
Contents

PREFACE	vii
1 BASIC CONCEPTS	1
1-1 Introduction	2
1-2 Definitions	2
1-3 Classification of Flows	4
Steady and Unsteady Flows	5
Uniform and Nonuniform flows	7
Laminar and Turbulent Flows	7
Subcritical, Supercritical, and Critical Flows	8
1-4 Terminology	8
1-5 Velocity Distribution	9
Energy Coefficient	11
Momentum Coefficient	13
Example 1-1	15
1-6 Pressure Distribution	16
Static Conditions	16
Horizontal, Parallel Flow	16
Parallel Flow in Sloping Channels	17
Curvilinear Flow	18
1-7 Reynolds Transport Theorem	20
1-8 Computer Program	21
1-9 Summary	21
References	26
2 CONSERVATION LAWS	27
2-1 Introduction	28
2-2 Conservation of Mass	28
2-3 Conservation of Momentum	29
2-4 Equation of Motion	31
Steady Flow	33

	Steady, Uniform Flow	33
	Unsteady, Nonuniform Flow	34
2-5	Specific Energy	34
2-6	Application of Momentum and Energy Equations	37
2-7	Channel Transition	38
	Example 2-1	42
2-8	Hydraulic Jump	43
	Example 2-2	45
2-9	Hydraulic Jump at Sluice Gate Outlet	47
	Example 2-3	48
2-10	Summary	50
	References	54
3	CRITICAL FLOW	55
3-1	Introduction	56
3-2	Rectangular Channel	56
	Specific Energy	56
	Unit discharge	58
	Specific force	59
	Wave Celerity	60
3-3	Non-Rectangular Channel	63
	Specific Energy	63
	Specific Force	64
3-4	Application of Critical Flow	65
	Constant-width Channel with Bottom Step	66
	Horizontal, Variable-width Channel	67
	Example 3-1	67
3-5	Location of Critical Flow	69
3-6	Computation of Critical Depth	70
	Design curves	70
	Trial-and-Error Procedure	71
	Numerical Methods	71
	Example 3-2	72
3-7	Critical Depths in Compound Channels	74
	General Remarks	75
	Example 3-3	77
	Algorithm for Computing the Critical Depths	79
3-8	Summary	80
	References	84
4	UNIFORM FLOW	87
4-1	Introduction	88
4-2	Flow Resistance	88
4-3	Flow Resistance Equations	89
	Chezy Equation	89

	Manning Equation	94
	Other Resistance Equations	100
4-4	Computation of Normal Depth	102
	Example 4-1	104
4-5	Equivalent Manning Constant	106
4-6	Compound Channel Cross Section	107
4-7	SUMMARY	109
	References	115
5	GRADUALLY VARIED FLOW	119
5-1	Introduction	120
5-2	Governing Equation	120
5-3	Classification of Water-Surface Profiles	122
5-4	General Remarks	125
5-5	Sketching of Water-Surface Profiles	127
	Example 5-1	129
	Example 5-2	131
5-6	Discharge From a Reservoir	131
	Example 5-3	134
5-7	Profiles in Compound Channels	136
	Example 5-4	137
	Example 5-5	140
5-8	Summary	144
	References	149
6	COMPUTATION OF GRADUALLY VARIED FLOW	151
6-1	Introduction	152
6-2	General Remarks	152
6-3	Direct-Step Method	156
	Example 6-1	158
6-4	Standard Step Method	160
	Example 6-2	164
6-5	Integration of Differential Equation	166
6-6	Single-step Methods	166
	Euler method	168
	Improved Euler method	169
	Modified Euler Method	170
	Fourth-order Runge-Kutta Method	171
6-7	Predictor-Corrector Methods	172
6-8	Simultaneous Solution Procedure	172
	Governing Equations	174
	Single and Series Channels	175
	Channel Networks	180
	Example 6-3	186
	Practical Applications	187

6-9	Computer Programs	188
6-10	Summary	188
	References	194
7	RAPIDLY VARIED FLOW	199
7-1	Introduction	200
7-2	Application of Conservation Laws	201
7-3	Channel Transitions	203
	General Remarks	203
	Subcritical Flow	204
7-4	Supercritical Flow	208
	Oblique Hydraulic Jump	210
7-5	Weirs	212
	Sharp-Crested Weirs	212
	Broad-Crested Weirs	214
7-6	Hydraulic Jump	215
	Ratio of Sequent Depths	215
	Length of Jump	216
	Jump Profile	217
	Jump types	217
	Energy loss	219
	Jump Location	220
	Control of Jump	222
7-7	Spillways	224
	Overflow Spillway	225
7-8	Energy Dissipators	228
	Stilling Basins	231
	Flip Buckets	232
	Roller Buckets	234
7-9	Summary	237
	References	241
8	COMPUTATION OF RAPIDLY VARIED FLOW	247
8-1	Introduction	248
8-2	Governing Equations	249
	Characteristic directions	251
	Coordinate Transformations	252
8-3	Computation of Supercritical Flow	254
	Finite-difference methods	254
	Boundary Conditions	256
	Verification	258
8-4	Computation of Sub- and Supercritical Flows	261
	Numerical Solution	261
	Verification	267
8-5	Simulation of Hydraulic Jump	270

