

---

# INDEX

---

- absolute pressure, 21
- absolute scale, 20
- absolute viscosity, 22
- absolute zero, 20
- absorber bed packing, 373
- accident, 451
- accounting, 507
- Accreditation Board for Engineering  
Technology (ABET), 32
- Act (SARA), 446, 447
- activated carbon bed, 394
- actual bed cross-section, 367
- acute exposures, 449
- adsorption tower, 365
- aerodynamic diameter, 322
- air exchange rate, 268
- algae, 522
- allowable stress, 279
- American Chemical Society, 6
- American Institute of Chemical  
Engineers, 6, 34
- amount of the uniform series, 503
- anatomy, 520
- angular speed, 355
- annual operating cost, 504
- annualized capital cost, 504
- aorta, 520, 524, 529
- Approximate Rate of Return, 505
- Archimedes' Law, 102
- arteries, 524
- artery, 520
- asbestos, 265
- astronaut pen, 551
- atmospheric pressure, 21
- atrium, 520, 529
- augmented matrix, 484
- autonomic nervous system, 521
- average velocity, 128, 316
  
- backward curved or backward  
inclined fans, 199
- bacteria, 522
- baghouse, 458
- ball valve, 220, 283
- BASIC, 483
- basic events, 458
- basophils, 523
- Batch centrifugal filters, 407
- Baume' scale, 103
- bed specific surface area, 368
- Bernoulli Equation, 79, 133, 210, 286
- Bingham plastics, 51
- Blake–Kozeny equation, 380, 383,  
387, 390
- blood, 523
- blood vessel branching, 527
- blood vessels, 520
- blowdown Makeup, 63
- body forces, 27
- bonds, 506

- boundary conditions, 11  
 Bourdon-tube pressure gauge, 244  
 Boyle's law, 110  
 brainstorming, 544  
 brake (or actual) horsepower, 292, 315  
 Break-Even Point, 505  
 Brookfield viscometer coaxial  
     viscometer, 43  
 Brownian movement, 535  
 bubbling aggregate fluidization, 392  
 Buckingham Pi Theorem, 13  
 bulk density, 367  
 buoyancy, 102  
 buoyant forces, 102, 342  
 Burke–Plummer equation, 381, 387, 393  
 bursting stress, 136  
 bushing, 222, 281  
 butterfly valve, 221, 283  
 BWG (Birmingham Wire Gauge)  
     number, 136  
 bypass, 63  
  
 C++, 483  
 cake resistance, 417  
 calming length, 139  
 capacity, 198  
 capillary, 521, 524  
 capillary rise, 23  
 capital, 508  
 capital recovery factor, 504  
 caps plugs, 281  
 cardiac muscle, 521  
 Carmen–Kozeny equation, 382  
 castor oil, 342  
 catalyst tower, 373  
 cavitation, 211, 255  
 Cell, 521  
 Celsius scale, 20  
 cement kiln, 416  
 Centrifugal compressors, 216  
 centrifugal fans, 199  
 centrifugal force, 354  
 centrifugal pumps, 207, 286, 298  
 centrifugation, 354  
 characteristic curve, 202  
 characteristic length, 535  
 Charles' Law, 110  
 check valves, 221  
 Chemical Engineering, 34  
 Chronic Exposure, 449  
 Chronotropic, 521  
 Churchill friction factor, 152  
 circular-basin, 348  
 Circulatory system, 521  
 clarification settling, 348  
 Clean Air Act, 428, 446  
 Clean Water Act, 447  
 Clot, 521  
 cold start-ups, 205  
 combustion effects, 268  
 Compensation and Liability Act  
     (CERCLA), 428, 446  
 compilers interpreters, 483  
 compliance stack test, 438  
 compound Interest, 501  
 Comprehensive Environmental Response,  
     428, 446  
 compressibility coefficient factor, 116  
 compressibility factor, 417  
 compressible cakes, 417  
 compressible flow, 167  
 compressors, 216  
 conservation of mass, 61  
 consistency number, 51  
 contact angle, 23  
 contraction, 303, 310  
 convection, 32  
 Conventional thickeners, 348  
 conversion constant/factor, 10  
 corpuscle, 521  
 cost of power, 513  
 Couette–Hatschek viscometer, 43, 45  
 Council for Environmental  
     Quality (CEQ), 428  
 coupling, 221, 281  
 creativity, 543  
 creeping Stokes flow, 124  
 creeping flow, 326  
 critical analytical thinking, 542  
 critical Reynolds number, 124, 139  
 critical velocity, 123  
 Cunningham's correction factor, 335, 535  
 cyclone, 430  
 cyclones, 354  
 cytoplasm, 521  
  
