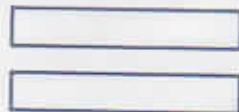


*pressure*



*force*



**SCHAUM'S<sup>®</sup>**  
outlines

*density*

*velocity*

# *Fluid Mechanics and Hydraulics*

---

*Fourth Edition*

**622** fully solved problems

**20** problem-solving videos online

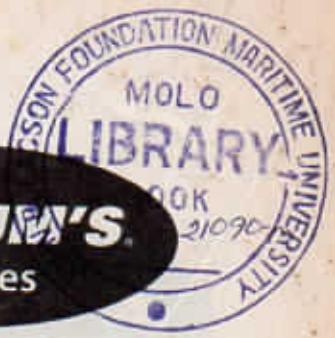


## USE WITH THESE COURSES

Introduction to Fluid Dynamics • Introduction to Hydraulics  
Fluid Mechanics • Statics and Mechanics of Materials



*Ronald V. Giles • Jack B. Evett, PhD • Cheng Liu*



**SCHAUM'S**  
outlines

# *Fluid Mechanics and Hydraulics*

## Contents

---

<b>SYMBOLS AND ABBREVIATIONS</b>	<b>xi</b>
<hr/>	
<b>Chapter 1 PROPERTIES OF FLUIDS</b>	<b>1</b>
Fluid Mechanics and Hydraulics. Definition of a Fluid. British Engineering (or fps) System of Units. International System of Units (SI). Specific or Unit Weight. Mass Density of a Body. Specific Gravity of a Body. Viscosity of a Fluid. Vapor Pressure. Surface Tension. Capillarity. Bulk Modulus of Elasticity ( $E$ ). Isothermal Conditions. Adiabatic or Isentropic Conditions. Pressure Disturbances.	
<hr/>	
<b>Chapter 2 FLUID STATICS</b>	<b>13</b>
Introduction. Fluid Pressure. Unit Pressure or Pressure. Difference in Pressure. Pressure Head $h$ . Pressure Variations in a Compressible Fluid. Vacuum and Atmospheric Pressure. Absolute and Gage Pressure. Barometers. Piezometers and Manometers.	
<hr/>	
<b>Chapter 3 HYDROSTATIC FORCE ON SURFACES</b>	<b>34</b>
Introduction. Force Exerted by a Liquid on a Plane Area. Force Exerted by a Liquid on a Curved Surface. Hoop or Circumferential Tension. Longitudinal Stress in Thin-Walled Cylinders. Hydrostatic Forces on Dams.	
<hr/>	
<b>Chapter 4 BUOYANCY AND FLOTATION</b>	<b>58</b>
Archimedes' Principle. Stability of Submerged and Floating Bodies.	
<hr/>	
<b>Chapter 5 TRANSLATION AND ROTATION OF LIQUID MASSES</b>	<b>71</b>
Introduction. Horizontal Motion. Vertical Motion. Rotation of Fluid Masses—Open Vessels. Rotation of Fluid Masses—Closed Vessels.	
<hr/>	
<b>Chapter 6 DIMENSIONAL ANALYSIS AND HYDRAULIC SIMILITUDE</b>	<b>82</b>
Introduction. Dimensional Analysis. Hydraulic Models. Geometric Similitude. Kinematic Similitude. Dynamic Similitude. The Inertia Force Ratio. Inertia-Pressure Force Ratio. Inertia-Viscous Force Ratio. Inertia-Gravity Force Ratio. Inertia-Elasticity Force Ratio. Inertia-Surface Tension Ratio. Time Ratios.	

