

TABLE K. CONSTANTS AND THEIR LOGARITHMS

Name (Radius of circle or sphere = 1)	Symbol	Number	Logarithm
Area of circle	$\pi$	3.141 592 654	0.497 149 873
Circumference of circle	$2\pi$	6.283 185 307	0.798 179 868
Surface of sphere	$4\pi$	12.566 370 614	1.099 209 864
	$\frac{1}{8}\pi$	0.523 598 776	$\bar{1}.718$ 998 622
Quadrant of circle	$\frac{1}{4}\pi$	0.785 398 163	$\bar{1}.895$ 089 881
Area of semicircle	$\frac{1}{2}\pi$	1.570 796 327	0.196 119 877
Volume of sphere	$\frac{4}{3}\pi$	4.187 790 205	0.622 088 609
	$\pi^2$	9.869 604 401	0.994 299 745
	$\pi^{\frac{1}{2}}$	1.772 453 851	0.248 574 936
Degrees in a radian	$180/\pi$	57.295 779 513	1.758 122 632
Minutes in a radian	$10800/\pi$	3 437.746 771	3.536 273 883
Seconds in a radian	$648000/\pi$	206 264.806	5.314 425 133
	$1/\pi$	0.318 309 886	$\bar{1}.502$ 850 127
	$1/\pi^{\frac{1}{2}}$	0.564 189 584	$\bar{1}.751$ 425 064
	$1/\pi^2$	0.101 321 184	$\bar{1}.005$ 700 255
Circumference/360	arc $1^\circ$	0.017 453 293	$\bar{2}.241$ 877 368
	sin $1^\circ$	0.017 452 406	$\bar{2}.241$ 855 318
Circumference/21600	arc $1'$	0.000 290 888	4.463 726 117
	sin $1'$	0.000 290 888	4.463 726 111
Circumference/1296000	arc $1''$	0.000 004 848	$\bar{6}.685$ 574 867
	sin $1''$	0.000 004 848	$\bar{6}.685$ 574 867
Base Napierian system of logs	$e$	2.718 281 828	0.434 294 482
Modulus common system of logs	$M$	0.434 294 482	$\bar{1}.637$ 784 311
Napierian log of 10	$1/M$	2.302 585 093	0.362 215 689
	$hr$	0.476 936 3	$\bar{1}.678$ 460 4
Probable error constant	$hr\sqrt{2}$	0.674 489 7	$\bar{1}.828$ 975 4

## INDEX

(The numbers refer to pages.)

- Absolute velocity, 60, 64, 422, 440  
Acceleration, 3, 11, 12, 21, 546  
Acre-foot, 375  
Adjutage, 178, 191  
Advantageous angle, 420  
  nozzle, 449  
  section, 283  
  velocity, 421, 436, 448, 469, 472, 482  
Air chamber, 242, 424, 510  
Air-lift pump, 528  
Air valve, 224, 248  
Anchor ice, 5  
Angle measurements, 108  
Answers to problems, 544  
Approach, angle of, 236, 445  
  velocity of, 51, 123, 145-153  
  apron of dam, 163  
Aqueducts, 210, 272, 300  
Archimedean screw, 504  
Areas of circles, 545, 556  
Atmospheric pressure, 2, 7, 20, 26, 41, 188, 472, 507  
Automatic devices, 251
- Backpitch wheel, 450  
Backwater, 344, 353, 355  
  function, 354  
Ball nozzle, 199  
Barker's mill, 453  
Barometer, 7, 8, 20, 472, 507  
Bazin's formula, 208, 316  
Bends in rivers, 411  
Bernoulli's theorem, 68, 203  
Blow-offs, 224  
Boiling point, 8, 20  
Bore, 350, 352  
Bridge piers, 342
- Bristol water level gage, 76  
Boyden diffuser, 476  
  hook gage, 79  
  turbine, 395, 462  
Brake, friction, 389  
Branched pipes, 254  
  hose, 534  
Breast wheels, 437, 528  
Brick conduits, 295, 206  
  sewers, 292  
Brooks, 272, 317  
Buckets, 435, 437, 450, 505  
Bucket pumps, 13  
Buoyancy, center of, 30
- Canal boat, 490  
  lock, 136  
Canals, 272-292  
Cascade wheel, 441  
Cast-iron pipes, 258, 295  
Catskill aqueduct, 300, 336  
Center of buoyancy, 30, 499  
  of gravity, 31  
  of pressure, 34, 36  
Centrifugal force, 62  
  pump, 521  
Chain pump, 13, 528  
Channels, 272-317  
Chemical methods for velocity, 334  
Chezy's formula, 275, 287, 313, 315  
Cippoletti weir, 170  
Circles, areas of, 545, 556  
  properties of, 280, 556  
Circular conduit, 276, 279, 280  
  orifices, 46, 116, 138  
Classification of pumps, 505, 527  
  of surfaces, 295, 304  
  of turbines, 447