	Governing Equations	271
	Numerical Solution	271
	Computational Procedure	273
	Results	274
8-6	Summary	276
	References	276
9	CHANNEL DESIGN	279
9-1	Introduction	280
9-2	Rigid-Boundary Channels	280
	Example 9-1	282
9-3	Most Efficient Hydraulic Section	283
9-4	Erodible Channels	286
	Permissible Velocity Method	286
	Example 9-2	288
	Tractive Force Method	289
	Example 9-3	292
9-5	Alluvial Channels	295
	Regime Theory	295
	Example 9-4	296
9-6	Summary	297
	References	298
10	SPECIAL TOPICS	301
10-1	Introduction	302
10-2	Flow in a Channel Connecting Two Reservoirs	302
	A. Mild bottom slope	302
	B. Steep bottom slope	307
10-3	Air Entrainment in High-Velocity Flow	308
10-4	Flow Through Culverts	312
10-5	Flow Measurement	315
	Velocity-area method	316
	Slope-area method	316
	Flumes	317
10-6	Summary	317
	References	319
11	UNSTEADY FLOW	323
11-1	Introduction	324
11-2	Definitions	324
11-3	Occurrence of Unsteady Flow	326
11-4	Height and Celerity of a Gravity Wave	326
	Continuity equation	327
	Momentum equation	328
	Example 11-1	330

11-5 Summary	331
References	332
12 GOVERNING EQUATIONS FOR ONE-DIMENSIONAL FLOW	333
12-1 Introduction	334
12-2 St. Venant Equations	334
Continuity Equation	335
Momentum Equation	337
12-3 General Remarks	340
12-4 Boussinesq Equations	341
Continuity equation	341
Momentum Equation in z -direction	342
Momentum Equation in x -direction	343
12-5 Integral Forms	345
12-6 Summary	346
References	347
13 NUMERICAL METHODS	349
13-1 Introduction	350
13-2 Method of characteristics	350
Characteristics	353
13-3 Initial and Boundary Conditions	356
13-4 Characteristic Grid Method	359
13-5 Method of Specified Intervals	361
13-6 Other Numerical Methods	362
13-7 Summary	363
References	364
14 FINITE-DIFFERENCE METHODS	367
14-1 Introduction	368
14-2 Terminology	368
Finite-difference approximations	368
14-3 Explicit Finite-Difference Schemes	372
Unstable scheme	372
Diffusive scheme	372
MacCormack Scheme	377
Lambda scheme	379
Gabutti Scheme	382
14-4 Implicit Finite-Difference Schemes	385
Preissmann Scheme	385
Beam and Warming scheme	388
VasilievVasiliev, O. F. scheme	390
14-5 Consistency	390
14-6 Stability	392

Example 14-1	396
14-7 Summary	397
References	400
15 TWO-DIMENSIONAL FLOW	407
15-1 Introduction	408
15-2 Governing Equations	408
15-3 Numerical Solution	416
15-4 MacCormack Scheme	419
General formulation	420
Boundary conditions	421
15-5 Gabutti Scheme	423
General formulation	423
Boundary conditions	425
15-6 Artificial Viscosity	426
15-7 Beam and Warming Schemes	427
General formulation	427
Factored schemes	430
Implicit split-flux factoring	431
Boundary conditions	433
15-8 Finite-Volume Scheme	434
Predictor part	436
Corrector part	436
15-9 Applications	437
Partial breach or opening of sluice gates	438
Propagation of a flood wave through channel contraction	440
Comparison with other methods	447
15-10 Summary	447
References	448
16 SEDIMENT TRANSPORT	453
16-1 Introduction	454
16-2 Sediment property	454
Sediment size	455
Size distribution	455
16-3 Sand-bed and gravel-bed streams	457
16-4 Threshold of sediment motion	458
Critical Shields stress for sediment mixture	460
16-5 Condition for significant suspension	460
16-6 Shields diagram	461
16-7 The Exner equation of bed sediment conservation	463
Exner equation for multiple size fraction	464
16-8 Bed-load transport relations	465
Bed load transport relations for poorly sorted sediment	467
16-9 Suspended-load transport	468

Entrainment Relations	469
16-10Resistance relations	471
Separation of form drag	472
16-11Summary	474
References	475
17 SPECIAL TOPICS	479
17-1 Introduction	480
17-2 Rating Curve	480
17-3 Flood Routing	481
17-4 Reservoir Routing	482
17-5 Channel Routing	484
17-6 Kinematic Routing	486
17-7 Diffusion Routing	489
17-8 Muskingum-Cunge Routing	491
17-9 Aggradation and Degradation of Channel Bottom	492
Introduction	492
Governing equations	493
Numerical Scheme	494
Applications	497
Aggradation due to sediment overloading	498
Knickpoint migration	499
References	502
Subject Index	507
Author Index	517

Nanometer Technology Designs

High-Quality Delay Tests

Ahmed, N.

2008, XVIII, 281 p. 140 illus., Hardcover

ISBN: 978-0-387-76486-3