---

---

<b>Chapter 7</b>	<b>FUNDAMENTALS OF FLUID FLOW . . . . .</b>	<b>102</b>
Introduction. Fluid Flow. Steady Flow. Uniform Flow. Streamlines. Streamtubes. Equation of Continuity. Flow Nets. Energy and Head. Energy Equation. Velocity Head. Application of the Bernoulli Theorem. Energy Line. Hydraulic Grade Line. Power.		
<b>Chapter 8</b>	<b>FLOW IN CLOSED CONDUITS . . . . .</b>	<b>138</b>
Introduction. Laminar Flow. Critical Velocity. Reynolds Number. Turbulent Flow. Shearing Stress at a Pipe Wall. Velocity Distribution. Loss of Head for Laminar Flow. Darcy-Weisbach Formula. Friction Factor. Minor Head Losses. Empirical Equations for Water Flow. Pipe Diagrams.		
<b>Chapter 9</b>	<b>COMPLEX PIPELINE SYSTEMS . . . . .</b>	<b>164</b>
Introduction. Equivalent Pipes. Pipes in Series. Pipes in Parallel. Branching Pipes. Pipe Networks.		
<b>Chapter 10</b>	<b>FLOW IN OPEN CHANNELS . . . . .</b>	<b>193</b>
Introduction. Steady Uniform Flow. Nonuniform Flow. Laminar Flow. The Chezy Formula. Coefficient $C$ . Discharge ( $Q$ ). Lost Head ( $h_L$ ). Vertical Distribution of Velocity. Specific Energy. Critical Depth. Maximum Unit Flow. For Critical Flow in Nonrectangular Channels. Nonuniform Flow. Hydraulic Jump. Open-Channel Flow in Circular Cross Sections. Most Efficient Cross Sections.		
<b>Chapter 11</b>	<b>FLOW OF COMPRESSIBLE FLUIDS . . . . .</b>	<b>234</b>
Introduction. Isothermal Flow. Isentropic Flow. The Convergent Nozzle. Compressible Flow Through a Constriction.		
<b>Chapter 12</b>	<b>MEASUREMENT OF FLOW OF FLUIDS . . . . .</b>	<b>242</b>
Introduction. Pitot Tube. Coefficient of Velocity. Coefficient of Contraction. Coefficient of Discharge. Lost Head. Weirs. Theoretical Weir Formula. Francis Formula. Bazin Formula. Fteley and Stearns Formula. The Triangular Weir Formula. The Trapezoidal Weir Formula. For Dams Used as Weirs. Time to Empty Tanks. Time to Empty Tanks. Time to Establish Flow.		
<b>Chapter 13</b>	<b>FORCES DEVELOPED BY MOVING FLUIDS . . . . .</b>	<b>276</b>
Introduction. The Impulse-Momentum Principle. The Momentum Correction Factor $\beta$ . Drag. Lift. Total Drag Force. Drag Coefficients. Lift Coefficients. Mach Number. Boundary Layer Theory. Flat Plates. Water Hammer. Supersonic Speeds.		
<b>Chapter 14</b>	<b>FLUID MACHINERY . . . . .</b>	<b>312</b>
Fluid Machinery. For Rotating Channels. Water Wheels. Turbines. Pumps, and Blowers. Specific Speed. Efficiency. Cavitation. Propulsion by Propellers. Propeller Coefficients.		

---

<b>Appendix</b>	<b>TABLES AND DIAGRAMS</b>	<b>335</b>
Table 1	(A) Approximate Properties of Some Gases . . . . .	335
	(B) Some Properties of Air at Atmospheric Pressure . . . . .	335
	(C) Mechanical Properties of Water at Atmospheric Pressure . . . . .	336
Table 2	Specific Gravity and Kinematic Viscosity of Certain Liquids . . . . .	337
Table 3	Frictional Factors $f$ for Water Only . . . . .	338
Table 4	Typical Lost Head Items . . . . .	339
Table 5	Values of $K$ . . . . .	340
Table 6	Some Values of Hazen-Williams Coefficient $C$ . . . . .	340
Table 7	Discharge Coefficients for Vertical Sharp-Edged Circular Orifices . . . . .	341
Table 8	Some Expansion Factors $\gamma$ for Compressible Flow Through Flow Nozzles and Venturi Meters . . . . .	342
Table 9	A Few Average Values of $n$ for Use in the Kutter and Manning Formulas and $m$ in the Bazin Formula . . . . .	342
Table 10	Values of $C$ from the Kutter Formula . . . . .	343
Table 11	Values of Discharge Factor $K$ in $Q = (K/n)y^{8/3}S^{1/2}$ for Trapezoidal Channels . . . . .	344
Table 12	Values of Discharge Factor $K'$ in $Q = (K'/n)b^{8/3}S^{1/2}$ for Trapezoidal Channels . . . . .	345
Diagram A-1	Friction Factors $f$ . . . . .	346
Diagram A-2	Friction Factors $f$ . . . . .	347
Diagram B-1	Flow Chart for Hazen-Williams Formula, $C = 100$ . . . . .	348
Diagram B-2	Pipe Diagram: Hazen-Williams Equation ( $C = 120$ ), British Engineering System . . . . .	349
Diagram B-3	Pipe Diagram: Hazen-Williams Equation ( $C = 120$ ), International System . . . . .	350
Diagram B-4	Pipe Diagram: Manning equation ( $n = 0.013$ ) British Engineering System . . . . .	351
Diagram B-5	Pipe Diagram: Manning equation ( $n = 0.013$ ) International System . . . . .	352
Diagram C	Pipe Orifices . . . . .	353
Diagram D	Flow Nozzles . . . . .	354
Diagram E	Venturi Meters . . . . .	355
Diagram F	Coefficient of Drag vs Re . . . . .	356
Diagram G	Drag Coefficients for Smooth, Flat Plates . . . . .	357
Diagram H	Drag Coefficients for Supersonic Velocities . . . . .	358
<b>INDEX</b>		<b>359</b>

