

Contents

<i>Foreword</i> by A. J. Chorin	<i>page</i> ix
<i>Preface</i>	xi
Introduction	1
Chapter 1 Dimensional analysis and physical similarity	12
1.1 Dimensions	12
1.2 Dimensional analysis	22
1.3 Physical similarity	37
Chapter 2 Self-similarity and intermediate asymptotics	52
2.1 Gently sloping groundwater flow. A mathematical model	52
2.2 Very intense concentrated flooding: the self-similar solution	55
2.3 The intermediate asymptotics	60
2.4 Problem: very intense groundwater pulse flow – the self-similar intermediate-asymptotic solution	65
Chapter 3 Scaling laws and self-similar solutions that cannot be obtained by dimensional analysis	69
3.1 Formulation of the modified groundwater flow problem	69
3.2 Direct application of dimensional analysis to the modified problem	71
3.3 Numerical experiment. Self-similar intermediate asymptotics	72
3.4 Self-similar limiting solution. The nonlinear eigenvalue problem	78
Chapter 4 Complete and incomplete similarity. Self-similar solutions of the first and second kind	82
4.1 Complete and incomplete similarity	82

4.2	Self-similar solutions of the first and second kind	87
4.3	A practical recipe for the application of similarity analysis	91
Chapter 5 Scaling and transformation groups.		
	Renormalization group	94
5.1	Dimensional analysis and transformation groups	94
5.2	Problem: the boundary layer on a flat plate in uniform flow	96
5.3	The renormalization group and incomplete similarity	102
Chapter 6 Self-similar phenomena and travelling waves		109
6.1	Travelling waves	109
6.2	Burgers' shock waves – steady travelling waves of the first kind	111
6.3	Flames – steady travelling waves of the second kind. Nonlinear eigenvalue problem	113
6.4	Self-similar interpretation of solitons	119
Chapter 7 Scaling laws and fractals		123
7.1	Mandelbrot fractals and incomplete similarity	123
7.2	Incomplete similarity of fractals	129
7.3	Scaling relationship between the breathing rate of animals and their mass. Fractality of respiratory organs	132
Chapter 8 Scaling laws for turbulent wall-bounded shear flows at very large Reynolds numbers		137
8.1	Turbulence at very large Reynolds numbers	137
8.2	Chorin's mathematical example	140
8.3	Steady shear flows at very large Reynolds numbers. The intermediate region in pipe flow	142
8.4	Modification of Izakson–Millikan–von Mises derivation of the velocity distribution in the intermediate region. The vanishing-viscosity asymptotics	150
8.5	Turbulent boundary layers	154
	<i>References</i>	163
	<i>Index</i>	170