

[ 561 ]

## INDEX

*Heavy type denotes a definition*

- Absolute magnitude, 416  
 Acceleration, 41, 42, 346, 406, 407, 427, 557, 560  
 Action, indication of thought, 22–24, 192–194; and reaction, 41, 50, 560  
 Addition, definition of, **278**; and error, 438, 439; and equality, 280, 289, 442, 443; of forces, 559; of fractions, 313–315; law of, first, 280–282; law of, second, 283–290, 322–327; physical, 277–289, 347; of times, 420, 421, 550  
 Aerodynamics, 423, 424, 430  
 Aether, 5, 155, 261  
 Agreement, method of, **94**–104; universal, 20–37, 215–218, 257, 303  
 Ampère's Law, 385  
 Analogy, in theories, 128–135, 141–144, 150, 157  
 Appearance and reality, 251–254  
 Archimedes, 18  
 Arguments (mathematical), 376  
 Aristotle, 52, 155  
 Art and science, 226–229  
 Assent, *see* Agreement  
 Association, uniform, *see* Uniform association  
 Astronomy, 31, 226  
  
 Bach, J. S., 227  
 Balance, perfect, 284, 285  
 Ball, R., 226  
 Bayes' Formula, 187–192, 200  
 Beauty, not measurable, 268  
 Bergson, H., 33  
 Berkeley, G., 19, 20  
 Between, **553**  
 Biochemistry, 33  
 Biot's Law, 147  
 Bodies, individual, 81–85, 87; solid, 79, 554  
 Bohr, N., 434  
 Börnstein, R., 8  
 Boswell, J., 20  
 Boyle's Law, 126, 127, 131, 134, 135, 146, 223, 433  
 Bragg, W. H., 44  
 Brinell test, 271  
 Brownian motion, 137, 139  
  
 Candle, standard, 379  
 Causation, Law of, 90–94, 108, 186  
 Cause, and effect, 57–67, 71, 72, 84, 101, 186; and experiments, 60–62, 65; indirect, 117; and Induction, 89–104; and logical deduction, 235, 236; particular, 97, 103, 104; plurality of, 75, 97, 98, 108; probability of, 185–192; psychological, 63–65, 140; temporal, 59, 60, 67; theoretical, 139; and volition, 241  
 Cavendish, 27  
  
 Chance (*see also* Probability), 86, 112, 155, 161–214; and error, 485, 487; and ignorance, 162–164; subjective and objective, 162, 163, 201, 207; theory of, 164, 200–214  
 Charge, electric, dimensions of, 383–385  
 Chemistry, 28, 33, 115, 225, 226; physical, 6  
 Circumstances, **94**  
 Coincidence, 162, 197–199, 200, 208, 209, 500, 501; numerical, 431, 433  
 Collection, complete, **460**–485; incomplete, 485–515  
 Colour, 25, 26, 28, 35; -blindness, 24; measurement of, 272, 273  
 Concepts, **44**–55, 78, 84, 118; fundamental, 106–107, 216; and hypothetical ideas, 124, 125, 141, 142; number of, 105; and reality, 174, 244, 245  
 Condition, equation of, **463**, 464, 486  
 Conditions, qualifying, **74**  
 Conductivity, electrical, 293, 294; thermal, 135, 136, 141–144  
 Conservatism, 260  
 Conservative system, 133  
 Constant, arbitrary, 530; and derived magnitudes, 342–346, 359, 360, 363–366; dielectric, 383–385, 431, 432; formal, **367**–369, 375, 376, 406, 415; and numerical law, 340–346; undetermined, 4, 409, 422, 425, 427–429; universal, 346, 387, 395, 396, 423, 425, 426, 433, 434  
 Continuity, 157, 158, 538–549; essential, 541–545  
 Coulomb's Law, 384, 385  
 Counting, 296–299  
 Criticism, 1–12  
 Current, electric, 53, 73, 74  
  
 Deduction, 9, 235, 236  
 Defining properties, 47–49  
 Definition, 46–57  
 Density, discontinuous, 543; measurement of, 275–277, 342–345, 382, 397–399; unit of, 380–382  
 Derivative, and continuity, 548; physical, 531–538  
 Derived magnitude, 276, 342–348; adjustment of, 504–515; and constants, 363–367; and dimensions, 371–376; discontinuity of, 543; unit of, 370–373  
 Determinism, 87  
 Dictionary (of theory), **122**–158, 530–531  
 Difference, method of, **94**–104  
 Dimensions, **372**–376 (*see also* Similarity, physical); and aerodynamics, 423, 430, 431; argument from, 4, **404**–436; and basic magnitudes, 422–427; and graphs, 434–436; and defined magnitudes, 376; meaning of, 389–393; of number, 301,

c.

