

Contents

1	Introduction	1
1.1	Preliminary Approaches	1
1.2	Dimension	1
1.3	Quantities: Dimensional, Dimensionless, Fundamental, and Derived.	2
1.4	Measurement of Physical Quantities	3
1.5	The Simple Pendulum.	4
1.6	Essential Principles.	5
2	Fundamental Principles of Dimensional Analysis	7
2.1	Power Law Formula for Dimension of Physical Quantity	7
2.2	The Pi Theorem	10
2.3	Selection of Fundamental Quantities.	12
2.4	Similarity Laws	14
2.5	Applying the Pi Theorem	15
	References	16
3	Problems in Fluid Mechanics	17
3.1	Typical Flows	17
3.1.1	Overflow.	17
3.1.2	Friction Drag for Flows in Tubes.	18
3.1.3	Velocity Profile of Viscous Flow in Cylindrical Tubes	21
3.1.4	Flows Past a Body	25
3.1.5	Resistance Related to Ships.	27
3.1.6	Lubrication of Bearings.	29
3.1.7	Water Waves	32
3.1.8	De Laval Nozzle	34
3.1.9	High Velocity Flow Past a Thin Aerofoil	36
3.1.10	Centrifugal Compressors	39

3.2	Similarity Criterion Numbers for Hydrodynamic Problems	41
3.3	Additional Similarity Criterion Numbers	44
3.4	Classification of Fluid Flow	46
	References	47
4	Problems in Solid Mechanics	49
4.1	Stress Analysis for Elastic Bodies and Stability Analysis for Simple Structures	49
4.1.1	Deflection of Beams	49
4.1.2	Deformation and Stress in Three-Dimensional Elastic Bodies	51
4.1.3	Application of Centrifugal Machine to Modeling Gravity Effect	54
4.1.4	Photoelastic Experiments	56
4.1.5	Critical Loading for Instability of Columns Under Compression	58
4.2	Vibration and Wave Motion of Elastic Bodies	59
4.2.1	Inherent Vibration of Finite Elastic Bodies	60
4.2.2	Forced Vibration of Elastic Bodies	60
4.2.3	Wave Velocity of Body Waves and Surface Waves in Elastic Bodies and Wave Dispersion in Elastic Waveguides	61
4.3	Stress Analysis of Elasto-Plastic Bodies	65
4.3.1	Static Tension of Cylindrical Rods	65
4.3.2	Modeling Stress Distribution in Elasto-Plastic Bodies	67
4.3.3	Modeling Cold-Rolled Steel Plates	68
4.3.4	Hardness	70
4.4	Tensile Fracture of Solids	75
	References	79
5	Heat Conduction and Thermal Stress in Solids	81
5.1	Heat Conduction in Solids	81
5.1.1	Heat Conduction for Prescribed Boundary Temperatures	82
5.1.2	Heat Conduction for Prescribed Temperature Gradient at Boundary	85
5.2	Thermal Stress in Elastic Bodies	87
5.2.1	Thermal Elastic Constitutive Relationship	88
5.2.2	Thermal Stress in Solids	90
	References	92

6	Problems of Coupling Fluid Motion and Solid Deformation	93
6.1	Water Hammers	93
6.1.1	Wave Velocity of Pressure Waves	93
6.1.2	Intensity of Water Hammer	96
6.2	Elastic Bearings with Liquid Lubricant	97
6.3	Fluttering of Airfoils	99
6.4	Vortex-Excited Vibration in Heat Exchangers	100
7	Hydro-Elasto-Plastic Modeling	103
7.1	Hydro-Elasto-Plastic Model	103
7.2	Similarity Parameters in Problems Related to Chemical Explosions	107
7.3	Similarity Parameters in Problems Related to High Velocity Impact	107
	Reference	108
8	Similarity Laws for Explosions	109
8.1	Explosion Waves in Air and Water	110
8.1.1	Explosion Waves in Air	110
8.1.2	Explosion Waves in Water	112
8.1.3	Intense Explosion of Point Source	114
8.2	Explosive Working	120
8.2.1	Explosive Forming	120
8.2.2	Explosive Welding	124
8.3	Blasting	128
8.3.1	Boleskov (Болесков) Formula for Blasting Using the Concentrated Charge Scheme	129
8.3.2	Excavation Blasting for Trenches or Tunnels	131
8.3.3	Directed Ejection Blasting of Planar Charge	132
	References	137
9	Similarity Laws for High Velocity Impacts	139
9.1	Rod Projectiles	139
9.2	Formation of High Velocity Jet and Jet Penetration into Target	141
9.3	Spallation of Armor Induced by Explosions	146
9.4	Hypervelocity Impacts	147
9.5	High Velocity Extension Fracture of Metallic Jets and Plates	149
9.6	Coal and Gas Outburst Phenomenon Related to Coupled Two-Phase Medium	152
9.6.1	Energy Origin of Outbursts	153
9.6.2	Critical Condition for Outburst	155
9.6.3	Simulation Experiments in Coal Shock Tube	156
	References	159

10	Normalization in Mathematical Simulations	161
10.1	Normalization of Functions	161
10.2	Normalization of Algebraic Equations	164
10.3	Normalization of Ordinary Differential Equations	166
10.4	Normalization of Partial Differential Equations	170
10.4.1	One-Dimensional Heat Conduction	171
10.4.2	Boundary Layer of Viscous Flows	173
	References	179
	Index	181