

Contents

<i>Preface</i>	<i>page</i>	ix
1 The basic fluid equations		1
1.1 Conservation of mass and momentum		2
1.2 The Lagrangian derivative		4
1.3 Conservation of energy		5
1.4 The equation of state and useful approximations		6
1.5 The MHD approximation		8
1.6 Some basic implications		11
1.7 Conservation of energy		12
1.8 Further reading		14
1.9 Problems		15
2 Compressible media		17
2.1 Wave propagation in uniform media		18
2.2 Non-linear flow in one dimension		26
2.3 Further reading		38
2.4 Problems		38
3 Spherically symmetric flows		44
3.1 Steady inflow/outflow		44
3.2 Explosion in a uniform medium		50
3.3 Further reading		58
3.4 Problems		58
4 Stellar models and stellar oscillations		60
4.1 Models of stars		60
4.2 Perturbing the models		62
4.3 Eulerian and Lagrangian perturbations		63
4.4 Adiabatic perturbations – a variational principle		66
4.5 The Schwarzschild stability criterion		73

4.6 Further reading	74
4.7 Problems	75
5 Stellar oscillations – waves in stratified media	78
5.1 Waves in a plane-parallel atmosphere	79
5.2 Vertical waves in a polytropic atmosphere	84
5.3 Further reading	87
5.4 Problems	87
6 Damping and excitation of stellar oscillations	90
6.1 A simple set of oscillations	91
6.2 Damping by conductivity	92
6.3 The effect of heating and cooling – the ϵ -mechanism	95
6.4 The effect of opacity – the κ -mechanism	97
6.5 Further reading	101
7 Magnetic instability in a static atmosphere	102
7.1 Magnetic buoyancy	102
7.2 The Parker instability	106
7.3 Further reading	111
7.4 Problems	111
8 Thermal instabilities	113
8.1 Linear perturbations and the Field criterion	114
8.2 Heating and cooling fronts	118
8.3 Further reading	120
8.4 Problems	120
9 Gravitational instability	123
9.1 The Jeans instability	123
9.2 Isothermal, self-gravitating plane layer	125
9.3 Stability of a thin slab	128
9.4 Further reading	130
9.5 Problems	131
10 Linear shear flows	134
10.1 Perturbation of a linear shear flow	135
10.2 Squire's theorem	136
10.3 Rayleigh's inflection point theorem	136
10.4 Fjørtoft's theorem	138

<i>Contents</i>	vii
10.5 Physical interpretation	139
10.6 Co-moving phase	141
10.7 Stratified shear flow	142
10.8 The Richardson criterion	144
10.9 Further reading	145
10.10 Problems	145
11 Rotating flows	150
11.1 Rotating fluid equilibria	150
11.2 Making rotating stellar models	151
11.3 Meridional circulation	154
11.4 Rotation and magnetism	156
11.5 Further reading	157
11.6 Problems	157
12 Circular shear flow	158
12.1 Incompressible shear flow in a rigid cylinder	158
12.2 Axisymmetric stability of a compressible rotating flow	162
12.3 Circular shear flow with a magnetic field	167
12.4 Circular shear flow with self-gravity	172
12.5 Further reading	176
12.6 Problems	176
13 Modes in rotating stars	178
13.1 The non-rotating ‘star’	178
13.2 Uniform rotation	181
13.3 Further reading	187
13.4 Problems	187
14 Cylindrical shear flow–non-axisymmetric instability	191
14.1 Equilibrium configuration	191
14.2 The perturbation equations	193
14.3 The Papaloizou–Pringle instability	195
14.4 Further reading	197
14.5 Problems	197
<i>References</i>	199
<i>Index</i>	203