- Coal used by steamers, 490  
 Cock valve, 223  
 Coefficient of contraction, 111  
   nozzles, 189  
   orifices, 112, 129  
   tubes, 184, 185  
 Coefficient of discharge, 115  
   channels, 293, 313  
   dams, 176  
   nozzles, 189  
   orifices, 118, 119, 121, 123  
   pipes, 201, 297, 298  
   sewers, 292  
   tubes, 185, 189, 192, 195  
   turbines, 456  
   weirs, 150, 152, 174, 175  
 Coefficient of roughness, 289, 297  
 Coefficient of velocity, 113  
   nozzles, 189  
   orifices, 114  
   tubes, 185, 195  
 Compound pipes, 240, 543  
   tubes, 191  
 Compressed air, 530  
 Compressibility of water, 5, 20  
 Computations, 15-22, 72, 138  
 Conduit pipes, 295  
 Conduits, 272-317  
 Conical tubes, 189  
   wheel, 451  
 Conservation of energy, 47, 193  
 Constants, tables of, 546, 556  
 Consumption of water, 376  
 Contracted weirs, 141, 149, 174  
 Contraction, of a jet, 110  
   coefficient of, 111  
   gradual, 182  
   sudden, 181  
   suppression of, 127  
 Converging tubes, 191  
 Cotton hose, 264  
 Crest, of a weir, 80, 142, 160  
   of a dam, 342  
   rounded and wide, 160  
 Critical velocity, 269  
 Cross-section, velocities in, 320  
 Croton aqueduct, 300, 301  
 Cubic feet, 2, 546  
 Current indicators, 325  
   meters, 96, 324, 336  
 Curvature factors, 218  
 Curved surfaces, 31  
 Curves, backwater, 161, 343  
   in pipes, 238, 245, 409  
   in rivers, 409  
 Cuttlefish, 493  
 Cutwater of piers, 344  
 Cycle of rainfall, 378  
 Dams, 39, 40, 43, 162, 176, 342  
 Danaide, 451  
 Data, fundamental, 1-22  
 Depth of flotation, 28  
 Design of turbines, 469  
   of power plants, 364  
   of water wheels, 451  
 Diameters of pipes, 230  
   water mains, 258, 260, 260  
 Differential pressure gages, 85  
 Diffuser, 474  
 Discharge, 65, 94, 115  
   conduits, 272-317  
   curves, 331, 339  
   fountain flow, 209  
   gaging of, 327  
   nozzles, 242, 265  
   orifices, 109-140  
   pipes, 211-271  
   rivers, 318-364  
   theoretic, 65  
   tubes, 177-210  
   turbines, 462  
   weirs, 141-176, 159  
 Discharge curves, 331, 339  
 Discharging capacity, 233  
 Disk valve, 223  
 Displacement pumps, 527  
 Distilled water, 6, 19  
 Ditches, 272, 292  
 Diverging tubes, 191  
 Diversions, 254  
 Double-acting pump, 512  
 Double floats, 322, 336  
 Downward-flow wheels, 446  
   turbines, 471

