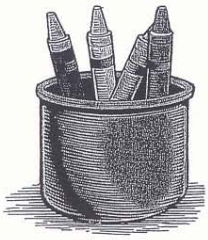
REFERENCE MANUAL

Tables of Physical & Chemical constants,
Mathematical functions, and useful information



Ross Nazir Ullah

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PREFACE

The vast field of Science today demands some reference book to be familiar with some notations not included in the prescribed Science text books. This book is specially prepared for F.Sc. and B.Sc. Physics students and teachers. I have included only those references and informations which we met across during the study of text books.

Some informations and references are included being interesting and informative. Major portion of this book is taken from my personal collection. It is hoped that it will be useful for science teachers and students. Comments and suggestions for further improvements will be accepted with gratitude.

Govt. College, Shakargarh.
January, 1992.

ROSS NAZIR ULLAH

Contents

TIME SCALE

A-bomb - 1945
aircraft - 1903
air, milatary - 1908
air, air force - 1913
Alchemy - 1000
Alphabet - 3800 B.C.
antibiotics - 1940
antimatter- (discovered) -1932
Apollow (moon flights) -- 1969
atomic nucleus(discovered) – 1911
automobile - 1885
ballistic missiles - 1944
biology(modern) -- 1953
blood circulation(discovered) -- 1628
bomber warfare - 1936
cholera epidemics - 1817
clock work(escapement) - 725
communications-satellite -- 1965
compass(navigational) - 1115
computer - 1943
DNA-structure(discovered) -- 1953
electrical energy - 1881
electromagnetism(theory) -- 1864
fertilizers, chemical - 1913
fibres(wholly synthetic) -- 1936
fossil-energy revolution - 1825
gas(natural) - 1821
gene structure - 1953
Geology (modern) - 1967
germ theory of disease - 1863
glass(man-made)-1400 B.C.
Gravity, Law of - 1687
Great wall of China -- 214 B.C.
Gun power - 1356
H- bomb - 1953
holograms - 1963
influenza - 1564
Lazer - 1960
machine gun warfare -- 1898
magnetic compass- 1115
Manned
spaceflight - 1961
Mars landers(Viking 1 & 2) – 1976
measles - 162 A.D.
meson theory - 1934
micro processor – 1971
microscope – 1660
missiles - 1943
modern Science
formulized – 1662
moon landings - 1969
motion pictures -- 1895
neutron discovered-1932
Nuclear energy – 1942
outer-planets mission
(Voyager 1 & 2) – 1977
paper – 100 A.D.
phonograph – 1877
Physics -- 1604
Plastics -- 1910
Quantum mechanics – 1926
radar – 1939
radio – 1901
radioactivity - 1896
rail roads – 1825
relativity – 1905
Renaissance – 1500
rockets – 1926
rubber – 1872
satellite, man-made – 1957
small pox epidemics – 251
sound recording – 1901
spacecraft – 1957
sputnik – 1957
street cars -- 1881
submarines – 1914
synthic dyes – 1865
telegraph – 1844
telephone – 1878
telescope – 1609
television boom – 1950
transistor - 1948
typewriter - 1867
vaccination -- 1796
vitamins – 1912
windmills -- 600
writing – 3500 B.C.
x-rays discovered – 1895
yellow fever – 1648
zero ("Arabic") - 683

Energy Sources(Time Scale)

Human muscle: Prehistoric
Fire wood : Prehistoric
Lamps : Prehistoric
Solar energy : Prehistoric
Wind energy: estimated 4000 B.C.
Animal muscle : 4000 B.C.
Natural gas : 900 B.C.
Water energy : 30 B.C.
Coal : 1 B.C.
Wind Mill : 600 A.D.
Explosive : 900 A.D.
Steam energy : 1712 A.D.
Coal gas (town gas) : 1792
Fossil-energy revolution : 1825
Petroleum industry : 1857
Electrical energy : 1881
Internal combustion
engine (for automobile etc.) : 1885
Nuclear energy : 1942
Lasers : 1960
Costly energy (oil from different
offshore sources) : 1973

Information Technology(Time Scale)

Maps & diagrams:
2400 B.C. (Mesopotamia)
seals : 2700 B.C. (Mesopotamia)
envelopes : 3600 B.C.(Mesopotamia)
writing : 3500 B.C. (Mesopotamia)
Egyptian hicroglyphics : 3000 B.C.
alphabet : 1800 B.C. (Sinai)
Chinese writing : 1500 B.C.
(Shang)
coins : 600 B.C. (Anatolia)
paper : 100 A.D. (China)
modern numerals : 680 (Southeastern
Asia)
priting : 700 (China)
paper money : 910 (China)
printing press : 1455 (Germany)
photography : 1839 (France)
electric telegraph : esp. 1844
S. Morse (U.S.)
telephone : 1878 (U.S.)
punched-card data processing :
esp. 1890 (U.S.)
sound recording : esp.1901 (U.S.)
radio : esp. 1901 (Italy)
electronics : 1906 (U.S.)
radio broadcasting boom :1922
(Worldwide)
computer : 1943 (Britain)
television boom : esp. 1950 (U.S.)
holography : esp. 1963 (U.S.)
communications satellite:esp.1965(U.S.)
microprocessor : 1971 (U.S.)
optical-fiber links:1980(various
countries)

Roster of Names

Thales (640? to 546 B.C.)
Greak philosopher. Recognized certain aspects of static electricity.

Pythagoras of Samos (580 to 500 B.C.)
Founder of the Pythagorean school of philosophers. Investigate Pythagorean theorem of geometry.

Democritus (about 470 B.C. to 370 B.C.)
Probably the greatest Greek physical philosopher; explained origin of world by eternal motion of infinite number of invisible and indivisible bodies, atoms.

Plato (427 to 347 B.C.)
One of the greatest of the Greak philosophers.

Aristotle (384 to 322 B.C.)
Greak philosopher; "....one of the greatest thinkers and scientific investigator the world has ever seen ...."; logic, ethics, metaphysics, psychology, zoology, astronomy. Written the first textbook in Physics.

Archimedes (287 to 212 B.C.)
Greak philosopher; from the Alexandrian school; Physics and geometry; Archimedes' principle.

Claudius Ptolemy (C. A.D. 90 to 168)
Egyption astromer, geographer, and mathematician; believed the earth was fixed center of solar system with stars and planets revolving about it.

Alhozen (965 to 1038)
Muslim scientist. Discovered the laws of reflection.

Averroes (1125 to 1198)
Islamic philosopher.

Fanciscan Roger Bacon (1214 to 1294)
Experimental scientist. Taught that belief should be based on observation and experimentation rather than on authority.

Leonardo da Vinci (1452 to 1519)
Great accomplishments in practically every field of the arts and science.

Nicolaus Copernicus (1473 to 1543)
Polish astromer; Copernican theory of solar system as accepted today.

Tycho Brahe (1546 to 1601)
Great observer.

Francis Bacon (1561 to 1626)
English statesman, philosopher, and essayest; theories on nature of light.

Galileo Galilei (1564 to 1642)
Italian astronomer; falling bodies; the laws of the pendulum; accelerated motion; the "leaning tower" experiment.

Johannes Kepler (1571 to 1630)
German mathematician and astronomer; explained tides are caused by the moon's attraction; noted mostly for his three laws of planetary motion.

Willebrord Snell (1591 to 1628)
A Dutch scientist; Snell's law.

Evangelista Torricelli (1608 to 1647)
A pupil of Galileo.

Blaise Pascal (1623 to 1662)
Son of Etienne Pascal. French mathematician and philosopher; investigations mostly in hydro-dynamics; discovered relationship between altitude and height of mercury column; Pascal's principle in fluids.

Robert Boyle (1627 to 1691)
British physicist and chemist; Boyle's law in 1662.

Christian Huygens (1629 to 1695)
Dutch physicist and mathematician; supported wave theory of light as opposed to Newton's corpuscular theory; proposed Huygen's principle of wave propagation.

Robert Hook (1634 to 1703)
English chemist and physicist; may have invented balance spring in watches; Hooke's law of elasticity.

Sir Isaac Newton (1642 to 1727)
English mathematician and physicist; noted, among many other things, for the three laws of motion, the law of Universal gravitation, and his ideas concerning the nature of light propagation; believed in the corpuscular theory as opposed to the wave theory.

Edmund Halley (1656 to 1742)
English astronomer and mathematician; in 1682 discovered comet named after him; predicted its return in 1759; published first map of winds on earth's surface.

Brook Taylor (1685 to 1731)
English jurist and mathematician.

Gabriel Daniel Fahrenheit (1686 to 1736)
German physicist; the Fahrenheit scale of temperature.

Daniel Bernoulli (1700 to 1782)
Swiss physicist; Bernoulli's theorem; worked in hydrodynamics and gas theory.

Lagrange (1736 to 1813)
Worked in theoretical mechanics.

Henry Cavendish (1731 to 1810)
Eccentric aristocrat, a millionaire; British chemist; determined value of G, gravitational constant; computed density of the earth; a superb experimenter.

Charles A. Coulomb (1736 to 1806)
French scientist and inventor; Coulomb's law of force between magnetic poles and between electric charges; the Coulomb named after him.

James Watt (1736 to 1819)
Scottish engineer; investigations in heat, primarily heat engines; the Watt is named after him.

Count Alessandro Volta (1745 to 1827)
Italian physicist; investigations in current electricity; discovered decomposition of water by electricity; the volt named in his honour.

John Dalton (1766 to 1844)
English chemist and physicist; noted chiefly for his views on atomic theory; his research related to gases, elasticity of vapours, and effect of heat in gases.

Thomas Young (1733 to 1829)
English physicist and physician; noted for discoveries in light; advocate of wave theory of light; Young's experiment in interference established our idea that light travels as a wave motion.

Malus (1775 to 1812)
Discovered the phenomenon of polarization of light by reflection.

Marie Andre Ampere (1775 to 1836)
French physicist and mathematician; investigations in electricity and magnetism; ampere named after him.

Karl Friedrick Gauss (1777 to 1855)
German mathematician; studies in electricity and magnetism; the gauss named in his honour.

Hans Christian Oersted (1777 to 1851)
Danish chemist and physicist; investigations on the magnetic effects of currents; sometimes regarded as father of electromagnetism; unit of magnetic field intensity, the oersted, named after him.

Sir Humphrey Davy (1778 to 1828)
English chemist; experiments in heat (ice experiment); the Carbon arc and the safety lamp.

