

TABLE OF CONTENTS

|  | Page |
|--|------|
| INTRODUCTION   | 1    |
| CHAPTER 1: EQUATIONS OF MOTION                       | 5    |
| CHAPTER 2: POTENTIAL VORTICITY                       | 11   |
| Problems   | 15   |
| CHAPTER 3: NON-DIMENSIONAL PARAMETERS                | 17   |
| Problems   | 20   |
| CHAPTER 4: GEOSTROHIC FLOW                           | 21   |
| Taylor-Proudman Theorem                              | 21   |
| Taylor Column  | 23   |
| Application to Geophysical Motion                    | 26   |
| $\beta$ -Plane Approximation                         | 28   |
| Problems   | 33   |
| CHAPTER 5: THE EKMAN LAYER                           | 35   |
| Ekman Layer Equations                                | 39   |
| Example of Cylindrical Flow                          | 43   |
| Ekman Layer Spiral                                   | 46   |
| Mass Transport in the Ekman Layer                    | 47   |
| Spin-up Time Scale                                   | 48   |
| Tea-cup Experiment                                   | 52   |
| Problems   | 54   |
| CHAPTER 6: THE GEOSTROPHIC MODES                     | 57   |
| The Geostrophic Mode in a Sphere                     | 58   |
| Geostrophically Free, Guided, and<br>Blocked Regions | 62   |
| Circulation  | 63   |
| Problems   | 65   |
| CHAPTER 7: INERTIAL MODES                            | 67   |
| $\lambda$ Real and $ \lambda  < 2$                   | 68   |
| Orthogonality  | 70   |
| Mean Circulation Theorem                             | 71   |
| Initial Value Problem                                | 72   |
| Inertial Modes in a Cylinder                         | 74   |
| Plane Wave Solution                                  | 77   |
| Problems   | 80   |
| CHAPTER 8: ROSSBY WAVES                              | 85   |
| Sliced Cylinder                                      | 86   |
| $\beta$ -Plane Problem                               | 89   |
| Plane Wave Solution                                  | 95   |
| Problems   | 97   |
| CHAPTER 9: VERTICAL SHEAR LAYERS                     | 99   |
| $E^{1/3}$ -Layer                                     | 100  |
| $E^{1/4}$ -Layer                                     | 102  |
| Sliced Cylinder                                      | 110  |
| An Ocean Model: Sverdrup's Relation                  | 114  |
| Problems   | 120  |

|  | Page |
|--|------|
| CHAPTER 10: ANALOGIES BETWEEN ROTATION AND STRATIFICATION        | 123  |
| Problems   | 131  |
| CHAPTER 11: THE NORMAL MODE PROBLEM FOR ROTATING STRATIFIED FLOW | 133  |
| The Steady Flow  | 137  |
| Potential Vorticity  | 141  |
| Problems   | 147  |
| CHAPTER 12: ROSSBY WAVES IN A ROTATING STRATIFIED FLUID          | 151  |
| The Potential Vorticity Equation                                 | 151  |
| Rossby Waves for a Stratified Fluid                              | 153  |
| Rossby Radius of Deformation                                     | 156  |
| Problems   | 159  |
| CHAPTER 13: INTERNAL WAVES IN A ROTATING STRATIFIED FLUID        | 161  |
| Plane Wave Solution  | 163  |
| Waves in Bounded Geometry  | 166  |
| Variable $N(z)$  | 176  |
| Oceanographic Results  | 187  |
| Problems   | 189  |
| CHAPTER 14: BOUNDARY LAYERS IN A ROTATING STRATIFIED FLUID       | 191  |
| The Stratified Ekman Layer                                       | 193  |
| The Side-wall Layers   | 196  |
| Problems   | 206  |
| CHAPTER 15: SPIN-DOWN IN A ROTATING STRATIFIED FLUID             | 209  |
| Spin-down in a Cylinder  | 212  |
| Secular Growth   | 219  |
| The Steady Solution  | 220  |
| The Decaying Modes   | 222  |
| Further Comments   | 226  |
| Problems   | 228  |
| CHAPTER 16: BAROCLINIC INSTABILITY                               | 231  |
| The Eady Model   | 232  |
| The Stability Criterion  | 236  |
| Experiments: Laboratory Models                                   | 243  |
| Problems   | 247  |
| APPENDIX BOUNDARY LAYER METHODS                                  | 249  |
| BIBLIOGRAPHY   | 263  |
| INDEX  | 269  |