36

- 374; simplicity of, 4, 373; uses of, 429–431; zero, 373–376  
 Dispersion, optical, 537  
 Dulong and Petit's Law (radiation), 153  
 Dynamical similarity, *see* Similarity, physical  
 Dynamics, 41, 42, 50, 78, 79, 118, 128, 156, 560; Newtonian, 148, 149
- Economy of thought, 222–229  
 Education, 4, 225, 226  
 Effects, intermixture of, 75, 97, 98, 108  
 Einstein, A., 4  
 Electromagnetic Field, 146–148  
 Empirical laws, 153, 154, 219, 348, 349, 354, 359, 360  
 Equality, **273**; and addition, 288, 289, 442, 443; and error, 442–449; laws of, 278; numerical and physical, 329–335  
 Equations, normal, 491  
 Errors (of measurement), 437–521; and addition, 438–439; and adjustment of observations, 486–487; and arithmetic mean, 469–473, 510–515; complete collections of, 459, 460; consequences of, 440–442; of consistency, **440**, 459–518; of derived magnitudes, 504–515; and equality, 442–445; and equation of condition, 462–468, 486; and fractions, 313; “huge,” 501; instrumental, 446; law of, 447–449, 452, 477–484; Gauss' law, 194, 481–484, 490, 492, 493, 498–499, 501, 503, 506, 510–512, 520; maximum, **448**, 478–480, 517–518; of method, 440–456, 477–481; and number, 455, 456; in numerical laws, 515–518; partial, **475**, 484; probable, 497–504, 518; probability of (*see* Probability); and residuals, 491, 495, 504–506; surveyors, 464, 494, 496–497; systematic, 440, 471–473; theory of, 445–452, 473–477; and true values, 462–464, 466; zero sum of, 511–518  
 Euclid, 554  
 Events, **550**; alternative, 168, 175, 177, 178, 180, 190, 195; independent, 181–183, 201, 204, 209, 210  
 Evolution, 222, 232, 233  
 Exchange, 113, 114  
 Existence (*see also* Reality), 11, 16, 54, 243, 244, 247  
 Experiments, 96–106, 542  
 Explanation, 113–118, 216–218; theoretical, 124, 133, 146–149; of science, 232, 233; ultimate, 239–243  
 Explosion, 99–104  
 External world (*see* Material world or “Other people”)  
 Extrapolation, 145, 356–358
- Facts, 57, 89–103, **101**, **260**; separation of, 95–98  
 Falling body, law of, 66, 147, 330, 368, 419  
 Faraday, 155, 161  
 Faraday's constant law, 382, 543  
 Fit, **297**  
 Force, 41–43, 65, 383; independence of, 41, 118; static and dynamic, 559, 560  
 Fourier's theory of heat, 140–145  
 Fractions, addition of, 313–315; decimal, 315–317; definition of, 310, 311; and number, 317–319  
 Free will, 205  
 Frequency and probability, 167–176  
 Functions, 72, 106, 124; analytic, **355**, 467, 481, 484; continuous, **539**, 545–548
- Galileo, 155, 221, 346, 558  
 Gases, laws of, 115, 117, 536 (*see also* Boyle's Law, Gay-Lussac's Law); theory of, dynamical, 126–140, 234  
 Gauss, C. F., 467 (*see also* Error, Gauss' law)  
 Gay-Lussac's Law, 126, 127, 131, 134, 135, 146, 223  
 Geiger, H., 44  
 Generalisation, in theory, 143, 144, 146  
 Generality, **69**, 81–83, 116, 117  
 Geology, 33, 226, 553  
 Geometry, 554–557  
 Geophysics, 33  
 Giotto, B., 227  
 God, 39, 64, 85, 155, 232, 233–235, 239, 241  
 Graphs, 350–352, 434–436, 532, 533; smooth, 355, 356  
 Gravitation, 120, 148, 149, 222, 560  
 Greater than, **273**
- $h$  (Gauss), **490**  
 $h$  (Planck), **434**  
 Hamilton, W., 57  
 Hardness, 4, 271, 272, 283, 345  
 Heat, conduction of, 141–144; quantity of, 287, 288  
 Hertz, H., 147, 148, 227  
 Heuristic method, 225  
 Hooke's Law, 40–42, 50, 60–64, 73, 77, 78, 79, 81  
 Huxley, T. H., 221  
 Hypothesis, -tical, **122**–158; changes in, 133; ideas, reality of, 245  
 Hysteresis, 373
- I, 246–248, 259  
 Idealism, 242  
 Identification, 31  
 Illusions, 251, 252, 254  
 Impenetrability, 31  
 Imposture, 23, 192, 193  
 Individuality, 81–85, 104  
 Individuals, 297–299  
 Induction, 9, 88–112, 354; causes of, 89–104, 111  
 Infinite, -y, 170, 171, 172, 175, 176  
 Initial values, 136  
 Instances, **94**–103  
 Integration, 420, 530  
 Interpolation, 145, 356–358  
 Invariability, 58, 69, 71, 90, 551  
 Iron, 43, 44  
 Isomers and isotopes, 49, 75, 226  
 Isoperiodic, **550**
- Jerk, **42**  
 Jevons, W., 57  
 Johnson, S., 19, 20  
 Judgement, fundamental, 17, 151, 216; internal and external, 19–24, 167, 302, 303; scientific, 20