## Index

- Absolute pressure, 14, 18  
Absolute viscosity, 3  
Acceleration, linear, 71  
Acoustic velocity, 5, 259  
Adiabatic conditions, 5, 119  
Archimedes' principle, 58  
Atmospheric pressure, 14, 18
- Barometers, 14  
Bazin formula, 194, 244  
Bernoulli theorem, 105, 106, 316  
Blowers, 312, 314  
Boundary layer theory, 278  
Branching pipes, 165  
British Engineering system of units, 1  
Broad-crested weir, 245, 263  
Buckingham Pi Theorem, 82, 89–92  
Bulk modulus of elasticity, 5  
values of, 336  
Buoyancy, 58  
center of, 58  
Buoyant force, 58
- Capillarity, 4, 11  
Cauchy number, 84  
Cavitation, 314  
Celerity, 279, 304, 305  
Center of buoyancy, 58  
Center of gravity, 34, 35, 58  
Center of pressure, 34, 37, 42  
Chezy formula, 193, 197  
Cipolletti weir, 245  
Coefficients:  
contraction, 242  
discharge, 242  
values of, 341  
drag, 277, 356–358  
flow nozzle, 354  
lift, 277  
orifice, 341, 353  
propeller, 315  
velocity, 242  
Venturi meter, 355  
Complex pipeline system, 164–167  
Compressible flow, 107, 109, 118, 234–237  
Conservation of mass, 102  
Constrictions, 236
- Continuity equation, 103, 107, 109  
Contracted weir, 243–245  
Convergent nozzle, 235  
Critical depth, 195, 211  
Critical flow, 195, 196, 211, 213  
Critical pressure ratio, 235  
Critical specific energy, 211  
Critical velocity, 138, 211
- Dams:  
forces on, 35  
stability of, 35  
Darcy-Weisbach formula, 140  
Density (*see* mass density)  
Differential manometer, 15  
Dimensional analysis, 82–84  
Discharge factors, 344, 345  
Discharge relation, 313  
Drag, 277  
coefficients, 277, 356–358  
Dynamic similitude, 83  
Dynamic viscosity, 3  
values of, 335, 336
- Efficiency:  
for pumps, 314  
for turbines, 314  
Empirical equations for water flow, 142, 143  
Energy:  
equation, 105  
kinetic, 104, 115  
line, 106  
potential, 104  
pressure, 105  
specific, 195  
Equivalent pipes, 164  
Euler number, 83, 92  
Euler's equation, 118  
Expansion factors, 342
- Finley and Stearns formula, 244  
Flexural formula, 35  
Floating bodies, stability of, 58  
Flotation, 58  
Flow:  
in closed conduits, 138–143