- Draft tube, 460  
 Drag of a ship, 489  
 Drop-down curve, 360  
   function, 361  
 Dropping head, 135  
 Duplex pump, 513  
 Duty of pumps, 518  
   water, 375  
 Dynamic pressure, 59, 399-431, 486  
 Dynamo, 396, 481  
 Dynamometer, 381  
 Effective head, 53, 124, 386  
   power, 388  
 Efficiency, 57, 382  
   jet, 134  
   jet propeller, 493  
   motors, 384, 391, 432  
   moving vanes, 420  
   paddle wheels, 495  
   pumps, 504-538  
   reaction wheel, 438  
   screw propeller, 495  
   turbines, 454, 456, 466, 474  
   water wheels, 436, 438, 439  
 Egg-shaped sewers, 289  
 Ejector pump, 529, 530  
 Elasticity of water, 10, 20  
 Electric analogies, 257, 539  
   generators, 396, 385  
 Elevations by barometer, 8  
 Elliptical orifices, 110  
 Emptying a canal lock, 137  
   a vessel, 69  
 End contractions, 149  
 Energy, 3, 68, 178  
   loss of, 133  
   in channels, 312  
   tubes, 178, 200  
   of a jet, 56  
 Engine, hydraulic, 526  
   pressure, 528  
   pumping, 517  
 English measures, 1, 547  
 Enlargement of section, 180, 309  
 Entrance angle, 446, 466  
 Eosine, 334  
 Erosion, 294, 341  
 Errors in computations, 15, 105  
   in measurements, 130, 142  
 Eureka turbine, 460  
 Evaporation, 369  
 Exit angle, 464, 467  
 Expansion of section, 179  
 Fair form of boat, 486  
 Fall increaser, 477  
 Falling bodies, 11, 44  
 Feet and inches, 1  
 Filaments, 274  
 Filling canal lock, 137  
 Filter bed, 249, 250, 268  
 Fire hose, 264, 270  
   engine, 537  
   service, 254  
 Floats, 250, 322  
 Flotation, depth of, 28  
   stability of, 29, 497  
 Flow, dynamic pressure, 58  
   blood in veins, 268  
   canals and conduits, 272-317  
   dams, 163-167, 176  
   fountain, 208  
   jets, 54, 56, 198  
   non-uniform, 346  
   orifices, 46, 109-140  
   pipes, 67, 211-271  
   revolving vessel, 62  
   rivers, 318-364  
   steady, 31, 67  
   tubes, 177-210  
   turbines, 461, 453-484  
   under pressure, 49  
 Flume, testing, 396  
 Foot, 1, 547  
 Foot valve, 509, 513  
 Force pump, 7, 505, 510  
 Force, unit of, 2  
 Forebay, 308, 362, 383  
 Foss' formula, 304  
 Fountain flow, 207, 208  
 Fourneyron turbine, 456, 476  
 Francis turbine, 456  
   float formula, 323