William Prout (1785 to 1850)
English physician and chemist. First to suggest (1816) the hypothesis that all atomic weights are multiples of that of hydrogen, and that hydrogen is the fundamental element of which all others are composed.

George Simon Ohm (1787 to 1824)
German physicist; noted primarily for Ohm's law of electric circuits; the unit of resistance, the ohm, named in his honour.

Joseph Von Fraunhofer (1787 to 1826)
German optician and physicist; studied the dark lines of the solar system; The Fraunhofer lines so named.

Michael Faraday (1791 to 1867)
English physicist and chemist; discovered electromagnetic induction and laws of electrolysis; the Faraday named in his honour.

Sadi Carnot (1796 to 1832)
Worked in Heat and Thermodynamics; Carnot engine.

Joseph Henry (1797 to 1879)
American physicist famous for work on electromagnetic induction; built first electromagnetic motor in 1829; the henry, unit of induction named after him.

Sir Charles Wheatstone (1802 to 1875)
English physicist; did many experiments on sound; shared first patent for electric telegraph; the wheatstone bridge is named after him.

Christian Johann Doppler (1803 to 1853)
Austrian physicist and mathematician; the Doppler effect in wave motion.

Heinrich Friedrich Lenz (1804 to 1865)
German physicist; investigated electrical conductivity of materials; discovered law governing induced currents--lenz's law.

Charles Darwin (1809 to 1882)
Grandson of Dr. Erasmus Darwin.

Bunsen (1811 to 1899)
Laid the foundation for modern spectroscopy.

James Prescott Joule (1818 to 1889)
English physicist; studies in heat and electricity; Joule's law; $H = I^2Rt$; determined the mechanical equivalent of heat; the joule named after him.

Sir George Stokes (1819 to 1903)
British physicist and mathematician; investigations in X-rays and cathode rays; Stokes' law of a falling particle used in oil-drop experiment.

Herman-Ludwig Helmholtz (1821 to 1894)
German physiologist and physicist; theories on hearing and colour-vision; studies in thermodynamics; invented resonators.

Clausius (1822 to 1888)
Worked in therodynamics.

Gustev Robert Kirchhoff(1824 to 1887)
German physicist; co-inventor of the spectroscope; studies in spectrum analysis; Kirchhoff's laws of electric circuits.

Lord William Thompson Kelvin (1824 to 1907)
Scottish mathematician and physicist; studies in heat and electricity; the Kelvin temperature scale.

Johann Balmer (1825 to 1898)
Swiss physicist; spectroscopy; the Balmer series.

James Clerk Maxwell (1831 to 1879)
Scottish natural philosopher; educated at Cambridge, later became professor of experimental physics there; noted for his publications on theory of heat and on electricity and magnetism.

Dimitri Mendeleev (1832 to 1907)
Russian chemist; many publications in various fields of chemistry; most of his work done in Russia; his proof of the periodic law in his most notable achievement.

Josef Stefan (1835 to 1893)
Austrian physicist; noted for the Stefan-Boltzmann law.

Johannes Van Der Waals (1837 to 1923)
Dutch physicist; investigations in thermodynamics and inter molecular attractions; Van der Waals' equation is a correction for Boyle's law for his pressures; Nobel prize for physics.

Gibbs (1839 to 1903)
Worked in chemical thermodynamics and statistical mechanics.

Edward William Morley (1838 to 1923)
American chemist; graduated from Williams College; remembered for his work on the Michelson-Morley experiment.

Wilhelm Konrad Roentgen (1845 to 1923)
German physicist; discovered and named X-rays; received the first Nobel prize in physics in 1901.

Thomas A. Edison (1847 to 1931)
American inventor; hundreds of inventions in electricity; the Edison effect.

Albert Abraham Michelson (1852 to 1931)
American physicist; born in Prussia; noted for studies in light; perfected many optical instruments, such as interferometer; most important experiments were the measurement of the velocity of light, determination of the length of the standard meter, and the Michelson-Morley experiment; received Nobel prize in physics in 1907.

Hendrik Antoon Lorentz (1853 to 1928)
Dutch physicist; contributed to understanding of quantum theory; explained magnetic effect on spectrum lines; co-author of the Lorentz-Fitzgerald contraction theory that gave an explaination of the negative result in the Michelson-Morley experiment; received the Nobel prize in Physics in 1902.

George Francis Fitzgerald (1851 to 1901)

Irish physicist; offered the contraction theory as an explaination of the result of the Michelson-Morley experiment.

Sir J.J. Thomson (1856 to 1940)
British physicist; extensive study of electric conduction in gases; discovered the existence of isotopes; founder of modern atomic physics; awarded the Nobel prize in physics in 1906; announced the discoverey of electron in 1897.

Heinrich Hertz (1857 to 1894)
Discovered photoelectric effect in 1887.

Karl Max Plank (1858 to 1947)
German physicist; proposed the quantum theory in 1900; Plank's constant h partly determines the value of a photon; Plank received the Nobel prize in Physics in 1918.

Pierre Curie (1859 to 1906)
French chemist and physicist; their most important investigations were in radioactivity; first to isolate radium; 1903 shared Nobel prize in physics with Henry A. Becquerel; the curie is named after them.

Friedrich Paschen (1865 to 1947)
German physicist; experimental spectroscopy; discovered Paschen infra-red series in hydrogen; co-discoverer of Paschen Back effect in magneto-optics; invented Paschen hollow cathode discharges.

Marie Curie (1867 to 1935)
Polish physical chemist; wife of Pierre Curie.

Robert Andrews Milikan (1868 to 1953)
American physicist; Professor of physics at California Institute of Technology; Nobel prize in physics in 1923; noted chiefly for his work in photoelectricity, and cosmic rays, and x-rays; best remembered for his determination of the value of e and Plank's constant.

C.T.R. Wilson (1869 to 1959)
Scottish physicist; studies in ionization; perfected the Wilson Cloud Chamber; preceded Milikan in work on electronic charges; shared Nobel prize for physics in 1927 with A.H. Compton.

Ernest Lord Rutherford (1871 to 1937)
British physicist; discovered and named alpha, beta, and gamma rays; studied radioactive transformations; the scattering of alpha particles experiment set the stage for the nuclear atom; Rutherford first to produce artificial transmutation; Nobel prize in chemistry in 1908.

William David Coolidge (1873 to _____)
American physical chemist; invented the coolidge x-ray tube.

Theodore Lyman (1874 to 1954)
American physicist; studies in ultravoilet light; measurement of wavelengths with diffraction grating; the Lyman series.

Sir Owen Williams Richardson (1879 to 1959)
English physicist; noted mostly for his work on emission of electrons from hot bodies; developed the equation named after him; equation relates the emission current and the temperature of the emitting substance; received the Nobel prize in physics in 1928.

Albert Einstein (1879 to 1955)
Austrian-Swiss-American mathematical physicis; theory of relativity; the photoelectric effect; Nobel prize in physics in 1921.

Max Von Laue (1879 to 1960)
German physicist noted for his studies in x-rays; demonstrated interference phenomena produced by reflection of x-rays from a crystal grating; awarded the Nobel prize in physics in 1914.

Clinton Joseph Davisson (1881 to ----)
American physicist; industrial research at Bell Telephone Laboratories; investigations in electricity and radiation energy; shared Nobel prize in physics in 1927 with G.P. Thomson.

Hans Geiger (1882 to ----)
German physicist; studies in radioactivity; atomic theory; cosmic rays; the Geiger counter.

Niels Bohr (1885 to 1963)
Danish theoretical physicist; awarded Nobel prize for physics in 1922; the Bohr theory of the hydrogen atom.

Henry Gwyn Moseley (1887 to 1915)
English physicist; made discovery of relationship between frequency of x-rays and atomic number that places elements in proper order in periodic table; a casualty of World War I.

Erwin Schroedinger (1887 to 1961)
Austrian physicist; famous for his work on wave mechanics; Schroedinger's wave equation; in 1933, he shared the Nobel prize with Dirac.

Louis Victor DeBroglie (1892 to 1987)
French physicist; investigations in nuclear physics; awarded Nobel prize in physics in 1929; wave nature of the electron.

Arthur Holly Compton (1892 to 1962)
American physicist; x-rays and Compton effect; shared Nobel prize with C.T.R. Wilson in 1927.

Lester Herman Germer (1896 to ----)
American physicist; studies in thermionics, erosion of metals, electron diffraction.

Irene Joliot (1897 to ----)

Jean F. Joliot (1900 to ----)
Husband-wife; both French physicists and chemists; studies in radioactivity and nuclear physics; produced artificial radioactivity by bombarding boron with fast alpha particles; shared Nobel prize in chemistry in 1935.

Enrico Fermi (1901 to 1954)
Italian physicist; investigations in nuclear physics; first to use neutron to produce artificial transmutation; Nobel prize in physics in 1938.

Ernest Orlando Lawrence (1901 to 1958)
American physicist; builder of first cyclotron; investigations in nuclear physics; awarded the Nobel prize in physics in 1939.

Werner Karl Heisenberg (1901 to 1976)
German physicist; famous for work on quantum theory and atomic structure; founding of quantum mechanics; evolved principle of indeterminancy; Nobel prize in physics in 1932.

Paul Adrien Dirac (1902 to 1984)
English physicist; predicted the existence of positron; nuclear physics and quantum mechanics; shared Nobel prize in 1933 with Erwin Schroedinger.

K.T. Bainbridge (1904 to ----)
American physicist; studies in nuclear physics, photoelectric effect, mass spectrography.

Carl D. Anderson (1905 to ----)
American physicist; research in gamma rays and cosmic rays; discovered positron in 1932; shared Nobel prize with Victor Hess in 1936.

Alfred O. Nier (1911 to ----)
American physicist; primary research deals with mass spectroscopy; aided in separating the isotopes of uranium.

Abdus Salam (1926 to ----)
Pakistani physicist; shared Nobel prize with Glashow and Weinberg in physics in 1979; contribution to the theory of the unified weak and electromagnetic interaction between elementary particles.