## INDEX

563

- Kant, I., 105, 393  
 Kaye, G. W. C., 105, 393  
 Kelvin, Lord, 7, 8, 261  
 Kepler's Law, 149  
 Kleeman, R., 44  
 Knowledge, degree of, 188–199, 209, 500
- Laby, T. H., 105, 393  
 Lamb, H., 231  
 Landolt, H., 7  
 Laplace, P. S., 122, 155  
 Laws, 38–87 (for Law, A's, *see* A's Law); and chance, 161–164; complexity of, 39, 43; compound, 118; definition of, 38, 39, 68–71; empirical, 153, 154, 219; equivalent, 26, 117; evidence for, 109–112 (*see also* Induction); explanation of, 112–118; expression of, 45–55; fundamental, 79–81, 106–107, 153–155; of God, 39, 64; importance of, 67–71; interconnection of, 49, 50; meaning of, 132; of Nature, 57, 64, 161; numerical, *see* Numerical laws; proof of, 104–112, 154, 173, 210–214; subsidiary, 78, 79; and theories, 83, 87, 105, 109, 130–132, 222–224, 552, 556, 558, 560; unrecognised, 43–45, 68; use of, 117  
 Least Squares, Method of, 491–509  
 Leverrier, U. J. J., 227  
 Light, theory of, 146–148  
 Literature, 225, 228  
 Locke, J., 31  
 Logic, 3, 23, 50–53, 129, 138; and causal relation, 234–236
- Mach, E., 7, 140, 152, 222–224  
 Magnitude, absolute, 416; basic, **378**–393, 422–427; continuous, 541–549; defined, 177, 376, 377, 537; derived, 276, 347–348, 534–538; fractional, 310–319; fundamental, 41, 277–289, 347, 348; negative, 319–321; no-dimensional, 373–376, 407–415, 423, 432, 433; quasi-derived, 379–**382**, 383, 426; relations between, 331–335; real, **444**–454, 486, 516–518, 539–541; true, **462**–464, 468–471, 486, 495  
 Mass, 30, 41, 42; negative, 5, 319, 320; and weight, 378, 379  
 Material world, 16, 19, 22, 23, 303  
 Materialism, 242  
 Mathematical continuity, **534**; tables, 526–529; theories, 141–144, 529–531  
 Mathematics and measurement, 523–525; and numerical laws, 335–338, 524–531; and physics, 8, 15, 23, 151, 305, 523–549  
 Maxwell, J. C., 147, 227, 228, 431, 433  
 Mean, **477**; arithmetic, 469–473, 510–515  
 Meaning, 132, **219**–229; and reality, 250  
 Measurable properties, 268  
 Measurement, arbitrary, 274, 275, 358–360; characteristic of physics, 5, 33; fundamental, 267–295; and Number, 447, 524–525; object of, 464–466; principles of, 6, 79, 267–289; standard series in, **280**, 440–442, 449–454, 518–521; theory of, 290–294, 321–327; unique, 321–327  
 Mechanism, 227, 242  
 Metaphysics, 9, 10, 11, 12, 15, 16, 155, 156, 243, 264
- Mill, J. S., 57–67, 70, 84, 89, 94, 97, 98, 116, 117, 118  
 Millikan, R., 465  
 Miracles, 64  
 Mohs' scale of hardness, 4, 271, 272, 283, 358, 397, 399, 400  
 Molecule, 131–139; reality of, 130, 234  
 Monsoon, 110  
 Motion, 10, 155–157, 557–559  
 Multiplication, 305–309; of probabilities, 177–181
- “Nearly,” 169, 170, 439, 459  
 Nebular hypothesis, 122  
 Negative magnitudes, 319–321  
 Newton, I., 18, 148, 155–157, 170, 227, 228, 379, 552, 560  
 Noah, 44  
 number, **269**, 295–301; and counting, 296, 297; dimensions of, 374; and error, 455, 456; fractional, 317–319; -judgements, 29–32, 36; and Number, 303–305; and numerals, 268, 301–303; unit of, 299–301, 374  
 Number, **269**, 295; fractional, 314, 315; irrational, 313, 554, 555; order of, 269, 270; physical significance of, 335–338, 353, 516, 524–528; and real magnitudes, 447  
 Numerals, **268**, 295 (*see also* number and Number); order of, 301–303, 311–313, 315, 316  
 Numerical laws, constants in, 340–346; and derived magnitudes, 342–346; empirical, 348–350, 353, 359, 360; and error, 515–518; form of, 338–341, 363, 364, 406; and graphs, 350–352, 524; interpolation in, 356–358; numerical relations in, 331–335; physical relations in, 329–331; proof of, 352–356, 515–518, 525–529; and theories, 144–146, 335–338, 516–518, 523–529; and true values, 462–464; use of, 330, 526, 527
- Observations, adjustment of (*see also* Errors), **486**–487  
 Ohm's Law, 43, 59–64, 71–73, 217, 223, 345, 377, 393  
 Opinions, 259, 260  
 Optics, 26, 35, 40, 78, 79  
 Order, 269, 270, 343–346  
 “Other people,” 22, 34–37, 246
- Parallelogram law, 10, 557  
 Pendulum, 405–407, 415, 420–422, 435, 436, 550  
 Period, **550**  
 Personality (*see also* Voluntary action), 20, 63–65  
 Phenomenal, 153–155, 158  
 Phenomenon, **94**  
 Physical properties, 30, 31; similarity (*see* Similarity, physical)  
 Physics and other sciences, 5, 32–34, 267  
 Planck, M., 395, 396  
 Planets, 85, 86  
 Poincaré, H., 4, 7, 166, 202, 206, 222, 543, 553  
 Point, **556**