 Darcy equation, 409  
 Darcy friction factor, 135, 313

- declining balance rate, 510
- dense phase fluidization, 385
- density ratio, 342
- Department of Justice, 473
- deposit thickness, 410
- diameter, 154
- diffuser, 207
- dilatant, 50
- dilution ventilation, 266
- dimensional analysis, 12
- dimensional consistency, 9
- dimensionless numbers, 13
- direct discharger, 430
- dose-response, 450
- double-declining balance method, 511
- double-suction impeller, 207
- drag, 325
- drag coefficient, 17, 325, 342
- drag force, 326
- ductwork, 266
- duties, 471
- dynamic pressure, 212
- dynamic similarity, 17
- dynamic viscosity, 22
  
- economic analysis, 500
- eddies, 72
- education pipe, 181
- effective mixture viscosity, 350
- effective particle diameter, 368, 370
- efficiency, 79, 198
- elbow, 221, 281, 299, 308, 311
- emergency planning, 448
- empty bed cross-section, 366
- empty tower velocity, 367, 378
- endocrine system, 521
- endothelium, 521
- enthalpy, 73
- entrance length, 139
- Environmental Protection Agency (EPA), 428, 468, 473
- eosinophils, 523
- equivalent diameter, 138, 139, 292, 321
- equivalent length, 223, 226, 294
- Ergun equation, 370, 381, 389
- erythrocytes (red blood cells), 521, 523, 534
- estuaries, 430
- ethics, 471
  
- Euler number, 16, 17
- Exact Rate of Return, 506
- excess reactant, 270
- exfiltration, 268
- exhaust fan, 266
- expanded bed, 377
- expanders, 281, 290
- exposure assessment, 450
- exposure limits, 263
  
- Fabricated Equipment Cost Index, 503
- Fahrenheit scale, 20
- fan laws, 200
- Fanning friction factor, 140, 150, 151, 316
- fans and blowers, 199
- Fatal Accident Rate (FAR), 452
- Fault tree analysis, 458
- Federal Bureau of Investigation, 468
- Field equation, 79
- filter, 403
- filter bag, 432, 433
- filter medium resistance, 412
- Filter-cake, 408
- filtration, 365, 403
- fitting, 221
- fixed beds, 378
- fixed capital costs, 509
- fixed-bed catalytic reactor, 365
- Flotation, 359
- flow rates, 155, 243
- Flow regimes in porous media, 370
- flow work, 73, 76
- flow-behavior index, 51
- fluid, 19
- fluid dynamics, 19
- fluid statics, 19
- fluidity, 44
- fluidization, 377
- fluidization conditions, 390
- fluidization particle dynamics, 365
- fluidized bed height, 390
- fly-ash, 336, 338
- forced ventilation, 268
- Form friction, 72
- formaldehyde foam, 265
- FORTTRAN, 483
- forward curved fans, 199
- fractional collection efficiency, 513

- friction factor, 135
- friction loss, 134, 305, 313, 316
- Froude number, 392
- Fungi, 522
  