Nobel Prize Winners in Physics

1901	Wilhelm Konrad Rontgen	1845-1923	Discovery of X-rays.
1902	Hendrik Antoon Lorentz	1853-1928	Influence of magnetism on the
	Pieter Zeeman	1865-1943	phenomena of atomic radiation.
1903	Henri Becquerel	1852-1908	Discovery of natural radioactivity
	Pierre Curie	1850-1906	and of the radioactive elements
	Marie Curie	1867-1934	radium and polonium.
1904	John W. Strutt(Rayleigh)	1842-1919	Discovery of argon.
1905	Philipp Lenard	1862-1947	Research in cathode rays.
1906	Joseph John Thomson	1856-1940	Conduction of electricity through gases.
1907	Albert A. Michelson	1852-1931	Invention of interferometer and spectroscopic and metrological investigations.
1908	Gabriel Lippmann	1845-1921	Photographic reproduction of colours.
1909	Guglielmo Marconi	1874-1937	Development of wireless teleg-
	Karl Ferdinand Braun	1850-1918	raphy.
1910	Johannes Diderik van der Waals	1837-1923	Equations of state of gases and fluids.
1911	Wilhelm Wien	1864-1928	Laws of heat radiation.
1912	Nils Gustaf Dalen	1869-1937	Automatic coastal lighting.
1913	Heike Kamerlingh Onnes	1853-1926	Properties of matter at low temperatures: production of liquid helium.
1914	Max von Laue	1879-1960	Diffraction of X-rays in crystals.
1915	Wilham Henry Bragg	1862-1942	Study of crystal structure by
	William Lawrence Bragg	1890-1971	means of X-rays.
1917	Charles Glover Barkla	1877-1944	Discovery of the characteristic X-rays of elements.
1918	Max Planck	1858-1947	Discovery of the elemental quantum.
1919	Johannes Stark	1874-1957	Discovery of the Doppler effect in canal rays and the splitting of spectral lines in the electric field.
1920	Charles Edouard Guillaume	1861-1938	Discovery of the anomalies of nickel-steel alloys.
1921	Albert Einstein	1879-1955	Discovery of the law of the photoelectric effect.
1922	Niels Bohr	1885-1963	Study of structure and radiations of atoms.
1923	Robert Andrews Millikan	1868-1953	Work on elementary electric charge and the photoelectric effect.
1924	Karl Manne Siegbahn	1886-1978	Discoveries in the area of X-ray spectra.
1925	James Franck	1882-1964	Laws governing collision between
	Gustav Hertz	1887-1975	electron and atom.
1926	Jean Perrin	1870-1942	Discovery of the equilibrium of sedimentation.
1927	Arthur H. Compton	1892-1962	Discovery of the scattering of X-rays by charged particles
	Charles T.R. Wilson	1869-1959	Invention of the cloud chamber, a device to make visible the paths of charged particles.

1928	Owen Willans Richardson	1879-1959	Discovery of the law known by his name(the dependency of the emission of electrons on temperature).
1929	Louis Victor de Broglie	1892-1987	Wave nature of electrons.
1930	Chandrasekhara Raman	1888-1970	Work on the scattering of light and discovery of the effect known by his name.
1932	Werner Heisenberg	1901-1976	Creation of quantum mechanics.
1933	Paul Adrien Maurice Dirac	1902-1984	Discovery of new fertile forms
	Erwin Schrodinger	1887-1961	of the atomic theory.
1935	James Chadwick	1891-1974	Discovery of the neutron.
1936	Victor Hess	1883-1964	Discovery of cosmic radiation.
	Carl David Anderson	1905-	Discovery of the positron.
1937	Clinton Joseph Davisson	1881-1958	Discovery of diffraction of
	George P. Thomson	1892-1975	electrons by crystals.
1938	Enrico Fermi	1901-1954	Artificial radioactive elements from neutron irradiation.
1939	E.O. Lawrence	1901-1958	Invention of the cyclotron.
1943	Otto Stern	1888-1969	Work with molecular beams and magnetic moment of proton.
1944	Isidor Isaac Rabi	1898-1988	Nuclear magnetic resonance.
1945	Wolfgang Pauli	1900-1958	Discovery of quantum exclusion principle.
1946	Percy Williams Bridgman	1882-1961	High-pressure physics.
1947	Edward Appleton	1892-1965	Upper atmosphere physics and discovery of Appleton layer.
1948	Patrick Maynard Stuart-Blackett	1897-1974	Discoveries in cosmic radiation and nuclear physics.
1949	Hideki Yukawa	1907-1981	Prediction of existence of meson.
1950	Cecil Frank Powell	1903-1969	Photographic method of studying nuclear processes; discoveries about mesons.
1951	John Douglas Cockcroft	1897-1967	Transmutation of atomic nuclei
	Ernest Thomas Sinton-Walton	1903-	by artificially accelerated atomic particles.
1952	Felix Bloch	1905-	Measure of magnetic fields in
	Edward Mills Purcell	1912-	atomic nuclei.
1953	Frits Zernike	1888-1966	Invention of phase contrast microscopy.
1954	Max Born	1882-1970	Work in quantum mechanics and
	Walther Bothe	1891-1957	Analysis of cosmic radiation using the coincidence method.
1955	Wills E. Lamb Jr.	1913-	Fine structure of hydrogen.
	Polykarp Kusch	1911-	Magnetic moment of electron.
1956	John Bardeen	1908-1987	Invention and development of
	Walter H. Brattain	1902-	transistor.
	William B. Shockley	1910-	
1957	Chen Ning Yang	1922-	Non-conservation of parity and
	Tsung Dao Lee	1926-	work in elementary particle theory.
1958	Pavel A. Cerenkov	1904-	Discovery and interpretation of
	Ilya M. Frank	1908-	Cerenkov effect of radiation
	Igor Y. Tamm	1895-1971	by fast charged particles in matter.

1959	Owen Chamberlain	1920-	Discovery of the antiproton.
	Emilio Gino Segre	1905-	
1960	Donald A. Glaser	1926-	Invention of the bubble chamber.
1961	Robert L. Hofstadter	1915-	Electromagnetic structure of nucleons from high energy electron scattering.
	Rudolf L. Mossbauer	1929-	Recoilless resonance absorption of gamma rays in nuclei; Mossbauer effect
1962	Lev D. Landau	1908-1968	Theory of condensed matter; phenomena of superfluidity and superconductivity.
1963	Eugene P. Wigner	1902-	Theory of the atomic nucleus and elementary particles through discovery and application of symmetry principles.
	Maria Goeppert-Mayer	1906-1972	Shell model theory and magic numbers for the atomic nucleus.
	J.Hans D. Jensen	1907-1973	
1964	Charles H. Townes	1915-	Invention of the maser and theory of coherent atomic radiation.
	Nikolai G. Basov	1922-	
	Alexander Prokhorov	1916-	
1965	Richard P. Feynman	1918-1988	Development of quantum electrodynamics.
	Julian S. Schwinger	1918-	
	Shin-Itiro Tomanaga	1906-1979	
1966	Alfred Kastler	1902-1984	Optical methods for studying Hertzian resonances in atoms.
1967	Hans A. Bethe	1906-	Theory of nuclear reactions, energy production in stars.
1968	Luis W. Alvarez	1911-	Development of the hydrogen bubble chamber and methods of data analysis.
1969	Murray Gell-Mann	1929-	Classifications of elementary particles and their ineractions.
1970	Hannes O.G. Alfven	1908-	Research in magnetohydrodynamics and plasma physics.
	Louis E. F. Neel	1904-	Discoveries in antiferromagnetism and ferrimagnetism important in solid state physics.
1971	Dennis Gabor	1900-1979	Invention of holography.
1972	Leon N. Cooper	1930-	Theory of superconductivity.
	John R. Schrieffer	1931-	
	John Bardeen	1908-1987	
1973	Leo Esaki	1925-	Discovery of tunnelling in semiconductors.
	Ivar Giaever	1929-	Discovery of tunnelling in superconductors.
	Brian D. Josephson	1940-	Theoretical prediction of a supercurrent through a tunnel barrier, the Josephson effect.
1974	Antony Hewish	1924-	Research in radio astrophysics; discovery of pulsars.
	Martin Ryle	1918-1984	Development of radio telescopes, technique of aperture synthesis.
1975	Aage Niels Bohr	1922-	Theory of the atomic nucleus based on the connection between collective motion and particle motion.
	Ben R. Mottelson	1926-	
	Leo J. Rainwater	1917-	
1976	Burton Richter	1931-	Independent discoveries of the psi or J particle believed to be the smallest building block of matter.
	Samuel C.C. Ting	1936-	

1977	John H. v. Vleck	1899-1980	Electronic structure of magnetic and disordered systems.
	Nevill F. Mott	1905-	Discoveries in solid state physics, use of amorphous material, in electronic switching and memory devices.
	Philip W. Anderson	1923-	
1978	Peter L. Kapitza	1894-1984	Inventions and discoveries in low-temperature physics.
	Arno A. Penzias	1933-	Discovery of cosmic microwave radiation; remnant of a primordial fireball.
	Robert W. Wilson	1936-	
1979	Steven Weinberg	1933-	Independent development of a theory that unifies electromagnetism and the weak nuclear force.
	Abdus Salam	1926-	
	Sheldon L. Glashow	1932-	
1980	James W. Cronin	1931-	Discovery of violations of fundamental symmetry.
	Val L. Fitch	1923-	
1981	Kai M.B. Siegbahn	1918-	Development of electron spectroscopy.
	Nicolaas Bloembergen	1920-	Development of laser spectroscopy.
	Arthur L. Schawlow	1921-	
1982	Kenneth G. Wilson	1936-	Theory for critical phenomina in phaes transitions.
1983	William A. Fowler	1911-	Studies of physical processes in the structure and evolution of stars.
	S. Chandrasekhar	1910-	
1984	Carlo Rubbia	1934-	Discovery of the subatomic field particles W^+, W^- and Z.
	Simon v.d. Meer	1985-	
1985	Klaus v. Klitzing	1943-	Discovery of the quantised Hall effect.
1986	Ernst Ruska	1906-	Design of the first electron microscope.
	Heinrich Rohrer	1933-	Development of the scanning tunnelling microscope.
	Gerd Binning	1947-	
1987	Karl A. Muller	1927-	Discovery of high-temperature superconductivity in copper oxide ceramic materials.
	J. G. Bednorz	1950-	
1988	Leon M. Lederman Melvin Schwartz Jack Steinberger		Established the existence of a second kind of neutrino, and employed the first beam of neutrinos.