- Flow (Cont.):**
- compressible, 107, 109, 118, 234–237
  - critical, 195, 196, 211, 213
  - gradually varied, 221–224
  - incompressible, 107, 109, 118
  - irrotational, 102
  - isentropic, 5, 234
  - isothermal, 5, 118, 234
  - laminar, 102, 138, 140, 193, 199, 299, 300
  - maximum unit, 195
  - measurement of, 242–245
  - nets, 104, 112
  - nonuniform, 102, 103, 193, 196, 217
  - one-dimensional, 102
  - in open channels, 193–197
  - rotational, 102
  - sonic, 235, 236, 178
  - steady, 102, 107, 109, 117, 193
  - subcritical, 195, 212
  - subsonic, 235, 236, 278
  - supercritical, 195, 212
  - supersonic, 278
  - three-dimensional, 102, 109
  - turbulent, 102, 138, 139, 195
  - two-dimensional, 102, 112
  - types of, 224
  - uniform, 102, 103, 193
  - unsteady, 102, 109
- Fluid Machinery, 312–315
- Forces:
- buoyant, 58
  - on curved surfaces, 34
  - on dams, 35
  - developed by fluids in motion, 276–280
  - on moving objects, 285, 286
  - on plane surfaces, 34
- Francis formula, 244
- Friction factor, 141
- values of, 338, 346, 347
- Friction velocity, 139
- Froude number, 84, 93, 195
- Fundamentals of fluid flow, 102–107
- Gage pressure, 10, 14, 18
- Gas constant, 2
- values of, 335
- Geometric similitude, 82
- Gradually varied flow, 221–224
- Hardy Cross method, 166
- Hazen-Williams formula, 142, 164, 166, 167
- coefficient of, 340
  - flow chart, 348
- Hazen-Williams formula (Cont.):
- pipe diagram, 349, 350
- Head:
- elevation, 105
  - pressure, 14, 105
  - velocity, 105, 106
- Head loss, 140, 194, 243, 339, 340
- friction, 140, 145
  - minor, 142
  - values of, 339, 340
- Hoop tension, 35
- Hydraulic grade line, 107
- Hydraulic jump, 196, 223
- Hydraulic models, 82
- Hydraulic radius, 138
- Hydraulic similitude, 82–84
- Hydrometer, 60
- Hydrostatic force on dams, 35
- Hydrostatic force on surfaces, 34, 35
- Ideal fluid, 8, 9
- Impulse-momentum, 276
- Incompressible flow, 107, 109, 118
- Inertia-elasticity force ratio, 84
- Inertia force ratio, 83
- Inertia-gravity force ratio, 84
- Inertia-pressure force ratio, 83
- Inertia-surface tension ratio, 84
- Inertia-viscous force ratio, 83
- International System of units, 1
- Irrotational flow, 102
- Isentropic conditions, 5, 234
- Isothermal conditions, 5, 118, 234
- Jet propulsion, 291, 292
- Kinematic similitude, 82
- Kinematic viscosity, 3
- values of, 335, 337
- Kinetic energy, 104, 115
- Kinetic energy correction factor, 106, 115, 116
- Kutter formula, 194
- coefficient of, 342, 343
- Laminar flow, 102, 138, 140, 193, 199, 299, 300
- Lift, 277
- coefficient, 277
- Longitudinal stress, 35
- Losses:
- entrance, 142
  - exit, 142

