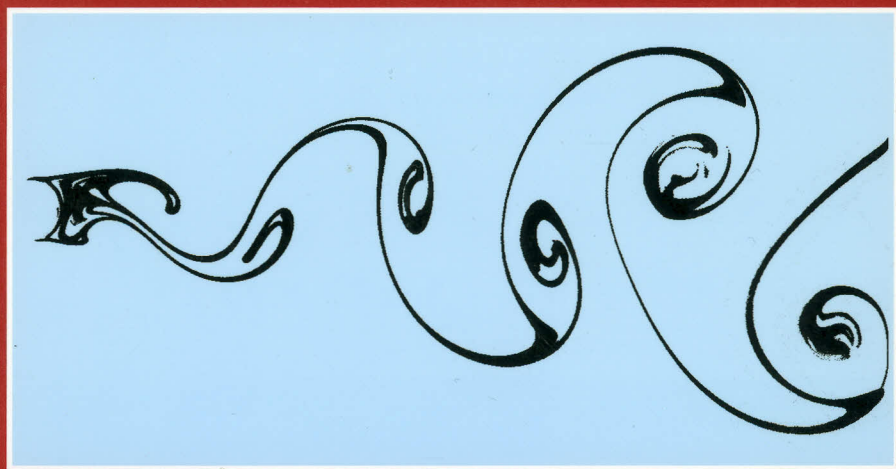


CAMBRIDGE TEXTS
IN APPLIED
MATHEMATICS

Introduction to Hydrodynamic Stability



5
P. G. DRAZIN

Introduction to Hydrodynamic Stability

P. G. DRAZIN

 **CAMBRIDGE**
UNIVERSITY PRESS

Contents

Preface	<i>page xv</i>
1 General Introduction	1
1.1 Prelude	1
1.2 The Methods of Hydrodynamic Stability	6
1.3 Further Reading and Looking	8
2 Introduction to the Theory of Steady Flows, Their Bifurcations and Instability	10
2.1 Bifurcation	10
2.2 Instability	19
2.3 Stability and the Linearized Problem	28
3 Kelvin–Helmholtz Instability	45
3.1 Basic Flow	45
3.2 Physical Description of the Instability	45
3.3 Governing Equations for Perturbations	47
3.4 The Linearized Problem	48
3.5 Surface Gravity Waves	50
3.6 Internal Gravity Waves	50
3.7 Rayleigh–Taylor Instability	51
3.8 Instability Due to Shear	52
4 Capillary Instability of a Jet	62
4.1 Rayleigh’s Theory of Capillary Instability of a Liquid Jet	62

5	Development of Instabilities in Time and Space	68
5.1	The Development of Perturbations in Space and Time	68
5.2	Weakly Nonlinear Theory	74
5.3	The Equation of the Perturbation Energy	82
6	Rayleigh–Bénard Convection	93
6.1	Thermal Convection	93
6.2	The Linearized Problem	95
6.3	The Stability Characteristics	97
6.4	Nonlinear Convection	100
7	Centrifugal Instability	123
7.1	Swirling Flows	123
7.2	Instability of Couette Flow	125
7.3	Görtler Instability	130
8	Stability of Parallel Flows	138
	Part 1: Inviscid Fluid	138
8.1	Stability of Plane Parallel Flows of an Inviscid Fluid	138
8.2	General Properties of Rayleigh's Stability Problem	144
8.3	Stability Characteristics of Some Flows of an Inviscid Fluid	149
8.4	Nonlinear Perturbations of a Parallel Flow of an Inviscid Fluid	154
	Part 2: Viscous Fluid	156
8.5	Stability of Plane Parallel Flows of a Viscous Fluid	156
8.6	Some General Properties of the Orr–Sommerfeld Problem	160
	8.6.1 Energy	161
	8.6.2 Instability in the inviscid limit	163
8.7	Stability Characteristics of Some Flows of a Viscous Fluid	167
8.8	Numerical Methods of Solving the Orr–Sommerfeld Problem	171
8.9	Experimental Results and Nonlinear Instability	172
8.10	Stability of Axisymmetric Parallel Flows	178
9	Routes to Chaos and Turbulence	208
9.1	Evolution of Flows as the Reynolds Number Increases	208
9.2	Routes to Chaos and Turbulence	211

10	Case Studies in Transition to Turbulence	215
10.1	Synthesis	215
10.1.1	Introduction	215
10.1.2	Instability of flow past a flat plate at zero incidence	216
10.2	Transition of Flow of a Uniform Stream Past a Bluff Body	219
10.2.1	Flow past a circular cylinder	219
10.2.2	Flow past a sphere	224
10.3	Transition of Flows in a Diverging Channel	225
10.3.1	Introduction	225
10.3.2	Asymptotic methods	226
10.3.3	Some paradoxes	231
10.3.4	Nonlinear waves	232
10.3.5	Conclusions	233
	References	237
	Index	249