The Great Philosophers

Name	Dates	Nationality	Representative Work
Heraclitus	c.544-483BC	Greek	On Nature
Parmenides	c.510-c.450BC	Greek	fragments
Socrates	469-399BC	Greek	----
Plato	428-347BC	Greek	Republic; Phaedo
Aristotle	384-322BC	Greek	Nichomachaen Ethics; Metaphysics
Epicurus	341-270BC	Greek	fragments
Lucretius	c.99-55BC	Roman	On the Nature of Things
Plotinus	AD205-270	Greek	Enneads
Augustine	354-430	N African	Confessions; City of God
Aquinas	c.1225-1274	Italian	Summa Theologica
Duns Scotus	c.1266-1308	Scottish	Opus Oxoniense
William of Occam	c.1285-1349	English	Commentary of the Sentences
Nicholas of Cusa	1401-1464	German	De Docta Ignorantia
Giordano Bruno	1548-1600	Italian	De la Causa, Principio e Uno
Bacon	1561-1626	English	Novum Organum, The Advancement of Learning
Hobbes	1588-1679	English	Leviathan
Descartes	1596-1650	French	Discourse on Method; Meditations on Philosophy
Pascal	1623-1662	French	Pensees
Spinoza	1632-1677	Dutch	Ethics
Locke	1632-1704	English	Essay Concerning Human Understanding
Leibniz	1646-1716	German	The Monadology
Vico	1668-1744	Italian	The New Science
Berkeley	1685-1753	Irish	A Treatise on Principles of Human Knowledge
Hume	1711-1776	Scottish	A treatise of Human Nature
Rousseau	1712-1778	French	The Social Contract
Diderot	1713-1784	French	D'Alembert's Dream
Kant	1724-1804	German	The Critique of Pure Reason
Fichte	1762-1814	German	The Science of Knowledge
Hegel	1770-1831	German	The Phenomenology of Spirit
Schelling	1775-1854	German	System of Transcendental Idealism
Schopenhauer	1788-1860	German	The World as Will and Idea
Comte	1798-1857	French	Cours de philosophie positive
Mill	1806-1873	English	Utilitarianism
Kierkegaard	1813-1855	Danish	Concept of Dread
Marx	1818-1883	German	Economics and Philosophical Manuscripts
Dilthey	1833-1911	German	The Rise of Hemeneutics
Pierce	1839-1914	US	How to Make our Ideas Clear
Nietzsche	1844-1900	German	Thus Spake Zarathustra
Bergson	1859-1941	French	Creative Evolution
Husserl	1859-1936	German	Logical Investigations
Russell	1872-1970	English	Principia Mathematica
Lukacs	1885-1971	Hungarian	History and Class Consciousness
Wittgenstein	1889-1951	Austrian	Tractatus Logico-Philosophical Investigations
Heidegger	1889-1976	German	Being and Time
Gadamer	1900-	German	Truth and Method
Sartre	1905-1980	French	Being and Nothingness
Merleau Ponty	1908-1961	French	The Phenomenology of Perception
Quine	1908-	US	Word and Object
Foucault	1926-1984	French	The Order of Things

Origin of few Physics words

Word	from	meaning
atom	atomos (Greek)	uncuttable
ammeter	ampere-meter	
astatine		unstable
cosmic rays	cosmos (Greek)	whole universe
c	celeritas (Latin)	velocity
electricity	electrics (Greek)	amber
ferromagnetic	ferrum (Latin)	iron
formaline	formaldehyde	
Francium	the native land of French Chemist, Mlle. M. Perey	
fusion	synonymous with melting	
k	konstant- German spelling	
light beam	Baum- German word for tree	
Leyden jar	University of Leyden, Netherlands	
Magnet	magnetism- a town in Turkey- Magnesia	
Physics	physiko (Greek) natural brief form of physical philosophy	
pneumatics	mechanics of gases (Greek)-	air
polonium	Madame Curie's native land	
radiation	ray Latin word 'radius'	
radium	intense radio-activity	
radio wave	wave that radiate	
transformer	that transforms volt-ampere relationship	
technetium	artificial- first discovery from man-made nuclear reactions	
virtual		as if

Foreign words used in Science

Word	Language	Meaning
Acceleration	Latin	to add speed
Ad-hesion	Latin	to stick to
Acoustics	Greek	to hear
Astigmatism	//	no point
Anode	//	upper root
Argon	//	inactive
Alkali	Arabic	ash
Bar	Greek	heavy
Cohesion	Latin	to stick to
Centripetal	//	move toward the centre
Centrifugal	//	flee from the centre
Caplillary tubes	//	hair-like
Cathode	Greek	lower root
Centigrade scale	Latin	hundred degrees
Cesium	Greek	sky blue
Convection	Latin	to carry together
Conduction	//	to lead together
Calorie	//	heat
Camera obscure	//	dark room
Chromatic	Greek	colour
Crystal	//	ice
Crystalline	//	transparent
Converge	Latin	to lean together
Convex surface	//	drawn together
Concave surface	//	with a hollow
Diopters	Greek	to see through
Dielectrics	//	through
Diverge	Latin	to lean apart
Deuterium	Greek	second
Dyne	//	force
Equilibrium	Latin	equal weights
Erg	Greek	work
Energy	//	work within
Electrostatics	Latin	to be stationary
Electrode	Greek	route of the electricity
Electrolysis	//	loosening by electricity
Electro dynamics	//	electricity in motion
Ether	//	blazing
Electrics	//	amber

Friction	Latin	rub
Force	//	strength
Fluids	//	to flow
Focus	//	hearth
Gravity	Latin	weighty
Gas	Greek	chaos
Galvanometer	//	to measure galvanic electricity
Hydrodynamics	//	the motions of water
Hyperopia	//	vision beyond
Helium	//	Sun
Halogens	//	salt formers
Inertia	Latin	idleness or laziness
Infrasonic waves	//	below sound
Insulator	//	island
Infrared	//	below the red
Ions	Greek	wanderer, goers, or travellers
Isotope	//	same place
Kinetic	//	to move or motion
Lever	Latin	to lift
Lumen	//	light
Lens	//	lentil seed
Liquids	//	to flow
Momentum	//	motion
Machine	//	invention or device
Meniscus	Greek	little moon
Mirror	Latin	to look at with astonishment
Myopia	Greek	shut vision
Microscope	//	to see the small
Monochromatic	//	one colour
Molecule	Latin	a small mass
Normal	//	carpenter's square used to draw perpendiculars
Octave	//	eighth
Optics	Greek	sight
Opaque	Latin	dark
Philosophers	Greek	lovers of wisdom
Period	//	round path or circle
Pendulum	Latin	hanging or swinging

Presbyopia	Greek	old man's vision
Photography	Latin	writing by light
Photons	Greek	light
Piezoelectricity	//	electricity through pressure
Proton	//	first
Quantum	Latin	how much ?
Rotational motion	//	wheel
Resonance	//	to sound again
Reflection	//	to bend back
Radius	//	spoke of a wheel
Refraction	//	to break back
Rubidium	//	dark red
Science	Latin	to know
Statics	Greek	to cause to stand
Spherical aberration	Latin	to wander away
Spectrum	//	image
Solenoid	Greek	pipe-shaped
Translational motion	Latin	to carry across
Torque	//	to twist
Trigonometry	Greek	the measurement of triangles
Transverse	Latin	lying across
Thermometer	Greek	heat measure
Thermodynamics	Latin	motion of heat
Transparent	//	to be seen across
Telescope	Greek	to see the distant
Telegraph	//	writing at a distance
Telephone	//	to speak at distance
Tritium	//	third
Ultrasonic waves	Latin	beyond sound
Umbra	//	shadow
Vacuum	//	empty
Vis viva	//	living force
⌈ Vibration	//	to shake
⌊ or Vibratory motion	//	to shake
Vitreous	//	glass

The Elements

All forms of matter---solids, liquids and gases---are made up of just over 100 basic elements; to date, 107 have been discovered.

The elements known to date

The table below lists all 107 known elements in alphabetical order. For clarity, they have been grouped into metals, non-metals and the noble gases. The dash means that the information is not known, or it too remote. Almost all information preceding the Christian era is unknown. The dashes will also be found for two elements discovered in 1974 and 1977. This is because neither their names nor their atomic weights have yet been determined.

By looking at the dates of discovery it can be seen that most elements---in fact, more than half of them---were identified during the second half of the eighteenth century and during the nineteenth century. Only ten were known two thousand years ago and only three were discovered in the next 1700 years.

Name	Symbol	Atomic No.	Atomic weight	Date of discovery	Discoverer
METALS					
Actinium	Ac	89	227	1899	Debierne-Giesel
Aluminium	Al	13	26.98	1825	Oersted
Americium	Am	95	243	1944	Seaborg and collaborators
Antimony	Sb	51	121.75	---	---
Barium	Ba	56	137.34	1808	Davy
Berkelium	Bk	97	247	1950	Seaborg and coll.
Beryllium	Be	4	9.012	1828	Wohler
Bismuth	Bi	83	208.98	—	—
Cadmium	Cd	48	112.40	1817	Stromeyer
Caesium	Cs	55	132.90	1860	Bunsen-Kirchhoff
Calcium	Ca	20	40.08	1808	Davy
Californium	Cf	98	251	1950	Seaborg and coll.
Cerium	Ce	58	140.12	1803	Klaproth
Chromium	Cr	24	51.99	1797	Vauquelin
Cobalt	Co	27	58.93	1735	Brandt
Copper	Cu	29	63.54	—	—
Curium	Cm	96	247	1944	Seaborg and coll.
Dysprosium	Dy	66	162.50	1886	De Boisbaudran
Einsteinium	Es	99	254	1952	Ghiorso and coll.
Erbium	Er	68	167.26	1843	Mosander
Europium	Eu	63	151.96	1896	Demarcay
Fermium	Fm	100	257	1953	University of Cal.
Francium	Fr	87	223	1939	Perey
Gadolinium	Gd	64	157.25	1880	Marignac
Gallium	Ga	31	69.72	1875	De Boisbaudran
Germanium	Ge	32	72.59	1886	Winkler
Gold	Au	79	196.96	—	—
Hafnium	Hf	72	178.49	1923	Coster-Hevesy
Hahnium	Ha	105	260	1970	Ghiorso and coll.
Holmium	Ho	67	164.93	1879	Cleve
Indium	In	49	114.82	1863	Reiche-Richter
Iridium	Ir	77	192.2	1803	Tennant
Iron	Fe	26	55.84	—	—
Kurchatovium	Ku	104	260	1967	Flerov and coll.
Lanthanum	La	57	138.91	1839	Mosander
Lawrencium	Lw	103	257	1961	Ghiorso and coll.
Lead	Pb	82	207.19	—	—
Lithium	Li	3	6.94	1817	Arfvedson