- galvanized iron piping, 299
- gas lifts, 181
- gate valve, 220, 282, 311
- Gauge pressure, 21
- Gauss Elimination, 485
- Gauss–Jordan Reduction, 485
- Gauss–Seidel, 489
- gc, 27, 37, 98
- geometric similiarity, 17, 291
- Gland, 521
- Globe valve, 220, 282
- globe valves straight through tee, 288
- granulocytes polymorphonuclear (PMN), 523
- gravity clarifiers, 348
- gravity filters, 404
- guardians, 473
  
- Hagen–Poiseuille, 137
- Happel's equation, 389
- hazard, 452
- Hazard identification, 450
- Hazardous Risk Assessment (HZRA), 452
- Hazen–Williams, 435
- HAZOP (Hazard and Operability) procedure, 457
- head loss problem, 155, 315
- Health Risk Assessment (HRA), 452
- heart, 521, 529
- heart attack, 526
- heat capacity at constant pressure, 74
- hemodynamics, 524
- homeostasis, 521
- honesty, 469
- hoods, 266
- hot-wire anemometer, 244
- hydraulic classification, 360
- hydraulic diameter, 126, 368, 369
- hydraulic radius, 138, 154, 369, 378
- hydrometer, 103
- hydrometer equation, 105
- hydrostatic equation, 98
- hydrostatic centrifugation equilibrium, 355
- hydrostatic pressure difference, 21
  
- ideal gas, 109
- ideal gas law, 109
- ideal power requirement, 292
- impermeable media, 365
- impulse momentum principle, 85
- incipient fluidization, 377
- incompressible, 22, 168
- increment cost, 507
- indirect discharger, 430
- indoor air quality, 264
- induced draft negative pressure fans, 205
- industrial piping, 297
- inferior vena cava, 529
- infiltration, 268
- initial conditions, 11
- inquiry, 544
- integrity, 469
- intensity of turbulence, 163
- intermediate range, 327
- interstitial velocity, 367
- intropic, 521
- inviscid, 50
- iron pipe size (IPS), 136
- isothermal flow, 171
  
- Jain Equation, 152
- JAVA, 483
  
- Kelvin, 20
- key component, 62
- kinematic viscosity, 22, 40
- Kinetic Energy, 28
- kinetic energy correction factor, 130
- Know Act, 448
  
- Lakes, 430
- laminar flow, 123, 124
- Leaf filters, 404
- left lower ventricle, 529
- left upper atrium, 530
- leukocytes, 521, 523
- leukocytes (white blood cells), 523, 534
- liabilities, 508
- limiting reactant, 270
- linear momentum, 86
- loading conveying velocity, 190
- local exhaust, 266
- loss coefficient, 223
- lymphocytes, 523