- Losses (Cont.):**  
 gradual contraction, 142  
 gradual expansion, 142  
 head, 140, 142, 194, 243, 339, 340  
 minor, 142  
 sudden contraction, 142  
 sudden expansion, 142  
 values of, 339, 340
- Mach number, 84, 93, 235, 278  
 Manning formula, 142, 194, 208  
   coefficient of, 342  
   pipe diagrams, 351, 352  
 Manometers, 15  
   differential, 15  
 Mass density, 2  
   values of, 335, 336  
 Mean velocity, 200  
 Metacenter, 58  
 Minor head losses, 142  
   values of, 339, 340  
 Moment of inertia, 34  
 Momentum, 102  
 Momentum correction factor, 276, 280  
 Moody diagram, 346  
 Most efficient cross sections, 197, 198, 210, 211
- Newtonian equation, 83  
 Newtonian fluids, 3, 8  
 Nonuniform flow, 102, 103, 193, 196, 217  
 Nozzles, 235, 256  
   coefficient of, 342, 354
- One-dimensional flow, 102  
 Open channels, 193–197  
 Orifices, 245, 290  
   coefficient of, 341, 353
- Piezometers, 15  
 Pipe diagrams, 143, 349–352  
 Pipe networks, 166  
 Pipes:  
   branching, 165  
   diagrams, 348–352  
   equivalent, 164  
   networks, 166  
   in parallel, 164  
   rough, 140  
   in series, 164  
   smooth, 140  
 Pitot tube, 242, 246
- Poises, 3  
 Powell formula, 194  
 Power, 107, 319  
 Power relation, 313  
 Pressure, 13–15  
   absolute, 14, 18  
   atmospheric, 14, 18  
   center of, 34, 37, 42  
   fluid, 13  
   gage, 10, 14, 18  
   stagnation, 129  
   unit, 13  
   vapor, 4  
 Pressure distribution, 5  
 Pressure head, 14, 105  
 Propeller coefficients, 315  
 Propeller propulsion, 314, 329  
 Properties:  
   of air, 335  
   of gases, 335  
   of liquids, 337  
   of water, 336  
 Propulsion:  
   jet, 291, 292  
   propeller, 314, 329  
   rocket, 292  
 Pumps, 312, 314  
   cavitation, 314  
   efficiency, 314  
   impeller, 315, 318  
   power, 319  
   specific speed, 313, 320  
   speed factor, 312  
   unit speed, 312
- Rectangular weir, 243, 260  
 Reynolds number, 83, 85, 92, 138  
 Rocket propulsion, 292  
 Rotation of liquid masses:  
   in closed vessels, 71  
   in open vessels, 71  
 Rotational flow, 102
- Saybolt seconds, 3  
 Shear velocity, 139  
 Shearing stress at pipe wall, 139, 145  
 Similitude:  
   dynamic, 83  
   geometric, 82  
   kinematic, 82  
 Specific energy, 195, 212, 213  
 Specific gravity, 2  
   values of, 337

- Specific heat, 5  
 Specific heat ratio, 236  
     values of, 335  
 Specific speed, 313, 320  
 Specific weight, 2  
     values of, 335, 336  
 Speed factor, 312  
 Speed relation, 312  
 Stability:  
     of dams, 35  
     of floating bodies, 58  
     of submerged bodies, 58  
 Stagnation pressure, 129  
 Steady flow, 102, 107, 109, 117, 193  
 Stokeses, 3  
 Streamline, 103  
 Streamtube, 103  
 Subcritical flow, 195, 212  
 Submerged bodies, stability of, 58  
 Supercritical flow, 195, 212  
 Supersonic speeds, 280  
 Suppressed weir, 243-245, 262, 268  
 Surface tension, 4, 10, 11  
     values of, 336
- Three-dimensional flow, 102, 109  
 Time ratios, 84  
 Translation of liquid masses, 71  
 Trapezoidal weir, 245  
 Triangular weir, 244, 261  
 Turbine, 312, 313  
     efficiency, 314  
     power delivered, 319  
     runner, 316  
     specific speed, 320  
     speed factor, 319  
     unit speed, 312  
 Turbulent flow, 102, 138, 139, 195  
 Two-dimensional flow, 102, 112  
 Types of open-channel flow, 224
- Uniform flow, 102, 103, 193  
 Unit discharge, 313  
 Unit power, 313  
 Unit speed, 312  
 Unsteady flow, 102, 109
- Vacuum, 14  
 Vapor pressure, 4  
     values of, 336
- Velocity:  
     coefficient of, 242  
     critical, 138, 211  
     distribution, 139, 195, 199  
     friction, 139  
     mean, 200  
     shear, 139  
     supersonic, 280
- Vena contracta, 254  
 Venturi meter, 256  
     coefficient of, 355
- Vessels:  
     rotating, 71  
     translating, 71
- Viscosity, 3  
     absolute, 3  
     dynamic, 3  
     kinematic, 3  
     values of, 335-337
- Water hammer, 279  
 Water wheels, 312  
 Weber number, 84, 93  
 Weirs, 243-245  
     broad-crested, 245, 263  
     Cipoletti, 245  
     contracted, 243-245  
     formulas for, 243-245  
     rectangular, 243, 260  
     suppressed, 243-245  
     trapezoidal, 245  
     triangular, 244, 261