Name	Symbol	Atomic No.	Atomic weight	Date of discovery	Discoverer
Lutetium	Lu	71	174.97	1907	Urbain-Welsbach
Magnesium	Mg	12	24.31	1808	Davy
Manganese	Mn	25	54.93	1774	Scheele-Gahn
Mendelevium	Md	101	256	1955	Ghiorso and coll.
Mercury	Hg	80	200.59	—	—
Molybdenum	Mo	42	95.94	1782	Hjelm
Neodymium	Nd	60	144.24	1886	Welsbach
Neptunium	Np	93	237	1940	McMillan-Abelson
Nickel	Ni	28	58.71	1751	Cronstedt
Niobium	Nb	41	92.90	1801	Hatchett
Nobelium	No	102	255	1958	Ghiorso and coll.
Osmium	Os	76	190.2	1803	Tennant
Palladium	Pd	46	106.4	1804	Wollaston
Platinum	Pt	78	195.09	1735	de Ulloa
Plutonium	Pu	94	244	1940	Seaborg and coll.
Polonium	Po	84	210	1898	Curie
Potassium	K	19	39.10	1807	Davy
Praseodymium	Pr	59	140.90	1885	Welsbach
Promethium	Pm	61	147	1945	Coryell and coll.
Protactinium	Pa	91	231	1917	Hahn-Meitner
Radium	Ra	88	226	1898	Curie
Rhenium	Re	75	186.2	1925	Noddack-Tacke
Rhodium	Rh	45	102.90	1804	Wollaston
Rubidium	Rb	37	85.47	1861	Bunsen-Kirchhoff
Ruthenium	Ru	44	101.07	1845	Claus
Samarium	Sm	62	150.35	1879	De Boisbaudran
Scandium	Sc	21	44.95	1879	Nilson
Silver	Ag	47	107.87	—	—
Sodium	Na	11	22.98	1807	Davy
Strontium	Sr	38	87.62	1787	Cruikshank
Tantalum	Ta	73	180.94	1802	Ekeberg
Technetium	Tc	43	97	1937	Perrier-Segre
Terbium	Tb	65	158.92	1843	Mosander
Thallium	Tl	81	204.37	1861	Crooks
Thorium	Th	90	232.03	1828	Berzelius
Thulium	Tm	69	168.93	1879	Cleve
Tin	Sn	50	118.69	—	—
Titanium	Ti	22	47.90	1791	Gregor
Tungsten	W	74	183.85	1783	D'Elhuyar
Uranium	U	92	238.03	1789	Klaproth
Vanadium	V	23	50.94	1830	Sefstrom
Ytterbium	Yb	70	173.04	1878	Marignac
Yttrium	Y	39	88.90	1794	Gadolin
Zinc	Zn	30	65.37	1520	Paracelsus
Zirconium	Zr	40	91.22	1789	Klaproth
Unnilhexium	Unh	106	263.0	1974	Ghiorso and coll.
Unnilseptium	Uns	107	262.0	1977	Flerov and coll.
NON-METALS					
Arsenic	As	33	74.21	1200	Albertus Magnus
Astatine	At	85	210	1940	Corson and coll.
Boron	B	5	10.811	1808	Gay-Lussac
Bromide	Br	35	79.90	1826	Balard
Carbon	C	6	12.011	—	—
Chlorine	Cl	17	35.453	1774	Scheele
Fluorine	F	9	18.99	1886	Moissan
Hydrogen	H	1	1.007	1766	Cavendish
Iodine	I	53	126.90	1812	Courtois

Name	Symbol	Atomic No	Atomic weight	Date of discovery	Discoveror
Nitrogen	N	7	14.00	1772	Rutherford
Oxygen	O	8	15.999	1774	Priestley
Phosphorus	P	15	30.97	1668	Brand
Selenium	Se	34	78.96	1817	Berzelius
Silicon	Si	14	28.08	1823	Berzelius
Sulphur	S	16	23.062	----	--------
Tellurium	Te	52	127.60	1782	Muller
NOBLE GASES					
Argon	Ar	18	39.94	1894	Ramsay
Helium	He	2	4.002	1895	Cleve-Ramsay
Krypton	Kr	36	83.80	1898	Ramsay
Neon	Ne	10	20.18	1898	Ramsay-Travers
Radon	Rn	86	222	1900	Dorn
Xenon	Xe	54	131.30	1898	Ramsay

Some characteristcis of common glasses

Glass	Approximate Composition	Annealing temperature/ °C
Soda($S_{/C}$)	Sodium calcium silicate	515
Lead(L_{qp})	Lead silicate	435
Pyrex	Sodium aluminium silicate	530-600
Silica	Silica	---
GEC B_{37}	Silica,boron,sodium	560
Monax	Silica(small amounts of sodium potassium,zinc and aluminium	560

PERIODIC TABLE OF THE ELEMENTS

Filled Shells	I	II											III	IV	V	VI	VII	0
	$^{-1}_{+1}$ 1 H Hydrogen 1.0079 1																	0 2 He Helium 4.00260 2
	$^{-1}_{+1}$ 3 Li Lithium 6.941 2-1	$^{-2}_{+2}$ 4 Be Beryllium 9.01218 2-2											$^{-3}_{+3}$ 5 B Boron 10.81 2-3	$^{-4}_{+2}$ $^{+4}$ 6 C Carbon 12.011 2-4	$^{-1}_{+1}$ $^{+2}_{+3}$ $^{+4}_{+5}$ 7 N Nitrogen 14.0067 2-5	$^{-2}$ 8 O Oxygen 15.9994 2-6	$^{-1}$ 9 F Fluorine 18.99840 2-7	0 10 Ne Neon 20.179 2-8
	$^{-1}_{+1}$ 11 Na Sodium 22.98977 2-8-1	$^{-2}_{+2}$ 12 Mg Magnesium 24.305 2-8-2											$^{-3}_{+3}$ 13 Al Aluminum 26.98154 2-8-3	$^{-4}_{+2}$ $^{+4}$ 14 Si Silicon 28.086 2-8-4	$^{-3}_{+3}$ $^{+5}$ 15 P Phosphorus 30.97376 2-8-5	$^{-2}_{+4}$ $^{+6}$ 16 S Sulfur 32.06 2-8-6	$^{-1}_{+5}$ $^{+7}$ 17 Cl Chlorine 35.453 2-8-7	0 18 Ar Argon 39.948 2-8-8
2	$^{-1}_{+1}$ 19 K Potassium 39.098 -8-8-1	$^{-2}_{+2}$ 20 Ca Calcium 40.08 -8-8-2	$^{+3}$ 21 Sc Scandium 44.9559 -8-9-2	$^{+2}_{+3}$ $^{+4}$ 22 Ti Titanium 47.90 -8-10-2	$^{+2}_{+3}$ $^{+4}_{+5}$ 23 V Vanadium 50.9414 -8-11-2	$^{+2}_{+3}$ $^{+6}$ 24 Cr Chromium 51.996 -8-13-1	$^{+2}_{+3}$ $^{+4}_{+6}$ $^{+7}$ 25 Mn Manganese 54.9380 -8-13-2	$^{+2}_{+3}$ 26 Fe Iron 55.847 -8-14-2	$^{+2}_{+3}$ 27 Co Cobalt 58.9332 -8-15-2	$^{+2}_{+3}$ 28 Ni Nickel 58.70 -8-16-2	$^{+1}_{+2}$ 29 Cu Copper 63.546 -8-18-1	$^{+2}$ 30 Zn Zinc 65.38 -8-18-2	$^{+3}$ 31 Ga Gallium 69.72 -8-18-3	$^{+2}_{+4}$ 32 Ge Germanium 72.59 -8-18-4	$^{+3}_{+5}$ 33 As Arsenic 74.9216 -8-18-5	$^{+4}_{+6}$ $^{-2}$ 34 Se Selenium 78.96 -8-18-6	$^{+1}_{+5}$ $^{+7}$ 35 Br Bromine 79.904 -8-18-7	0 36 Kr Krypton 83.80 -8-18-8
2-8	$^{-1}_{+1}$ 37 Rb Rubidium 85.4678 -18-8-1	$^{+2}$ 38 Sr Strontium 87.62 -18-8-2	$^{+3}$ 39 Y Yttrium 88.9059 -18-9-2	$^{+4}$ 40 Zr Zirconium 91.22 -18-10-2	$^{+3}_{+5}$ 41 Nb Niobium 92.9064 -18-12-1	$^{+6}$ 42 Mo Molybdenum 95.94 -18-13-1	$^{+4}_{+6}$ $^{+7}$ 43 Tc Technetium (97) -18-13-2	$^{+3}$ 44 Ru Ruthenium 101.07 -18-15-1	$^{+3}$ 45 Rh Rhodium 102.9055 -18-16-1	$^{+2}_{+4}$ 46 Pd Palladium 106.4 -18-18-0	$^{+1}$ 47 Ag Silver 107.868 -18-18-1	$^{+2}$ 48 Cd Cadmium 112.40 -18-18-2	$^{+3}$ 49 In Indium 114.82 -18-18-3	$^{+2}_{+4}$ 50 Sn Tin 118.69 -18-18-4	$^{+3}_{+5}$ 51 Sb Antimony 121.75 -18-18-5	$^{+4}_{+6}$ $^{-2}$ 52 Te Tellurium 127.60 -18-18-6	$^{+1}_{+5}$ $^{+7}$ 53 I Iodine 126.9045 -18-18-7	0 54 Xe Xenon 131.30 -18-18-8
2-8-18	$^{-1}_{+1}$ 55 Cs Cesium 132.9054 -18-8-1	$^{+2}$ 56 Ba Barium 137.34 -18-8-2	57-71 See Lantha-nides	$^{+4}$ 72 Hf Hafnium 178.49 -32-10-2	$^{+5}$ 73 Ta Tantalum 180.9479 -32-11-2	$^{+6}$ 74 W Wolfram 183.85 -32-12-2	$^{+4}_{+6}$ $^{+7}$ 75 Re Rhenium 186.207 -32-13-2	$^{+3}_{+4}$ 76 Os Osmium 190.2 -32-14-2	$^{+3}_{+4}$ 77 Ir Iridium 192.22 -32-15-2	$^{+2}_{+4}$ 78 Pt Platinum 195.09 -32-17-1	$^{+1}_{+3}$ 79 Au Gold 196.9665 -32-18-1	$^{+1}_{+2}$ 80 Hg Mercury 200.59 -32-18-2	$^{+1}_{+3}$ 81 Tl Thallium 204.37 -32-18-3	$^{+2}_{+4}$ 82 Pb Lead 207.2 -32-18-4	$^{+3}_{+5}$ 83 Bi Bismuth 208.9804 -32-18-5	$^{+2}_{+4}$ 84 Po Polonium (209) -32-18-6	$^{+1}_{+5}$ $^{+7}$ 85 At Astatine (210) -32-18-7	0 86 Rn Radon (222) -32-18-8
2-8-18-32	$^{-1}_{+1}$ 87 Fr Francium (223) -18-8-1	$^{+2}$ 88 Ra Radium 226.0254 -18-8-2	89-103 See Acti-nides	$^{+4}$ 104 Rf-Ku (Rutherfordium; Kurchatovium) (261) -32-10-2	105 Ha Hahnium (262) -32-11-2	106 Unh Unnilhexium (263) -32-12-2	107 Uns Unnilseptium (262?)											Noble Gases