- Politics, 259, 260  
 Predicate, 53  
 Prediction, 69  
 Probability, *a priori*, 190, 191, 490, 491, 493; addition of, 176, 177; Bayes' formula for, 187–191; and "cases," 165, 177, 183, 184; of causes, 185–192, 489; in complete collections, 459, 460; as defined magnitude, 177; equal, 165–168, 168–174; and error, 460, 477, 485, 487–491, 497–502, 509–511; experimental, 166–168, 172–174; and frequency, 168–176; general, 174; independent, 181–183; infinitesimal, 175, 176; multiplication of, 177–181  
 Processes, 65–67  
 Properties, defining, 47–49; measurable, 268; physical, 30, 31  
 Psychology, 17  
 Qualities and quantities, 283, 347; primary and secondary, 31  
 Radiation, laws of, 153  
 Radioactivity, law of, 535, 536, 547  
 Random, 204–207  
 Rayleigh, Lord, 414, 424  
 Rays, ionising, 44, 286  
 Real, -ity, 11, 156, 234; and appearance, 251, 254; and concepts, 174, 244, 245; metaphysical, 243, 244, 253–256; scientific, 244, 253; and theories, 139, 203, 245, 246, 249, 250; and truth, 245, 252  
 Refractive index, 543  
 Relation, converse, 273; field of, 273; symmetrical, 74, 116, 270, 330, 331; transitive, 76, 77, 270  
 Relativity, 4, 157, 557–559  
 Repetition, as proof of laws, 109–112  
 Residuals, 491, 495  
 Resistance, electrical, 43, 123, 124, 293, 294, 345, 346  
 Resonator, 417, 418, 423–426  
 Röntgen, W. C., 147  
 Routines, 16, 90, 91, 93–103, 109  
 Rowland, H., 147  
 Russell, B., 9, 258, 269  
 Satisfaction, intellectual, 68, 69, 118, 198, 216–218  
 Satisfactory measurement, 281  
 Scale, 413, 435  
 Schweidler, E., 547  
 Science, and art, 227, 229; and daily life, 18, 21, 115; and education, 4, 225, 226; explanation of, 232, 233; and imagination, 224, 226; meaning of, 215–229; object of, 1–3, 68; possibility of, 231, 232; subject-matter of, 15–37, 238, 239; truth of, 218, 219; value of, 68, 69, 215–229  
 Sensations, 16; abnormal, 24–29, 35  
 Series, standard, 280, 440–442, 449–454, 518–521; stepped, 454, 480, 517, 539–549  
 Shakespeare, W., 227  
 Shape, dimensions of, 386–388, 425  
 Silver, 43–46, 48, 50, 51, 53–55, 59, 72, 73, 81, 85, 86, 110, 111, 116  
 Similarity, physical, 409–420  
 Similitude, principle of, 417–421  
 Simplicity, 19, 118, 144, 157, 217, 219  
 Smell, 28  
 Sound, 25  
 Space, 9, 10, 33, 54, 80, 432, 553–557; Euclidean, 4, 454; -judgements, 29–31, 36, 553; occupation of, 555–557; reality of, 249  
 Specific heat, 287, 288  
 Stallo, J. B., 140  
 Stefan's Law, 153  
 Steinmetz' Law, 373  
 Step, in measurement, 454, 461, 480, 517, 539–549  
 Straight line, 350, 351, 353, 554  
 Subject and predicate, 53  
 Substance, 71, 75, 80, 82, 106, 286  
 Surprise, 195–199  