- Francis weir formula, 154  
 Free surface, 4, 25  
 Frictional resistances, 44  
   channels, 273, 295  
   pipes, 214  
   pumps, 507, 513  
   turbines, 432, 458  
   water wheels, 403, 434  
   ships, 486  
 Friction brake, 389  
   factors, 259, 261, 270  
   heads, 216, 218  
 Friez recording gage, 76
- Gages, 2, 75, 76, 79, 81-86, 250, 338, 386  
 Gaging flow, 95, 129, 142  
   of rivers, 321, 332, 335, 374  
 Gallon, 1, 2, 546  
 Gate of a turbine, 456, 458, 479  
 Gates, pressure on, 38  
 Gate valve, 224  
 Girard turbine, 476  
 Glacier, flow of, 305  
 Governor, 483  
 Gradient, hydraulic, 237, 239  
 Graphic methods, 105  
 Gravity, acceleration of, 11, 12, 21,  
   44, 485, 546  
   center of, 32  
   water supply, 377  
 Greek letters, 17  
 Ground water, 372  
 Guides, 469
- Hammer in water pipes, 412  
 Head, 25, 81, 134, 142, 178, 388  
   and pressure, 25, 26, 41, 51  
   effective, 53  
   losses of, 133, 217, 218, 250, 306  
   measurement of, 76, 79, 130, 234  
 Heat units, 518  
 Historical notes, 11, 23, 206  
 Holyoke tests, 394  
 Hook gage, 79, 319, 384  
 Horizontal impulse wheels, 444  
   range of a jet, 54, 199
- Horse-power, 3, 18, 547  
   effective, 388  
   nominal, 397  
 Horseshoe conduits, 306  
 Hose, 264, 270, 534  
 House-service pipes, 245  
 Hunt turbine, 459  
 Hurdy-gurdy wheel, 443  
 Hydraulic constants, 546  
   engine, 526  
   gradient, 237, 239  
   jump, 349  
   mean depth, 273  
   motors, 388, 432-484  
   press, 84  
   radius, 272, 543  
   ram, 524  
 Hydraulic-electric analogies, 539  
 Hydraulics, defined, 13  
   theoretical, 44-74  
 Hydromechanics, 13, 416, 486  
 Hydrometric balance, 325  
   pendulum, 324  
 Hydrostatic head, 25, 41, 68  
 Hydrostatics, 13, 22-45
- Ice, 4, 5, 7, 18, 19  
 Immersed bodies, 36, 407  
 Impact, 178, 180, 401, 446  
 Impeller pump, 528  
 Impulse, 58, 399, 401, 408  
   turbines, 457, 476  
   wheels, 441-450  
 Inch, 1, 547  
 Inclined pipes, 203  
 Inclined tubes, 202  
 Incrustations in pipes, 259  
 Inertia, moments of, 37, 499  
 Injector pump, 528  
 Instruments, 75-108  
 Inward-flow turbines, 456, 472  
 Inward-projecting tubes, 190  
 Irrigation, hydraulics, 375
- Jersey City aqueduct, 302  
 Jet propeller, 492

- Jet pump, 528  
 Jets, 54-60, 196, 205, 404, 442  
   contraction of, 2, 110  
   energy of, 56  
   from nozzles, 102, 196  
   height of, 199, 209  
   impulse of, 56, 58, 418  
   on vanes, 417  
   path of, 54, 56, 58  
   range of, 55, 56  
 Jonval turbine, 456  
 Jump, 350
- Keely motor, 24  
 Kilowatt, 396, 547  
 Kinetic energy, 3, 45  
 Knot, 485  
 Kutter's formula, 287, 313-316, 319
- Lampe's formula, 268, 270  
 Leakage, 384, 437, 509  
 Least squares, method of, 107  
 Leffel turbine, 459  
 Lift pump, 505  
 Lighthouses, 419  
 Linen hose, 264  
 Liter, 547  
 Lock-bar pipe, 262  
 Lock of canal, 136  
 Log, nautical, 323, 485  
 Logarithms, 15, 553-556  
 Long pipes, 230  
   tubes, 200  
 Loss of head, 133, 217, 218, 250, 306  
   contraction, 181, 182  
   curvature, 218, 222  
   entrance, 213  
   expansion, 186  
   friction, 194, 212, 214  
 Loss of weight in water, 27  
 Lowell tests, 394
- Masonry dams, 40, 43  
   conduits, 300  
 Mathematical tables, 545-556
- Mean velocity, 92, 225, 274, 275, 322, 330  
 Measurement of water, 77, 129, 384  
 Measuring instruments, 75-108  
 Mercury, 7, 51, 83, 84  
 Mercury gage, 83, 85  
 Metacenter, 30, 498  
 Meter, 547  
 Meters, current, 96, 324  
   Premier, 93  
   Simplex, 92  
   Venturi, 89  
   water, 88, 132  
 Method of least squares, 107  
 Metric measures, 3, 18, 41, 72, 138, 173,  
   210, 269, 312, 547  
 Mile, 485  
 Mill power, 396  
 Miner's inch, 131  
 Mississippi river, 321  
 Module, 132  
 Modulus of elasticity, 10, 20, 414  
 Moments of inertia, 37, 499  
 Motors, hydraulic, 386, 391  
 Mouthpiece, 191  
 Moving vanes, 419  
 Mud valves, 224
- Nautical mile, 485  
 Naval hydromechanics, 485  
 Navigation canals, 362  
 Negative pressure, 69  
 Niagara power plants, 394, 478  
   turbines, 477  
 Non-uniform flow, 346  
 Normal pressure, 31  
 Nozzles, 102, 196, 242, 387, 442, 448,  
   529  
   jets from, 102, 199, 219  
 Numerical computations, 15
- Oar, action of, 494  
 Oblique weirs, 172  
 Observations, discussion of, 75-108  
 Obstructions in channels, 302  
   in pipes, 259  
 Ocean waves, 351, 408, 501