Lanthanides	$^{+3}$ 57 La Lanthanum 138.9055 -18-9-2	$^{+3}_{+4}$ 58 Ce Cerium 140.12 -19-9-2	$^{+3}$ 59 Pr Praseodymium 140.9077 -21-8-2	$^{+3}$ 60 Nd Neodymium 144.24 -22-8-2	$^{+3}$ 61 Pm Promethium (145) -23-8-2	$^{+2}_{+3}$ 62 Sm Samarium 150.4 -24-8-2	$^{+2}_{+3}$ 63 Eu Europium 151.96 -25-8-2	$^{+3}$ 64 Gd Gadolinium 157.25 -25-9-2	$^{+3}$ 65 Tb Terbium 158.9254 -26-9-2	$^{+3}$ 66 Dy Dysprosium 162.50 -28-8-2	$^{+3}$ 67 Ho Holmium 164.9304 -29-8-2	$^{+3}$ 68 Er Erbium 167.26 -30-8-2	$^{+3}$ 69 Tm Thulium 168.9342 -31-8-2	$^{+2}_{+3}$ 70 Yb Ytterbium 173.04 -32-8-2	$^{+3}$ 71 Lu Lutetium 174.97 -32-9-2
Actinides	$^{+3}$ 89 Ac Actinium (227) -18-9-2	$^{+4}$ 90 Th Thorium 232.0381 -18-10-2	$^{+4}_{+5}$ 91 Pa Protactinium 231.0359 -20-9-2	$^{+3}_{+4}$ $^{+5}_{+6}$ 92 U Uranium 238.029 -21-9-2	$^{+3}_{+4}$ $^{+5}_{+6}$ 93 Np Neptunium 237.0482 -22-9-2	$^{+3}_{+4}$ $^{+5}_{+6}$ 94 Pu Plutonium (244) -24-8-2	$^{+3}_{+4}$ $^{+5}_{+6}$ 95 Am Americium (243) -25-8-2	$^{+3}$ 96 Cm Curium 247? -25-9-2	$^{+3}_{+4}$ 97 Bk Berkelium (247) -27-8-2	$^{+3}$ 98 Cf Californium (251) -28-8-2	$^{+3}$ 99 Es Einsteinium (254) -29-8-2	$^{+3}$ 100 Fm Fermium (257) -30-8-2	$^{+3}$ 101 Md Mendelevium (258) -31-8-2	$^{+2}_{+3}$ 102 No Nobelium (255) -32-8-2	$^{+3}$ 103 Lr Lawrencium (260) -32-9-2

Oxidation States — Atomic Number — Symbol — Name — Atomic Weight — Electron Configuration

KEY: $^{+1}_{-3}$ 79 Au Gold 196.9665 -32-18-1

Transition Elements

Note:
Atomic weights are those of the most commonly available long-lived isotopes on the 1973 IUPAC Atomic Weights of the Elements. A value given in parentheses denotes the mass number of the longest-lived isotope. Adapted from *Merck Index: An Encyclopedia of Chemicals and Drugs*, Merck and Co., Inc., 9th ed.: 1976.

Basic dimensions and units in the SI (International) System

Dimension	Unit	Unit symbol	Definition and Standard
length	metre	m	The length of the standard metre rod kept at Sevres, in France. It is defined as 1,650,763.73 times the wavelength of the red-orange light emitted by a krypton lamp. It is approximately one forty-millionth part of the equator.
mass	kilogram	kg	The mass of the standard kilogram in platinum and iridium kept at Sevres. It is approximately equal to that of a litre of pure water. The redefining of this dimensional standard in terms of a number of carbon atoms is being considered.
time	second	s	The duration of 9,192,631,770 vibrations of the radiation produced by the caesium atom. It corresponds to 1/86,400 of the mean solar day.
electric current	ampere	A	The amount of current which, when flowing through two parallel, rectilinear conductors one metre in length and one metre apart, will produce a force equal to two ten-millionths of a newton (a unit of force). An ampere is roughly equivalent to the flow of 6 million million million electrons per second.
temperature	kelvin	K	The kelvin is equal to the degree celsius or centigrade. It is defined as 1/273.16 of the thermodynamic temperature of the triple point (freezing point) of water. This point is 273.16 K and absolute zero is 0 K.
luminous intensity	candela	cd	One sixtieth of the light emitted in a perpendicular direction by a square centimetre of a black body (an ideal luminous source) at the temperature of melting platinum.
amount of substance	mole	mol	The amount of substance which contains as many elementary units (atoms or molecules) as there are atoms in twelve grams of the isotope carbon-12 (approximately 6×10^{23}).

APPENDIX 3. UNITS

Additional units

Quantity	Unit	Symbol	
Additional units			
Angle	radian		rad
Solid angle	radian		rad
Other named units			
Frequency	Hertz	Hz	1/s
Force	Newton	N	kg m/s²
Energy	Joule	J	Nm
Pressure	Pascal	Pa	N/m²
Power	Watt	W	J/s
Electric charge	Coulomb	C	A s
Potential	Volt	V	J/C
Resistance	Ohm	Ω	V/A
Conductance	Siemens	S	A/V
Capacitance	Farad	F	C/V
Magnetic flux	Weber	Wb	V s
Inductance	Henry	H	Wb/A
Magnetic induction	Tesla	T	Wb/m²
Light flux	Lumen	Lm	Cd rad

3. Tables of weights and measures

(For comprehensive list see *Encyclopaedia Britannica)*

UNITS OF CAPACITY

In the UK the commercial units of capacity both for fluids and dry substances are the gallon and units derived from it. In the US the gallon and derived units are legal measures only for fluids; for dry substances, the units are the bushel and units derived from it.

UK (liquids and solids)

60 minims	= 1 fluid drachm
8 fluid drachms	= 1 fluid ounce
5 fluid ounces	= 1 gill
4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon
2 gallons	= 1 peck
4 pecks	= 1 bushel
3 bushels	= 1 sack
8 bushels	= 1 quarter
12 sacks	= 1 chaldron
1 UK gallon	= 1·20094 US gallon = 277·42 in^3
1 UK minim	= 0·960754 US minim

US (liquid)

60 minims	= 1 fluid dram
8 fluid drams	= 1 fluid ounce
4 fluid ounces	= 1 gill

4 gills	= 1 liquid pint
2 liquid pints	= 1 liquid quart
4 liquid quarts	= 1 gallon
42 gallons	= 1 barrel
1 US gallon	= 231 in^3

US (dry measure)

2 dry pints	= 1 dry quart
8 dry quarts	= 1 peck
4 pecks	= 1 bushel
1 bushel (US)	= 0.968 939 bushel (UK)
	= 2150·42 in^3 = 35·239 071 669 dm^3

The bushel is sometimes called the stricken or struck bushel.

UNITS OF AREA

144 square inches	= 1 square foot
9 square feet	= 1 square yard
$30\frac{1}{4}$ square yards	= 1 square rod, pole or perch
40 square rods	= 1 rood
4 roods	= 1 acre
640 acres	= 1 square mile
4840 square yards	= 1 acre
1 square yard	= 0·836127 square metre
1 acre	= 2·25 ver. ees (Jersey)
	= 2·625 ve gees (Guernsey)

UNITS OF LENGTH

12 lines	= 1 inch (in)
12 inches	= 1 foot (ft)
3 feet	= 1 yard (yd)
$5\frac{1}{2}$ yards	= 1 rod, pole or perch
40 rods	= 1 furlong
8 furlongs	= 1 mile

The English mile is 1760 yards whereas the Irish mile (obsolete) is 2240 yards. A Gunter's chain consists of a hundred links and is 22 yards long. In the USA an Engineer's chain of 100 feet is also used.

1 yard = 0·9144 metre
5 miles ≈ 8 kilometres

5. Conversion factors for SI and CGS units

Quantity	Measured in CGS	SI	A	B
Mass	gram (g)	kilogram (kg)	10^{3}	
Length	cm	metre (m)	10^{2}	
Time	second (s)	second (s)	1	
Volume	cm^{3}	$metre^{3}$	10^{6}	
Area	cm^{2}	$metre^{2}$	10^{4}	
Density*	$g\ cm^{-3}$	$kg\ m^{-3}$	10^{3}	
Velocity	$cm\ s^{-1}$	$m\ s^{-1}$	10^{2}	
Moment of Inertia	$g\ cm^{2}$	$kg\ m^{2}$	10^{7}	
Force	dyne	newton (N)	10^{5}	
Work	erg	joule (J)	10^{7}	
Power	$erg\ s^{-1}$	watt (W)	10^{7}	
Capacitance		farad (F)	10^{-9}	$8{\cdot}988 \times 10^{20}$
Charge		coulomb (C)	10^{-1}	$2{\cdot}998 \times 10^{10}$
Current	biot	ampere (A)	10^{-1}	$2{\cdot}998 \times 10^{10}$
Electric field strength		$V\ m^{-1}$ or $N\ C^{-1}$	10^{6}	$3{\cdot}335 \times 10^{-11}$
Electric flux		coulomb (C)	1·257	$2{\cdot}998 \times 10^{10}$
Inductance	cm	henry (H)	10^{9}	$1{\cdot}113 \times 10^{-21}$
Intensity of magnetization		$Wb\ m^{-2}$	$7{\cdot}958 \times 10^{2}$	$3{\cdot}335 \times 10^{-11}$
Magnetic field strength	oersted	$A\ m^{-1}$	$1{\cdot}257 \times 10^{-2}$	$2{\cdot}998 \times 10^{10}$
Magnetic flux	maxwell	weber (Wb)	10^{8}	$3{\cdot}335 \times 10^{-11}$
Magnetic flux density	gauss	tesla	10^{4}	$3{\cdot}335 \times 10^{-11}$
Magnetic pole strength		weber (Wb)	$7{\cdot}958 \times 10^{6}$	$3{\cdot}335 \times 10^{-11}$
Magnetomotive force	gilbert	ampere turn (A)	1·257	$2{\cdot}988 \times 10^{10}$

