Contents

Preface		ix
	PART ONE	
Chapter I	Wave Generation	
1.1	Review of Ideal Fluid Theory	3
1.2	Review of Surface Gravity Waves	8
1.3	Generation of Gravity Waves by Atmospheric Pressure Fluctuations	10
1.4	Statistical Resonance Theory	13
1.5	Stability of Parallel Shear Flow	15
1.6	Gravity Waves Generated by Shear Flow Instability	19
	References	25
Chapter II	Rotating Fluids	
2.1	Review of Coriolis Force	26
2.2	Rotational Rigidity and Inertia Waves	28
2.3	The Conservation of Potential Vorticity	31
	·	v

vi		CONTENTS
2.4	Illustrative Examples	34
2.5	The β Effect in a Rotating Spherical Annulus	36
2.6	Inertial Western Boundary Current	39
2.7	Another Western Boundary Current	41
	References and Supplementary Reading	43
Chapter III	Density Currents	
3.1	Review of Nonrotating Shallow Water Theory	44
3.2	The Hydrostatic Approximation in a Rotating Fluid	45
3.3	Conservation Theorems	47
3.4	Inertia-Gravity and Kelvin Waves	48
3.5	Flow through a Rotating Open Channel	50
3.6	Internal Motions in Layers of Slightly Different	
	Density	53
3.7	Shallow Water Theory on a Rotating Sphere	57
	References	60
	w.	
Chapter IV	Quasi-Geostrophic Motion	
4.1	The Transition from Shallow Water to Quasi-Geo-	
	strophic Theory	61
4.2	Quasi-Geostrophic Vorticity Equation	65
4.3	Barotropic Instability	68
4.4	Baroclinic Instability	71
4.5	Energetics of Geostrophic Flow	73
4.6	Planetary Waves	75
	References	76
Chapter V	Laminar Viscous Flow	
5.1	Review of Navier-Stokes Equations	77
5.2	Laminar Ekman Flow	80
5.3	Parametric Ekman Theory	82
	Reference	86
Chapter VI	Shear Turbulence	
6.1	Stability of Viscous Shear Flow	87

CONTENTS		vii
6.2	Reynolds Equations	91
6.3	Rough Similarity Law in a Smooth Pipe	94
6.4	Homogeneous Isotropic Turbulence	96
	References	101
Chapter VII	Wind Driven Circulation	
7.1	The Turbulent Ekman Layer	102
7.2	Where Does the Momentum Go?	104
7.3	Sverdrup Theory	106
7.4	Inertial Western Boundary Layers	111
7.5	Comparison with Observations	113
	References	115
Chapter VIII	Wind Driven Appendix	
8.1	Depth of the Turbulent Ekman Layer	116
8.2	Ekman Transport Generalized	121
8.3	Example of Wind Stress-Vortex Interaction	125
8.4	Equatorial Undercurrent	127
	References	132
	PART TWO	
Chapter IX	Stratification	
9.1	Equation of State and the Parcel Method	135
9.2	Rotating Stratified Fluids	138
9.3	Boussinesq Approximation	141
9.4	Internal Waves	144
9.5	Critical Layer in a Stratified Shear Flow	147
9.6	Instability of a Stratified Shear Flow	150
9.7	The Effect of Shear on Unstable Stratification-	
	Langmuir Cells	153
9.8	Wave-Wave Interactions	155
9.9	Inertia-Gravity Waves	164
	References	167

viii	CONTENTS

Chapter X	Convection	
10.1	Introduction	168
10.2	The Critical Rayleigh Number	170
10.3	Power Integrals	173
10.4	Finite Amplitude Convection	175
10.5	Convection at Large Prandtl Number	178
10.6	Similarity Theory of Thermal Turbulence	181
10.7	Evaporative Convection	184
10.8	Haline Convection	186
	References	188
Chapter XI	Thermohaline Convection	
11.1	Introduction	189
11.2	Instability of Temperature-Salinity Stratifications	191
11.3	Interaction of Salt Fingers with Larger Scales of Motion	196
11.4	Transition to Turbulence	200
11.4	Cold Fresh Layers over Warm Salty Layers	203
11.6	General Thermodynamic Relations	205
11.7	Forced Convection	211
11.7	References	215
Chapter XII	Horizontal Convection and Thermoclines	
12.1	Nonrotating Thermocline	216
12.2	Thermocline in a Rotating Annulus	221
12.3	Thermocline in a Rotating Spherical Sector	227
	References	233
Appendix	The Ocean Pycnocline	234
	References	242
Index		243