- Ogee dams, 165  
 Ohm's law, 539  
 Oil, 51, 86  
 Oil differential gage, 87  
 Operating devices, 248  
 Orifices, 46, 109-140, 387  
 Oscillations, 497, 543  
 Outward-flow turbine, 444  
 Overshot wheels, 434, 528
- Paddle wheels, 493  
 Paraboloid, 63  
 Patent log, 486  
 Path of a jet, 54  
 Peak load, 382  
 Pelton wheel, 441, 442  
 Pendulum, hydrometric, 324  
 Penstock, 383, 385, 392  
 Perimeter, wetted, 272  
 Physical properties of water, 3  
 Piers, 342  
 Piezometer, 230, 234, 238, 246  
 Pipes, 42, 143, 211-271, 530  
   curves in, 219, 410  
   friction factors for, 217, 269  
   friction heads for, 218, 270  
   smooth, 67  
 Piston pump, 512  
 Pitometer, 93, 247  
 Pitot's tube, 101, 247, 324, 486  
 Plates, moving, 408, 488  
 Plunger pumps, 513  
 Pneumatic turbine, 476  
 Poiseuille's law, 268  
 Poncelet wheel, 439  
 Potential energy, 3, 45  
 Power, 3, 56, 452, 506  
   dynamometer, 387  
 Press, hydrostatic, 24  
 Pressure, atmospheric, 7, 8, 20, 41  
   center of, 34, 36  
   dynamic, 399-431  
   energy of, 177  
   flow under, 49  
   gages, 81, 85  
   horizontal, 32  
   measurement of, 81-88, 82
- Pressure, negative, 69  
   normal, 31  
   of waves, 409, 502  
   on dams, 39, 40  
   regulator, 247  
   submerged body, 31  
   transmission of, 23  
   unit of, 2, 20  
 Pressure gage, 8, 81, 85  
   head, 25, 26, 41, 68, 244  
   regulator, 247, 249  
 Price current meter, 97  
 Probable errors, 130  
 Prony brake, 389  
 Propeller, 492, 496  
 Propulsion, work in, 490  
 Pulsometer, 529  
 Pumps, 7, 377, 504  
 Pumping through hose, 534  
 Pumping through pipes, 530  
 Pumping engines, 517  
 Poppet valve, 515
- Radius, hydraulic, 272  
   gyration, 499  
 Ram, hydraulic, 524, 526  
   in pipes, 412  
 Range of a jet, 54, 199  
 Rain gage, 365  
 Rainfall, 365  
 Rating curve, 330  
 Rating a meter, 100  
 Reaction, 58, 400  
   experiments on, 403  
   turbines, 457-467, 521  
   wheel, 430, 453  
 Reciprocating pumps, 527  
 Recording apparatus, 77, 91  
 Rectangular conduits, 282, 284  
   orifices, 122, 127, 139  
 Reducer, 240  
 Regulating devices, 248  
 Regulator, pressure, 247  
 Relative capacities of pipes, 235  
   velocity, 60, 425  
 Relief valves, 249  
 Reservoirs, 78, 380