Quantity	*Measured in* *CGS*	*SI*	*A*	*B*
Permeability		H m^{-1} or Wb A^{-1} m^{-1}	$7{\cdot}958 \times 10^{5}$	$1{\cdot}113 \times 10^{-21}$
Permittivity		C m^{-1} V^{-1}	$8{\cdot}854 \times 10^{-12}$	$8{\cdot}988 \times 10^{20}$
Potential difference		volt (V)	10^{8}	$3{\cdot}335 \times 10^{-11}$
Reluctance		A Wb^{-1}	$1{\cdot}257 \times 10^{-8}$	$8{\cdot}988 \times 10^{20}$
Resistance		ohm (Ω)	10^{9}	$1{\cdot}113 \times 10^{-21}$
Resistivity		ohm metre	10^{11}	$1{\cdot}113 \times 10^{-21}$
Surface tension	dyn cm^{-1}	N m^{-1}	10^{3}	
Thermal conductivity	erg s^{-1} cm^{-1} $°C^{-1}$	W m^{-1} $°C^{-1}$	10^{5}	
Viscosity (dynamic)	poise	kg m^{-1} s^{-1}	10	
Viscosity (kinematic)	stokes	m^{2} s^{-1}	10^{4}	
Volume susceptibility	Mx Oe^{-1} cm^{-2}	Wb A^{-1} m^{-1}	$1{\cdot}59 \times 10^{-1}$	

Column A gives the number of CGS (e.m.u.) units in one SI unit.

Column B gives the number of CGS (e.s.u.) units in one CGS (e.m.u.) unit.

The product of column A and column B gives the number of CGS (e.s.u.) units in one SI unit. The numerical values of the two columns are calculated using $2{\cdot}988 \times 10^{9}$ m s^{-1} as the velocity of light.

* The density of water at 4°C is 1000 kg m^{-3} in SI units.

Conversion Factors

	To change British to S.I. units				To change S.I. to British units			
Mass	lb	→ kg	×	0·454	kg	→ lb	×	2·20
Length	ft	→ m	×	0·305	m	→ ft	×	3·28
	mi	→ km	×	1·61	km	→ mi	×	0·621
Speed	ft/s	→ m/s	×	0·305	m/s	→ ft/s	×	3·28
	mi/h	→ m/s	×	0·447	m/s	→ mi/h	×	2·24
Acceleration	ft/s^2	→ m/s^2	×	0·305	m/s^2	→ ft/s^2	×	3·28
Force	pdl	→ N	×	0·138	N	→ pdl	×	7·23
	lbf	→ N	×	4·45	N	→ lbf	×	0·225
Pressure	lbf/in^2	→ Pa	×	6890	Pa	→ lbf/in^2	×	$1·45 \times 10^{-4}$
Energy	ft pdl	→ J	×	0·042	J	→ ft pdl	×	23·7
	ft lbf	→ J	×	1·36	J	→ ft lbf	×	0·735
	Btu	→ J	×	1055	J	→ Btu	×	$9·48 \times 10^{-4}$
Power	h p	→ W	×	746	W	→ h p	×	$1·34 \times 10^{-3}$

	c.g.s. → S.I.				S.I. → c.g.s.			
Force	dyn	→ N	×	10^{-5}	N	→ dyn	×	10^5
	gf	→ N	×	$9·81 \times 10^{-3}$	N	→ gf	×	102
Energy	erg	→ J	×	10^{-7}	J	→ erg	×	10^7
	cal	→ J	×	4·186	J	→ cal	×	0·239

Area $mile^2 \rightarrow m^2$: $x\ 2.59 \times 10^6$ $\quad m^2 \rightarrow mile^2$: $x\ 3.86 \times 10^{-7}$

$acre \rightarrow m^2$: $x\ 4.05 \times 10^3$ $\quad m^2 \rightarrow acre$: $x\ 2.47 \times 10^{-4}$

1 are = $100\ m^2$; 1 hectare = $10^4\ m^2$ = 2.47 acres

1 quintal = 1000 kg ; 1 ton = 100 kg = 10 quintals

1 parsec (pc) = 30.857×10^{15} m; 1 astronomical unit (Au) = 0.1496×10^{12} m

1 fathom = 6 ft = 1.8288 m; 1 statute mile = 1.609344 km

1 nautical mile (international) = 1.852 km

$1\ ft^3$ (water) = 62 .5 lb $\quad 1\ ft^3$ (water) = 6.25 Imper4ial gallons

$1\ ft^3$ = 7.48 U.S. gallons 1 Imperial gallon = 10 lbs

1 U.S. gallon = 8.33 lbs 1 Imperial gallon = $277\ in^3$

1 U. S. gallon = $231\ in^3$ $\quad 1\ in^3$ (water) = 0.36 lbs

2.3 ft (column of water) = 1 lb $/in^2$ (pressure)

1 ft (high column of water) = 0.434 lb $/in^2$

1 kg = 2.2056 lbs

Conversion Factors

Units of Length:

1 inch = 2.54 cm = 25.4 mm
1 foot = 12 inches = 30.48 cm = 304.8 mm
1 yard = 3 ft = 36 inches = 91.44 cm = 0.914 m
1 meter = 100.0 cm = 39.40 inches = 3.28 ft = 1.09 yds
1 mile = 1.609 km = 5280 ft = 1760 yds
1 km = 0.621 miles = 1000.0 m

Units of Area:

1 $inch^2$ = 6.452 cm^2
1 ft^2 = 144 $inch^2$ = 929.03 cm^2
1 acre = 43560 ft^2 = 4047 m^2 = 0.4047 hectrares
1 $mile^2$ = 640.0 acres = 259.0 hectares = 2.59 km^2
1 km^2 = 247.11 acres = 100 hectares
1 hectare = 10,000 m^2 = 2.471 acres

Volume:

1 ft^3 (of water) = 7.48 U.S. gallons = 28.307 litre
= 6.227 Imp. Gallons = 62.43 lbs
1 m^3 = 1000 litres = 220 Imp. Gallons
= 264 U.S. gallons = 2283 lbs = 25.31 ft^3
1 acre ft = 43560 ft^3 = 1234 m^3
1 Imp. Gallon of water = 10 lbs = 1.201 U.S. gallons = 4.55 litre
1 litre of water = 2.2 lbs

Weight:

1 lb = 16 oz = 7000 grains = 453.6 gm
1 gm = 15.43 grains
1 short ton = 2000 lbs = 0.9078 metric tons
1 long ton = 2240 lbs

Power:

1 kilowatt = 1.341 horse-power = 737.6 ft. lb/sec
1 horse-power = 0.7457 kilowatt = 746 watts = 550 ft.lb/sec
= 33000 ft.lb/min

Discharge:

1 ft^3/sec (cusec) = 449 U.S. gallons/min
= 374 Imp. gallons/min
= 1.98 acre ft /day
= 724 acre ft /year
= 28.3 litre/sec
= 0.08 acre ft /hour
1 m^3/sec = 22.83 mgd = 35.32 ft^3 /sec
1 mgd = 1.548 ft^3 /sec

Temperature:

$^{o}F = 32 + 9/5 \times {}^{o}C$

Equivalence of some usual measurements units to those in the International System (IS)

Unit	Symbol	Conversion rate
Length		
Fermi	F	1 F = 1.5×10^{-15} m
Angstrom	Å	1 Å = 10^{-10} m
inch	in	1 in = 2.54×10^{-2} m
foot	ft	1 ft = 3.048×10^{-1} m
yard	yd	1 yd = 0.9144 m
Area		
barn	b	1 b = 10^{-28} m^2
square inch	in^2	1 in^2 = 6.4516×10^{-4} m^2
square foot	ft^2	1 ft^2 = 9.290304×10^{-2} m^2
square yard	yd^2	1 yd^2 = 8.361274×10^{-1} m^2
Volume		
barrel	-	1 barrel = 1.589873×10^{-1} m^3
cubic inch	in^3	1 in^3 = 1.638706×10^{-5} m^3
cubic foot	ft^3	1 ft^3 = 2.831685×10^{-2} m^3
cubic yard	yd^3	1 yd^3 = 7.645549×10^{-1} m^3
Mass		
atomic mass unit	u	1 u = 1.660566×10^{-27} kg
pound	lb	1 lb = 2.814952×10^{-2} kg
ton (short)	-	1 ton(s) = 9.071847×10^{-2} kg
ton (long)	-	1 ton(l) = 1.016047×10^{3} kg
Temperature		
degree Celsius	^oC	$T_K = T_C + 273.15$
degree Fahrenheit	^oF	$T_K = (T_F + 459.67)/1.8$
degree Rankine	^oR	$T_K = T_R/1.8$
Energy		
British thermal unit	btu	1 btu = 1.055056×10^{3} J
calorie	cal	1 cal = 4.186800 J
electron volt	eV	1 eV = 1.602190×10^{-19} J
erg	erg	1 erg = 1.0×10^{-7} J
kilowatthour	kWh	1 kWh = 3.6×10^{6} J
Power		
British thermal unit/hour	btu/h	1 btu/h = 2.930711×10^{-1} W
calorie/second	cal/s	1 cal/s = 4.186800 W
horse power	hp	1 hp = 7.456999×10^{2} W

Unit	Symbol	Conversion rate
Pressure		
standard atmosphere	atm	1 atm = 1.01325×10^{5} Pa
bar	bar	1 bar = 1.00×10^{5} Pa
pound per square inch	psi	1 psi = 6.894757×10^{3} Pa
torr	torr	1 torr = 1.33322×10^{2} Pa
Thermodynamics, heat transfer		
energy/unit area	btu/ft^2	1 btu/ft^2 = 1.135653×10^{4} J/m^2
thermal conductivity	$\frac{btu}{h \cdot ft \cdot {}^oF}$	1 btu/(h . ft . ^oF) = 1.7307 W/(m . K)
thermal diffusivity	ft^2/h	1 ft^2/h = 2.580640×10^{-5} m^2/s
thermal resistivity	$\frac{{}^oF \cdot h \cdot ft^2}{btu}$	1 ^oF . h . ft^2/btu = 1.762280×10^{-1} K . m^2/W
specific heat	cal/(g . ^oC)	1 cal/(g . ^oC) = 4.186800×10^{3} J/(kg . K)
heat flow	$\frac{btu}{h \cdot ft^2}$	1 btu/(h . ft^2) = 3.155×10^{-8} W/m^2
dynamic viscosity	cP	1 centipoise = 1×10^{-3} Pa . s
Radioactivity		
curie	Ci	1 Ci = 3.7×10^{10} Bq
roentgen	R	1 R = 2.579760×10^{-4} C/kg
rad	rad	1 rad = 10^{-2} Gy
rem	rem	1 rem = 10^{-2} Sv

Unit IS	Symbol IS
metre	m
square metre	m^2
cubic metre	m^3
kilogram	kg
kelvin	K
joule	J
watt	W
pascal	Pa
becquerel	Bq
coulomb/kg	C/kg
grey	Gy
sievert	Sv

Energy, Work, Heat

The electron volt (eV) is the kinetic energy an electron gains from being accelerated through the potential difference of one volt in an electric field. The Mev is the kinetic energy it gains from being accelerated through a million-volt potential difference.