 Syllogism, 51, 77, 235, 236  
 Systems, individual, 81–85, 104; properties of, 83, 418  
 Tait, P. G., 7  
 Taste, 28  
 Temperature, centigrade, 4, 396–402; dimensions of, 377, 396–402; and electrical resistance, 123, 124; and energy, 129, 433, 434; measurement of, 359, 396–402; unit of, 127  
 Theology, 156, 161, 221  
 Theory, 6, 115–158; atomic, 455, 544; and causes, 139; of chance, 201–214; definition of, 122, 149, 150; dictionary of, 122–125; development of, 132–137; discontinuous, 157, 544; example of, formal, 123; explanation by, 116, 117, 146–149; of force, 560; Faraday's, 147; Fourier's, 140–145, 147; of gases, 126–137; and laws, 83, 87, 105, 109, 130–132, 218, 220, 222; mathematical, 140, 149–158, 529–531, 538; Maxwell's, 147, 148; mechanical, 140, 154–158; meaning of, 132, 235–237, 249, 250; of measurement, 445–452; and numerical laws, 144–146, 335–338, 516–518, 523–529; philosophical, 233–235; and practice, 120, 121; and reality, 139, 234, 245, 246; of space, 556, 557; of time, 552, 553; truth of, 152, 158, 237, 249, 250; value of, 132, 149–158, 222–224  
 Time, 9, 10, 33, 54, 66, 80, 136, 550–553; addition of, 420, 421, 550; as independent variable, 125, 552; -interval, 65, 553; -judgement, 29–32, 36; measurement of, 391, 550, 551; reality of, 12, 249; and uniformity, 111, 112, 552; unit of, 5, 550  
 Trial, 168–172, 202, 211, 213  
 Tristram Shandy, 69  
 True values, 462–464  
 Truth, 218, 219, 256–264  
 Tubal-Cain, 44  
 Uniform, -ity, 40, 58, 70, 89, 90, 107–112, 132  
 Uniform association, 39, 71–87, 109; and causal relation, 90; duality of, 72, 74; and equality, 331; symmetrical, 74–76, 81–83, 104, 116, 117; transitive, 76–79

## INDEX

565

- Unit, basic, 30, 393, 396; change of, 299–301, 363–367; choice of, 280, 290, 291, 299–301, 361–363; derived, 382, 383; of derived magnitude, 370–373; and dimensions, 371–373; electrical, 383–385, 394; and fractions, 314; fundamental (*see* basic); of fundamental magnitude, 361–363; and multiplication, 308–309; natural, 395, 396; permanence of, 362; of number, 299–301, 374; practical, 363, 393, 394; of time, 5, 530; of volume, 380–382
- Universe, 416–419
- Valency, 225
- Variable, 123, 541; independent, 125, 552
- Velocity, 535–537
- Viscosity, 134–136, 423
- Volume, dimensions of, 379–382, 385–388, 423–426; measurement of, 387, 461, 555; unit of, 380–382
- Voluntary action, 63–65, 84, 87, 156, 204, 205, 211, 212, 241
- Watts, W., 28
- Weight and mass, 30, 378, 379; measurement of, 277–280; negative, 5, 319, 320; of observations, 502–504
- Whewell, W., 57
- Wiechert, E., 11
- Winkelmann, A., 2
- Words, 51, 138
- Young's Modulus, 43
- Zero, 321, 364