- Resistance of plates, 487  
   of ships, 486  
 Reversibility, 528  
 Revolving tubes, 429  
   vanes, 423  
   vessel, 62  
 Rife hydraulic engine, 526  
 Ring nozzle, 198  
 Rivers, 318-364  
 River water, 4, 7, 17  
 Riveted pipes, 260, 296  
 Rochester water pipe, 242  
 Rod float, 323  
 Rolling of a ship, 31, 498  
 Roman aqueducts, 13, 265  
   pipes, 13, 211  
 Rotary pumps, 527  
 Rounded crests, 160  
   orifices, 109, 128  
 Rudder, action of, 500  
 Runoff, 372
- Salt water, 7, 19  
 Sand, weight in water, 28  
   filter bed, 250  
 Screens, 308, 310  
 Screw propeller, 495  
   turbine, 477  
 Seepage, 376  
 Sewage, 7, 530  
 Sewers, 289, 318  
 Ships, 485-503  
 Shock, 434  
 Short pipes, 230  
   tube, 184  
 Siamese joint, 534  
 Siphon, 239, 260  
 Skin of water, 4, 79  
 Slip of a ship, 495, 496  
 Slope, 273, 317  
 Small pipes, 268  
 Smooth nozzle, 198  
   pipes, 67  
 Snow, 372  
 Sound, velocity of, 28  
 Specific gravity, 42  
 Speed of wheels, 428, 437
- Speed of ships, 486  
   of turbines, 457, 461  
 Sphere, 29, 33  
 Square vertical orifices, 120, 139  
 Squares, table of, 545, 548  
 Stability of dams, 40  
   of flotation, 29, 497  
 Standard orifice, 186  
   tube, 184  
   weirs, 141  
 Standpipe, 213  
 Statical moment, 37  
 Steady flow, 273, 318, 539  
 Steamer, coal used by, 491  
 Steam plants, 381  
 Steel pipes, 295, 296  
 Stone, weight of, 28  
 Storage of water, 378, 381  
 Strength of pipes, 34, 42  
 Submerged bodies, 31  
   dams, 342  
   orifices, 109, 126  
   surfaces, 487  
   tubes, 194  
   turbines, 458  
   weirs, 157  
 Sub-surface float, 322, 333, 336  
   velocities, 323, 330  
 Suction, 8, 504, 506  
 Suction pump, 504, 507  
 Sudbury conduit, 301, 314  
 Suppressed weirs, 152, 175  
 Suppression of contraction, 127  
 Surface curve, 167, 348  
   float, 322  
   velocity, 321, 330  
 Surfaces, center of pressure, 36, 39  
   jets upon, 58, 405  
   pressure on, 32, 399  
 Syringe, 505
- Tables, x, 545-556  
 Tank, 76, 125, 384  
 Temperature, 6, 130, 547  
 Test of motors, 388  
   pumping engines, 519  
   turbines, 392, 481

Theoretical hydraulics, 44-74  
 Theoretic discharge, 65  
   velocity, 46, 52  
 Thermal heat unit, 518  
 Throttle valve, 223  
 Tidal bore, 350  
   waves, 397, 501  
 Tide gate, 38  
 Tides, 397, 452, 501  
 Time, 2, 18  
 Transmission of pressures, 24  
 Transporting capacity, 294, 339  
 Trapezoidal conduits, 286  
   weirs, 170  
 Triangular orifices, 110  
 Triangular weirs, 168  
 Trigonometric functions, 545, 552  
 Triple nozzle, 444  
 Troughs, 272  
 Tubes, 101, 177-210, 429  
 Tubercles in pipes, 259, 262  
 Tunnel, Niagara, 478  
 Turbines, 14, 383, 453-484, 528  
 Tutton's formula, 304  
 Twin screws, 496  
   turbines, 461

