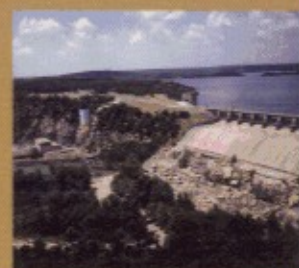
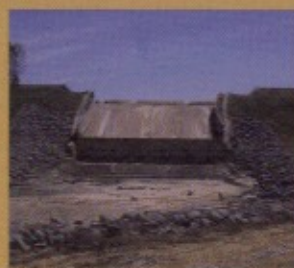
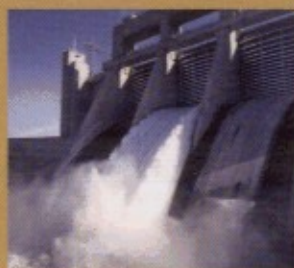


INTERNATIONAL STUDENT EDITION



Elementary Hydraulics

James F. Cruise

Mohsen M. Sherif

Vijay P. Singh

Not for Sale in
North America

Contents

1 Introduction 1

- 1.1 Definition of Hydraulics 3
- 1.2 Distinction Among Hydraulics, Hydrology, and Fluid Mechanics 3
- 1.3 Classification of Hydraulics 4
- 1.4 Subject Matter of Hydraulics 7
- 1.5 Environmental and Water Resources Problems Involving Hydraulic Applications 8
- 1.6 Classification of Hydraulic Problems 10
- 1.7 Scientific Approach to Investigating Hydraulic Problems 11
- 1.8 Simplification of Scientific Approach 15
- 1.9 Hydraulic Modeling 16
- 1.10 Scientific Foundations for the Study of Hydraulics 20
- 1.11 Dimensions 20
- 1.12 Systems of Units 22
- 1.13 Scope and Organization of the Book 25
 - Reading Aid 25
 - Problems 26
 - References 28

2 Fluid Properties 29

- 2.1 Measure of Fluid Mass and Weight 32
- 2.2 Viscosity 34
- 2.3 Compressibility of Fluids 39

2.4	Thermal Expansion	41
2.5	Surface Tension	42
2.6	Vapor Pressure	45
	Reading Aid	46
	Problems	46
	References	50

3 Forces, Motions, and Energy 51

3.1	Hydraulic Parameters	52
3.2	Forces	53
3.3	Motions	59
3.4	Relation between Forces and Motion	61
3.5	Energy	61
3.6	Relation between Force and Energy	64
3.7	Mass, Momentum, and Energy Fluxes	64
3.8	Significance of Relative Magnitudes of Forces or Energy	65
3.9	Regimes of Flow	68
	Reading Aid	70
	Problems	71
	References	72

4 Hydrostatics 73

4.1	Pressure at a Point	74
4.2	Pressure Field	75
4.3	Variation of Pressure in a Fluid at Rest	76
4.4	Standard Atmosphere	78
4.5	Hydrostatic Force on Immersed Surfaces	78
4.6	Graphical Representation of Hydrostatic Forces	85
4.7	Buoyancy and Stability	92
4.8	Measurement of Pressure	98

4.9	Manometer	99
	Reading Aid	102
	Problems	103
	References	112

5 Governing Equations 113

5.1	Mass Conservation: The Continuity Equation	114
5.2	Energy Conservation: The Bernoulli Equation	123
5.3	Momentum Conservation: The Momentum Equation	130
5.4	Choice between Energy and Momentum Equations	139
	Reading Aid	140
	Problems	141
	References	152

6 Dimensional Analysis and Hydraulic Similarity 153

6.1	Fundamental Dimensions, Systems of Units, and Hydraulic Variables	154
6.2	Empirical Formulation of General Flow Equation	156
6.3	Methods of Dimensional Analysis	158
6.4	Hydraulic Scale Models	169
6.5	Types of Similarity	170
6.6	Dominating Forces	174
6.7	Distorted Models	183
	Reading Aid	186
	Problems	187
	References	191

