
Contents

<i>Preface</i>	<i>page ix</i>
Prologue	1
PART I MICROHYDRODYNAMICS	7
1 Basic concepts in viscous flow	9
1.1 The fluid dynamic equations	9
1.2 Scaling arguments and the Stokes approximation	12
1.3 Buoyancy and drag	13
1.4 Properties of Stokes flow	16
1.4.1 Linearity	16
1.4.2 Reversibility	17
1.4.3 Instantaneity	20
1.4.4 And more . . .	21
Appendix: Three Stokes-flow theorems	22
A.1 Minimum energy dissipation	22
A.2 A corollary: Uniqueness	24
A.3 Reciprocal theorem	25
Exercises	26
2 One sphere in Stokes flow	28
2.1 Three single sphere flows: rotation, translation, straining	28
2.1.1 Rotation	30
2.1.2 Translation	33
2.1.3 Straining	37

vi	<i>Contents</i>	
	2.2 Hydrodynamic force, torque, and stresslet	40
	2.2.1 Force	40
	2.2.2 Torque	41
	2.2.3 Stresslet	42
	2.2.4 Computing the hydrodynamic force	43
	2.3 Faxén laws for the sphere	45
	2.4 A sphere in simple shear flow	47
	Exercises	50
3	Toward more sophisticated solution techniques	53
	3.1 Point force solution	53
	3.2 Point torque and stresslet	55
	3.3 Integral representation	59
	3.4 Multipole representation	60
	3.5 Resistance matrices	62
	3.6 Motion of different types of particles	67
	3.7 Slender-body theory	78
	3.8 Boundary integral method	80
	Exercises	82
4	Particle pair interactions	84
	4.1 A sedimenting pair	84
	4.2 A pair in shear	89
	4.3 Pair lubrication interactions	93
	4.4 Stokesian Dynamics	99
	INTERLUDE: FROM THE MICROSCOPIC TO THE MACROSCOPIC	103
5	A short presentation of statistical and stochastic concepts	105
	5.1 Statistical physics	105
	5.2 Averaging concepts	107
	5.2.1 Ensemble and other averages	107
	5.2.2 Probability distributions	108
	5.3 Fluctuational motion	113
	5.3.1 Random walks and diffusion	114
	5.3.2 Brownian motion	116
	5.4 Two routes to diffusive dynamics	118
	5.4.1 A macroscopic approach: Stokes–Einstein relation and Smoluchowski equation	118

<i>Contents</i>		vii
5.4.2	A microscopic approach: Langevin equation	120
5.5	Chaotic dynamics	123
PART II TOWARD A DESCRIPTION OF MACROSCOPIC PHENOMENA IN SUSPENSIONS		125
6	Sedimentation	127
6.1	One, two, three . . . spheres	127
6.2	Clusters and clouds	132
6.3	Settling of a suspension of spheres	135
6.4	Influence of the lateral walls of a vessel: Intrinsic convection	139
6.5	Velocity fluctuations and hydrodynamic diffusion	143
6.6	Fronts	146
6.7	Setting of particles in an inclined vessel: Boycott effect	149
6.8	More on polydispersity and anisotropy	151
7	Shear flow	155
7.1	Suspension viscosity	155
7.1.1	Computing the Einstein viscosity	157
7.1.2	First effects of particle interaction on μ_s	160
7.2	Non-Newtonian rheology in suspensions	161
7.2.1	Rate and time dependence of viscosity	161
7.2.2	Normal stresses in suspensions	164
7.2.3	Stress mechanisms	168
7.3	Microstructure of sheared suspensions	170
7.3.1	Concentrated suspension microstructure	170
7.3.2	Smoluchowski theory of suspension microstructure	173
7.4	Constitutive modeling of suspension stress	180
7.5	Irreversible dynamics in shear flow	182
7.5.1	Shear-induced diffusion	183
7.5.2	Shear-induced migration	184
7.6	Orientable particles	190
8	Beyond Stokes flow: Finite inertia	192
8.1	Limit of the Stokes approximation	193
8.1.1	Influence of inertia far from a body	193

8.1.2	Oseen solution for a translating sphere	196
8.2	Settling spheres at finite inertia	198
8.3	Migration under dilute conditions in pressure-driven flow	201
8.3.1	Observations	201
8.3.2	Analytical approaches	204
8.4	Particle motion in finite- Re simple-shear flow	208
8.5	Weak-inertia rheology	211
Epilogue		213
<i>References</i>		217
<i>Index</i>		225