32
7 The equations of motion	34
The exact equations, 34; The Boussinesq equations, 35	
8 The stability problem	37
The linearized equations, 37; The boundary conditions, 40; Normal modes, 42	
9 General stability characteristics	44
Exchange of stabilities, 44; A variational principle, 45	
10 Particular stability characteristics	50
Free-free boundaries, 50; Rigid-rigid boundaries, 51; free-rigid boundaries, 52	
11 The cells	52
12 Experimental results	59
13 Some applications	62
Problems for chapter 2	63

3 CENTRIFUGAL INSTABILITY	
14	Introduction 69
15	Instability of an inviscid fluid 71
	Three-dimensional disturbances, 73; Axisymmetric disturbances, 77; Two-dimensional disturbances, 80
16	Instability of Couette flow of an inviscid fluid 82
17	The Taylor problem 88
	Axisymmetric disturbances, 90; Two-dimensional disturbances, 103; Three-dimensional disturbances, 104; Some experimental results, 104
18	The Dean problem 108
	The Dean problem, 108; The Taylor–Dean problem, 113
19	The Görtler problem 116
	Problems for chapter 3 121
4 PARALLEL SHEAR FLOWS	
20	Introduction 124
	The inviscid theory
21	The governing equations 126
22	General criteria for instability 131
23	Flows with piecewise-linear velocity profiles 144
	Unbounded vortex sheet, 145; Unbounded shear layer, 146; Bounded shear layer, 147
24	The initial-value problem 147
	The viscous theory
25	The governing equations 153
26	The eigenvalue spectrum for small Reynolds numbers 158
	A perturbation expansion, 159; Sufficient conditions for stability, 161
27	Heuristic methods of approximation 164
	The reduced equation and the inviscid approximations, 165; The boundary-layer approximation near a rigid wall, 167; The WKBJ approximations, 167; The local turning-point approximations,

	171; The truncated equation and Tollmien's improved viscous approximations, 175; The viscous correction to the singular inviscid solution, 177	
28	Approximations to the eigenvalue relation 180	
	Symmetrical flows in a channel, 181; Flows of the boundary-layer type, 183; The boundary-layer approximation to $\phi_3(z)$, 184; The WKBJ approximation to $\phi_3(z)$, 185; The local turning-point approximation to $\phi_3(z)$, 188; Tollmien's improved approximation to $\phi_3(z)$, 191	
29	The long-wave approximation for unbounded flows 196	
30	Numerical methods of solution 202	
	Expansions in orthogonal functions, 203; Finite-difference methods, 206; Initial-value methods (shooting), 207	
31	Stability characteristics of various basic flows 211	
	Plane Couette flow, 212; Poiseuille flow in a circular pipe, 216; Plane Poiseuille flow, 221; Combined plane Couette and plane Poiseuille flow, 223; The Blasius boundary-layer profile, 224; The asymptotic suction boundary-layer profile, 227; Boundary layers at separation, 229; The Falkner–Skan profiles, 231; The Bickley jet, 233; The hyperbolic-tangent shear layer, 237	
32	Experimental results 239	
	Problems for chapter 4 245	
5 UNIFORM ASYMPTOTIC APPROXIMATIONS		
33	Introduction 251	
	Plane Couette flow	
34	The integral representations of the solutions 256	
35	The differential equation method 263	
	General velocity profiles	
36	A preliminary transformation 265	

37	The inner and outer expansions	267
	The inner expansions, 268; The outer expansions, 271; The central matching problem, 276; Composite approximations, 278	
38	Uniform approximations	280
	The solution of well-balanced type, 280; The solutions of balanced type, 280; The solutions of dominant-recessive type, 283	
39	A comparison with Lin's theory	285
40	Preliminary simplification of the eigenvalue relation	290
41	The uniform approximation to the eigenvalue relation	295
	A computational form of the first approximation to the eigenvalue relation, 299; Results for plane Poiseuille flow, 301	
42	A comparison with the heuristic approximations to the eigenvalue relation	305
	The local turning-point approximation to $\phi_3(z)$, 305; Tollmien's improved approximation to $\phi_3(z)$, 306; The uniform approximation to $\phi_3(z)$ based on the truncated equation, 308; The uniform approximation to $\phi_3(z)$ based on the Orr-Sommerfeld equation, 309	
43	A numerical treatment of the Orr-Sommerfeld problem using compound matrices	311
	Symmetrical flows in a channel, 315; Boundary-layer flows, 316	
	Problems for chapter 5	317

6 ADDITIONAL TOPICS IN LINEAR STABILITY THEORY

44	Instability of parallel flow of a stratified fluid	320
	Introduction, 320; Internal gravity waves and Rayleigh-Taylor instability, 324; Kelvin-Helmholtz instability, 325	
45	Baroclinic instability	333
46	Instability of the pinch	339
47	Development of linear instability in time and space	345
	Initial-value problems, 345; Spatially growing modes, 349	

48	Instability of unsteady flows	353
	Introduction, 353; Instability of periodic flows, 354; Instability of other unsteady basic flows, 361	
	Problems for chapter 6	363

7 NONLINEAR STABILITY

49	Introduction	370
	Landau's theory, 370; Discussion, 376	
50	The derivation of ordinary differential systems governing stability	380
51	Resonant wave interactions	387
	Internal resonance of a double pendulum, 387; Resonant wave interactions, 392	
52	Fundamental concepts of nonlinear stability	398
	Introduction to ordinary differential equations, 398; Introduction to bifurcation theory, 402; Structural stability, 407; Spatial development of nonlinear stability, 416; Critical layers in parallel flow, 420	
53	Additional fundamental concepts of nonlinear stability	423
	The energy method, 424; Maximum and minimum energy in vortex motion, 432; Application of boundary-layer theory to cellular instability, 434	
54	Some applications of the nonlinear theory	435
	Bénard convection, 435; Couette flow, 442; Parallel shear flows, 450	
	Problems for chapter 7	458

APPENDIX. A CLASS OF GENERALIZED AIRY FUNCTIONS

A1	The Airy functions $A_k(z)$	465
A2	The functions $A_k(z, p)$, $B_0(z, p)$ and $B_k(z, p)$	466
A3	The functions $A_k(z, p, q)$ and $B_k(z, p, q)$	472
A4	The zeros of $A_1(z, p)$	477
	Addendum: Weakly non-parallel theories for the Blasius boundary layer	479
	<i>Solutions</i>	481
	<i>Bibliography and author index</i>	559
	<i>Motion picture index</i>	595
	<i>Subject index</i>	597