- Mach number, 17, 168  
 MacMichael viscometer, 43  
 makeup, 63  
 Manning equation, 434  
 manometers, 105  
 Martinelli correlations, 179  
 mass flow rate, 63  
 mass flux, 64  
 MathCad, 481, 483  
 Mathematica, 481, 483  
 Matlab, 481, 483  
 maximum financial return, 500  
 mean effective diameter, 368  
 mean free path, 535  
 mean hydraulic radius, 380  
 mechanical energy equation, 133  
 Meriam red oil, 303  
 mesh, 368  
 Mesopotamia, 4  
 methane, 302  
 microorganism, 522  
 minimum incipient velocity, 377  
 minimum fluidization condition, 385  
*minimum fluidization velocity*, 385  
 minimum thickness of pipe wall, 280  
 mist eliminator, 407  
 mixed-flow impellers, 207  
 molecular diffusion, 32  
 momentum, 37  
 momentum balance, 85  
 momentum flux, 40  
 monocytes, 523  
 Moody Friction Factor, 135, 150  
 Moral courage, 466  
 Moral Obligation, 468  
 multi-dimensional flow, 535  
 multirating tables, 202
- National Environmental Policy Act  
 (NEPA), 428  
 National Response Center (NRC), 447  
 natural gas, 302  
 natural ventilation, 268  
 Navier–Stokes equation, 91  
 net positive suction head (NPSH),  
 211, 307  
 neutropils, 523  
 Newtonian fluid, 39, 50  
 Newton–Raphson method, 490  
 NEWTON'S LAW OF VISCOSITY, 38  
 Newton's law range, 327  
 Newton's Method of Tangents, 491  
 Newton's second law, 27  
 no slip, 126  
 nominal pipe size (NPS), 136  
 non-circular conduits, 153  
 nonlinear algebraic equation, 490  
 non-Newtonian, 50, 51  
 nonwetting, 23  
 normal stress pressure, 27  
 Nucleoplasm, 521  
 numerical integration, 495  
 numerical methods, 481
- Occupational Health and Safety Admin  
 (OSHA), 446, 468  
 onset of fluidization, 385  
 open channel flow, 434  
 open or void bed cross-section, 367  
 open-ended problem, 541  
 operating bed height, 395  
 optimum economic pipe diameter, 298  
 orientation, 370  
 oriented beds, 370  
 orifice meter, 256, 291  
 Osborne Reynolds, 123
- packed bed, 365, 389  
 parallel pumps, 213  
 particle Reynolds number, 325  
 particle specific surface area, 368  
 Particulate concentration, 439  
 PASCAL, 483  
 Pascal fluid, 50  
 perchloroethylene, 440  
 permafrost, 549  
 permeability, 382, 384  
 permeable media, 365  
 perpetual life, 505  
 personal responsibility, 468  
 photosynthesis, 522  
 pinch valve, 220, 283  
 pipe diameter, 548  
 Pitot tube, 248, 289, 438  
 pivot row, 486  
 plasma, 522, 523  
 plate-and-frame filter, 404, 413, 414  
 platelets, 523, 534

- plug valve, 220
- plugs, 222
- pneumatic conveyors, 188
- point of operation, 202
- porosity, 366
- porous cake, 403
- porous media, 365
- porous medium friction factor, 393
- positive displacement pumps, 206
- potential energy, 29
- potential head, 98
- pound-force, 27
- power, 198, 317
- power law equation, 51
- power plant, 317
- precapillary sphincters, 522
- present net worth, 504
- present worth, 502
- pressure, 21
- pressure head, 98
- primary dimensions, 13
- prime movers, 197
- procedure-oriented language, 482
- processing plant, 299
- profit, 508
- protoplasm, 522
- protozoan, 522
- pseudoplastic, 50
- pulse, 522
- pulse-jet fabric filter, 432
- pump requirement, 308
- pump-motor efficiency, 209
- pumps, 206
- purge, 63
  
- quantification hazard analysis, 458
- questioning, 545
  
- radial fans, 199
- radial tip-forward curved heel, 200
- radiation, 32
- Rankine, 20
- rate of deformation, 126
- rate of momentum, 37, 38
- real gas, 111, 116
- reciprocating compressors, 216
- reciprocating pumps, 206
- recovered material, 513
- recycle, 63
  
- red blood cells, 523
- Redlich–Kwong (R–K) equation, 117, 118
- reducer, 222, 281
- relative roughness, 150
- relative velocity, 325
- reservoir, 299, 305
- resistance coefficient, 223
- Resource Conservation and Recovery Act (RCRA), 428, 446
- return bend, 311
- Reynolds number, 16, 124, 316, 285, 292
- rheograms, 127
- rheology, 49
- rheopectic, 51
- right lower ventricle, 530
- right upper atrium, 529
- rights ethics, 471
- risk, 448, 449, 452
- risk assessment, 449
- risk characterization, 450
- risk management, 449
- rivers, 430
- Roman Empire, 4
- rotameter, 244
- rotary compressors, 216
- rotary pump, 206
- rotary vacuum filters, 404
- roughness, 150, 315, 370
  