Undershot wheels, 439, 450  
 Uniform flow, 67, 204, 274  
 Unit of heat, 518  
 Units of measure, 1, 18, 547  
 Unsteady flow, 334  
 Uplift, dams, 40

Vacuum, 7, 13, 188, 504  
   compound tube, 188  
   pumps, 517  
   standard tube, 187  
   turbines, 475  
 Valves, 223, 248, 251  
 Vanes, 417, 440, 469  
   in motion, 423  
   revolving, 429  
 Variations in discharge, 130, 337  
   in rainfall, 368  
 Velocities in a cross-section, 204, 310, 320

Velocity, 2, 18, 44  
   absolute, 60  
   coefficient of, 113  
   critical, 269  
   curves of, 204  
   from orifices, 47  
   in conduits, 275  
   in pipes, 204, 267, 274  
   in rivers, 321  
   mean, 274, 275  
   measurement of, 95, 96, 101, 322  
   of approach, 51, 145-153  
   of sound and stress, 10, 21  
   of the bore, 352  
   of waves, 501  
   relative, 60  
   to move materials, 301, 339  
 Velocity-head, 47, 68  
 Venturi water meter, 89, 205  
 Vermeule's formula, 371  
 Vertical jets, 46, 114, 199, 219  
   orifices, 116, 118, 121  
 Vertical turbines, 451  
   wheels, 444  
 Vessel, emptying of, 69  
   moving, 61  
   revolving, 63  
 Viscous flow, 541  
 Vortex whirl, 71

Waste of water, 246  
   weirs, 162  
 Water, barometer, 8, 20, 507  
   boiling point of, 8  
   compressibility, 9  
   distilled, 6, 19  
   dynamic pressure, 58, 399  
   freezing of, 4, 5, 18  
   hammer, 248, 412  
   mains, 227, 251  
   maximum density, 4, 6  
   measurement of, 77, 132, 384  
   meters, 88  
   physical properties, 3-20  
   pipes, 34, 42, 211-271  
   power, 381-398  
   pressure of, 2, 18, 23

Water, storm, 373  
   supply, 365-381  
   surface of, 4, 24  
   vapor, 507  
   waste of, 251  
   weight of, 6, 19  
 Water-pressure engine, 451  
 Watershed, 370  
 Water wheels, 423, 432-452  
 Waterwitch, 493  
 Waves, 351, 408, 501  
 Weighing water, 77, 385  
 Weight of ice, 7, 19  
   masonry, 40  
   mercury, 8, 83  
   sand, 28  
   sewage, 7  
   submerged bodies, 27  
   water, 6, 19, 485  
 Weirs, 80, 141-176, 386  
 Wetted perimeter, 272  
 Wheel pit, 478  
 Wheels, breast, 426, 450  
   horizontal, 445, 459  
   impulse, 443, 448

Wheels, overshot, 435, 449  
   reaction, 430, 453, 473  
   turbine, 453-484  
   undershot, 434, 450  
   vertical, 443, 460  
 Whirl at orifice, 71  
 Wide crests, 161  
 Williams and Hazen's formula, 304  
 Wind, 322, 328, 332, 370  
 Wire, line, 541  
 Wood conduits, 281, 297  
 Wood pipes, 263, 295  
 Work, defined, 3, 382  
   friction, 216, 276  
   motors, 433, 481  
   propulsion, 490  
   pumping, 505  
   ships, 490, 494  
   vanes, 421, 425  
   units of, 3, 18, 547

Yield of watershed, 378  
 Young man, 17, 513, 544