## CONTENTS

1	Principles of continuum mechanics 1
1.1	Basic concepts
1.2	Material derivative
1.3	Deformation rates
1.4	Rivlin-Ericksen tensors
1.5	Strain tensor
1.6	Kinematics of steady shear flows $\hfill \ldots \hfill \ldots \hfill \ldots \hfill 24$
	1.6.1 Plane shear flow
	1.6.2 Poiseuille flow
	1.6.3 Couette flow
	1.6.4 Helical flow
	1.6.5 Torsional flow
	1.6.6 Cone-and-plate flow
1.7	Continuity equation
1.8	Stress and volume force
1.9	Equations of motion
1.10	Energy equation for fluid flow
2	Material properties occurring in steady shear flows 45
2 2.1	Material properties occurring in steady shear flows 45 The flow function
2.1	The flow function
2.1	The flow function
2.1 2.2	The flow function
2.1 2.2 3	The flow function
2.1 2.2 3	The flow function
2.1 2.2 3 3.1	The flow function
2.1 2.2 3 3.1 3.2	The flow function
<ol> <li>2.1</li> <li>2.2</li> <li>3.1</li> <li>3.2</li> <li>3.3</li> </ol>	The flow function
<ol> <li>2.1</li> <li>2.2</li> <li>3.1</li> <li>3.2</li> <li>3.3</li> <li>3.4</li> </ol>	The flow function
<ol> <li>2.1</li> <li>2.2</li> <li>3.1</li> <li>3.2</li> <li>3.3</li> <li>3.4</li> </ol>	The flow function

viii Contents

4.2	Weissenberg effect
4.3	Die-swell
4.4	Axial shear flow
5	Simple unsteady flows
5.1	Linear viscoelasticity
	5.1.1 Sudden change in shear rate
	5.1.2 Creep test and creep recovery 171
	5.1.3 Oscillatory stress and deformation
	5.1.4 Tuning a shock absorber
	5.1.5 Flow in the vicinity of a vibrating wall
	5.1.6 Rayleigh problem for a Maxwell fluid
	5.1.7 Unsteady Couette flow
5.2	Non-linear effects in unsteady pipe flow
	5.2.1 Constitutive equation for slow and slowly varying
	processes
6	Nearly viscometric flows 213
6.1	Shear flows with a weak unsteady component
6.2	Plane steady boundary layer flows
	6.2.1 Stagnation point boundary layer
	6.2.2 Modified lubricating film theory
6.3	Stability of plane shear flows
7	Extensional flows
7.1	Theoretical principles
7.2	Applications
8	Special rheological laws 259
8.1	Fluids without memory
	8.1.1 Minimum principle for generalised Newtonian fluids 262
8.2	Integral models
	8.2.1 Flow between eccentric rotating discs
	8.2.2 Boundary layer at a plane wall with homogeneous suction 273
8.3	Differential models
8.4	Approximation for slow and slowly varying processes 281

```
Contents ix
```

9	Secondary flows	287
9.1	General theory	287
92	Rotational symmetric flows	292
	9.2.1 Conical nozzle flow	294
	9.2.2 Flow round a rotating body	303
	9.2.3 Flow through curved pipes	309
9.3	Plane flows	312
	9.3.1 Convergent channel flow	315
9.4	Steady flow through cylindrical pipes	320
	9.4.1 Isothermal conditions	323
	9.4.2 Effect of dissipation	324
	9.4.3 Effect of a transverse temperature gradient	327
9.5	Periodic pipe flow	330
Appen	dix Set of formulas for special curvilinear coordinates	335
Ackno	wledgements	340
Refer	rences	341
Index	•••••••••••••••••••••••••	345