- Safe Drinking Water Act, 428, 438
- Saybolt viscometer, 43
- scale-up scale-down, 17
- schedule number, 279
- screen mesh, 323, 324, 368
- screw conveyor, 188
- Section 7003, 447
- sedimentation, 348
- settling velocities, 360
- shaft work, 77, 79
- shear rate, 126
- shear stress, 19, 27, 39, 40
- simple interest, 501
- Simpson's Rule, 496
- simultaneous linear and nonlinear equations, 484
- sinking fund deposit factor, 503
- sinking fund method, 503, 515
- sizing, 155

- skin friction, 72  
 slip, 535  
 slurry filtering medium, 403  
 smooth fluidization, 391  
 Society of Chemical Engineers, 4  
 solid fraction, 366  
 sonic flow, 167  
 specific cake resistance, 412, 417  
 specific gravity, 22  
 specific surface, 379  
 specific volume, 117  
 speed of sound, 168  
 stack effects, 268  
 stagnation point, 289, 303  
 standard conditions, 112  
 standard screen mesh size, 367  
 static pressure, 71, 303  
 stem cells, 522  
 Stokes' law, 326  
 stop valves, 220  
 storage tank, 308  
 Stormer viscometer, 43  
 STP, 112  
 straight blade fans, 199  
 straight through tee, 288  
 straight-vane single-suction closed  
   impeller, 207  
 stress, 27  
 sublimation, 22  
 success, 455  
 sudden contraction, 222, 225  
 sudden expansion, 222, 224  
 sum of the year's, 511  
 superficial velocity, 367, 378  
 Superfund, 447  
 Superfund Amendments and  
   Reauthorization, 446, 447  
 superior vena cava, 529  
 surface forces, 27  
 surface tension, 23  
 system, 267  
  
 Tees, 221, 281  
 Temperature, 20  
 terminal settling velocity, 333, 342  
 terminal velocity, 350  
 The Art of Problem Definition, 543  
 Theodore–Reynolds equation, 458  
 theoretical power, 299  
  
 thermodynamics, 72  
 thixotropic, 51  
 threshold limit value (TLV), 269  
 throat, 252  
 time rate of shear, 126  
 Title III, 448  
 top event, 458  
 total annualized cost, 504  
 total capital cost, 504  
 toxicity, 449  
 toxicity assessment, 450  
 trapezoidal rule, 495  
 transition length, 139  
 trial-and-error calculation, 155  
 triangle form, 485  
 turbine, 305  
 turbulent flow, 123, 147  
 Tyler U.S. Standard Screen Scales,  
   324, 368  
  
 ultimate density, 367  
 uniform annual payment, 503, 515  
 union, 221  
 Unit Operations, 6, 31  
 units, 9  
 universal gas constant, 111  
 utilitarianism, 471  
  
 valves, 219, 308  
 Van der Waals' equation, 119  
 vane anemometer, 244  
 vapor pressure, 21  
 vein, 522  
 velocity gradient, 40, 126  
 velocity pressure, 71  
 velocity profile, 42, 131  
 ventricle, 522  
 Venturi discharge coefficient, 254  
 Venturi formula, 254  
 Venturi meter, 252  
 Venturi scrubbers, 216  
 virial equation, 117, 118  
 virtue, 471  
 viruses, 522  
 viscosity, 22, 39, 40  
 viscous flow, 123  
 Visual Basic NET, 483  
 void fraction, 366, 379, 410  
 void fraction wetted surface, 379

void volume, 366, 410  
volume fraction, 350  
volumetric efficiency, 206  
volumetric flow rate,  $q$ , 128  
volute, 207

wall effects, 535  
water softener unit, 382  
wetted perimeter, 154  
wetted surface, 379

wetting, 23  
white blood cells, 523  
wind effects, 268  
working capital costs, 510

Y, 222  
yeast, 522  
yield stress, 51

zero porosity bed height, 395