7 Flow Resistance and Velocity Distributions 192

7.1	Factors Affecting Flow Resistance	194
7.2	Steady Uniform Flow	195

7.3	Resistance Equations for Steady Uniform Flow	200
7.4	Velocity Distributions in Steady, Uniform Flow	202
7.5	Power Law Velocity Distributions	211
	Reading Aid	213
	Problems	214
	References	217

8 CLOSED CONDUIT FLOW 218

8.1	General Energy Considerations	219
8.2	Resistance Applications and Friction Losses in Pipes	221
8.3	Empirical Resistance Equations	229
8.4	Minor Losses in Pipes	232
8.5	Water Distribution Systems	236
8.6	Transient Flow in Closed Conduits	246
8.7	Surge Tanks	251
	Reading Aid	252
	Problems	254
	References	260

9 Pumps 261

9.1	Introduction	262
9.2	Overall Efficiency of Hydraulic Machines	263
9.3	Classifications of Pumps	263
9.4	Positive (Displacement) Pumps	265
9.5	Dynamic Pressure Pumps	273
9.6	Pumps Operating in Combination	289
	Reading Aid	291
	Problems	292
	References	296

10 Channel Geometry 297

- 10.1 Channel Flow 298**
- 10.2 Types of Open Channels 299**
- 10.3 Channel Geometry 300**
- 10.4 Geometric Elements 302**
- 10.5 Cross-Sectional Asymmetry 305**
- 10.6 Compound Sections 306**
- 10.7 Channel Slope 311**
- 10.8 River Hydraulic Geometry 314**
- 10.9 Hydraulic Geometry of Basins 318**
- 10.10 Measurement of Geometric Elements of Natural Rivers 320**
 - Reading Aid 324**
 - Problems 325**
 - References 327**

11 Resistance in Open Channels 329

- 11.1 Steady, Uniform Flow in Open Channels 330**
- 11.2 Calculation of Normal Depth 335**
- 11.3 Other Applications 338**
- 11.4 Channel Efficiency 339**
- 11.5 Resistance in Steady Nonuniform Flow 343**
- 11.6 Clarifying Remarks 345**
 - Reading Aid 346**
 - Problems 347**
 - References 348**

12 Energy Principles in Open-Channels 350

- 12.1 Total Energy and Specific Energy 351**
- 12.2 Specific Energy Diagram 354**

12.3	Mathematical Solution of the Energy Equation	358
12.4	Critical Flow Conditions	359
12.5	Discharge-Depth Relation for Constant Specific Energy	367
12.6	Applications of Energy Principle	368
12.7	The Discharge Problem	387
12.8	Dimensionless Representation of Specific Energy Diagram	389
	Reading Aid	390
	Problems	391
	References	393

13 Momentum Principles in Open-Channels 395

13.1	Momentum Function	396
13.2	Hydraulic Jump (Standing Wave)	400
13.3	Conjugate or Sequent Depths	401
13.4	Energy Loss in Hydraulic Jump	410
13.5	Geometry of Hydraulic Jumps	412
13.6	Classification of Hydraulic Jumps	415
13.7	Underflow (Sluice) Gates	416
13.8	Forced Jumps	420
13.9	Hydraulic Jumps in Expanding Sections	423
13.10	Hydraulic Jumps in Rectangular Channels with Sloping Beds	426
13.11	Oblique Jumps	428
	Reading Aid	430
	Problems	431
	References	435

14 Gradually Varied Flow 437

14.1	Gradually Varied Flow Equation	438
14.2	Water Surface Profiles	443
14.3	Outlining Water Surface Profiles	451

14.4	Jump Location and Water Surface Profiles	457
14.5	Control Sections	464
	Reading Aid	465
	Problems	466
	Reference	469

15 Computation of Water Surface Profiles 470

15.1	Numerical Integration Method	471
15.2	Direct Step Method	474
15.3	Standard Step Method	481
15.4	HEC-RAS	484
15.5	Geographical Information Systems Applications	489
	Reading Aid	491
	Problems	492
	References	496

16 Design of Hydraulic Controls and Structures 497

16.1	Basic Principles	498
16.2	Design of Hydraulic Drainage and Control Structures	499
	Reading Aid	541
	Problems	543
	References	546

Glossary 548

Credits 553

Index 554