The last two items in this table are not properly energy units but are included for convenience. They arise from the relativistic mass-energy equivalence formula $E = mc^2$, and represent the energy released if a kilogram or atomic mass unit (amu) is destroyed completely.

	Btu	erg	ft-lb	hp-hr	JOULES	Cal	kw-hr	ev	Mev	kg	amu
1 British thermal unit =	1	1.055×10^{10}	777.9	3.929×10^{-4}	1055	252.0	2.930×10^{-4}	6.585×10^{21}	6.585×10^{15}	1.174×10^{-14}	7.074×10^{12}
1 erg =	9.481×10^{-11}	1	7.376×10^{-8}	3.725×10^{-14}	10^{-7}	2.389×10^{-8}	2.778×10^{-14}	6.242×10^{11}	6.242×10^{5}	1.113×10^{-24}	670.5
1 foot-pound =	1.285×10^{-3}	1.356×10^{7}	1	5.051×10^{-7}	1.356	0.324	3.766×10^{-7}	8.464×10^{18}	8.464×10^{12}	1.509×10^{-17}	9.092×10^{9}
1 horsepower-hour=	2545	2.685×10^{13}	1.980×10^{6}	1	2.685×10^{6}	6.414×10^{5}	0.7457	1.676×10^{25}	1.676×10^{19}	2.988×10^{-11}	1.800×10^{16}
1 Joule =	9.481×10^{-4}	10^{7}	0.7376	3.725×10^{-7}	1	0.239	2.778×10^{-7}	6.242×10^{18}	6.242×10^{12}	1.113×10^{-17}	6.705×10^{9}
1 calorie =	3.968×10^{-3}	4.186×10^{7}	3.087	1.559×10^{-6}	4.186	1	1.163×10^{-6}	2.613×10^{19}	2.613×10^{13}	4.659×10^{-17}	2.807×10^{10}
1 kilowatt-hour =	3413	3.6×10^{13}	2.655×10^{6}	1.341	3.6×10^{6}	8.601×10^{5}	1	2.247×10^{25}	2.270×10^{19}	4.007×10^{-11}	2.414×10^{16}
1 electron volt =	1.519×10^{-22}	1.602×10^{-12}	1.182×10^{-19}	5.967×10^{-26}	1.602×10^{-19}	3.827×10^{-20}	4.450×10^{-26}	1	10^{-6}	1.783×10^{-36}	1.074×10^{-9}
1 million electron volts=	1.519×10^{-16}	1.602×10^{-6}	1.182×10^{-13}	5.967×10^{-20}	1.602×10^{-13}	3.827×10^{-14}	4.450×10^{-20}	10^{6}	1	1.783×10^{-30}	1.074×10^{-3}
1 kilogram =	8.521×10^{13}	8.987×10^{23}	6.629×10^{16}	3.348×10^{10}	8.897×10^{16}	2.147×10^{16}	2.497×10^{10}	5.610×10^{35}	5.610×10^{29}	1	6.025×10^{26}
1 atomic mass unit =	1.415×10^{-13}	1.492×10^{-3}	1.100×10^{-10}	5.558×10^{-17}	1.492×10^{-10}	3.564×10^{-11}	4.145×10^{-17}	9.31×10^{8}	931.0	1.660×10^{-27}	1

1 m-kgf = 9.807 joules 1 watt-sec = 1 joule = 1 nt-m 1 cm-dyne = 1 erg

Electromagnetic Spectrum

Rays	Frequency	Wave-length	Photon Energy
Cosmic rays	10^{23}Hz	10^{-11}cm	below$10^{8}$to 10^{20}eV
γ-rays	$6x10^{20}$to 10^{18} Hz	$10^{-10}$to 10^{-8}cm	$10^{5}$to 10^{7} eV
X - rays	$6x10^{19}$to $6x10^{15}$Hz	$10^{-9}$to 10^{-5}cm	10 to 10^{5}eV
Ultra-violet	$2x10^{16}$to $8x10^{14}$Hz	$1.4x10^{-6}$to$4x10^{-5}$cm	1 to 10^{2}eV
Visible	$8x10^{14}$to $4x10^{14}$Hz	$4x10^{-5}$to $8x10^{-5}$cm	1 eV
Infra-red(heat radiation)	$4x10^{14}$to $3x10^{11}$Hz	$8x10^{-5}$to 0.04 cm	$10^{-3}$to 1 eV
Microwaves	$10^{13}$to 10^{9} Hz	10^{-6} to 10^{-4}cm	10^{-2} to 10^{-3}
Electrical radio waves	$10^{13}$to 10^{3} Hz	0.01cm to 100 Km	$10^{-10}$to 10^{-1}eV
TV, Radar	7 x $10^{9}$to 2 x10^{6}Hz	$4x10^{-1}$to $3.5x10^{-4}$m	10^{-3} to 10^{-10}eV
Micropulsation	-----	$1x10^{8}$ to $5x10^{10}$ m	10^{-14} to 10^{-17} eV

Spectrum of visible portion

Colour of light	Wavelength $x10^{-7}$m	Frequency $x10^{14}$Hz
Red	6.470 to 7.000	4.634 to 4.284
Orange	5.850 to 6.470	5.125 to 4.634
Yellow	5.750 to 5.850	5.215 to 5.125
Green	4.912 to 5.750	6.104 to 5.215
Blue	4.240 to 4.912	7.115 to 6.104
Violet	4.000 to 4.240	7.495 to 7.115

Radio and TV waves

	Range	Frequency	Wave-length
TV	UHF	$2.1x10^{8}$to $6.9x10^{9}$	.1 to 1 m
TV	VHF	$5x10^{7}$to $1.2x10^{8}$	1 to 10 m
TV	HF (or VL)	$2x10^{6}$to $4x10^{7}$	10 to 100 m
Radio	FM(frequency modulation)	$8.8x10^{7}$to $1.08x10^{8}$	1 to 10 m
Radio	MW	$5.3x10^{5}$to $1.605x10^{6}$	200 to 550 m
Radio	SW 1 (MF)	$2.3x10^{6}$to $7.0x10^{6}$	49 to 120 m
Radio	SW 2 (MF)	$7.0x10^{6}$to $22.0x10^{6}$	13 to 41 m
	LF	$3x10^{4}$to $3x10^{5}$	1000 to 10,000 m
	VLF	$3x10^{3}$to $3x10^{4}$	10,000 to 100,000 m
	ELF(extremely)	--- to $3x10^{3}$	100,000 to ----- m

Luminous Efficiency

Source	Luminous Efficiency (lumens/watt)	lumens
tungsten lamp (watts):		
40	11	440
75	14	1,050
100	15	1,500
mercury vapour (watts):		
150 (low)	13	1,950
400 (High)	30	12,000
sodium vapour, 220 watts	50	11,000
fluorescent lamp (watts):		
10	40	400
30	50	1,500
40	60	2,400

Length of light waves (specific colours)

Very dark red	0.00081 mm	Green	0.00052 mm
Red	0.00065 mm	Bluish green	0.00050 mm
Reddish orange	0.00064 mm	Blue	0.00047 mm
Orange	0.00060 mm	Indigo	0.00043 mm
Yellow	0.00058 mm	Violet	0.00041 mm

The Electromagnetic Spectrum (Specific characteristics)

Name	Type of transition	Characteristic temperature ($h\nu/k$, °K)	Artificial production	Detection
Gamma rays	Nuclear	10^9 to 10^{10}	Betatron	Geiger and Scintillation Counters, Ionization Chamber
X-rays	Inner Electron	10^8	X-ray tube	" " "
Ultraviolet radiation	" "	10^6 to 10^7	" "	" " "
Visible light	Outer Electron	10^4 to 10^5	Gas discharge, Arcs, Sparks	Photoelectric and Photomultiplier Cells
Infrared radiation	Molecular vibration	10^2 to 10^3	Hot filaments	Bolometer, Thermopile
Microwaves	Molecular rotation	10	Magnetron, Klystron, Traveling-wave tube	Crystal
FM and TV broadcasting	Electron Spin	10^{-1} to 1	Electrical circuit, AC Generator	Electrical circuit
AM broadcasting	Nuclear Spin			

The 100-year Journey toward Absolute Zero

Date	Investigator	Country	Development	Temp. °K
1860	Kirk	Scotland	First step toward deep refrigeration: reached temperatures below freezing point of Hg.	234.0
1877	Cailletet	France	First liquefied oxygen: used throttling process from pressure vessel, obtaining fine mist only.	90.2
1884	Wroblewski & Olzewski	Poland	First property measurements at low temperatures: used small quantities of liquid N_2 and O_2.	77.3
1898	Dewar	England	First liquefied hydrogen: used Joule-Kelvin effect and counterflow heat exchanger.	20.4
1908	Kamerlingh-Onnes	Netherlands	First liquefied helium: used same method as Dewar; shortly thereafter, lowered pressure over liquid to get 1°K.	4.2
1927	Simon	Germany & England	Developed helium liquefier: used adiabatic expansion from pressure vessel with liquid H_2 precooling.	4.2
1933	Giauque & MacDougall	U.S.	First adiabatic demagnetization: Principle first proposed by Giauque and Debye in 1926.	0.25
1934	Kapitza	England & U.S.S.R.	Developed helium liquefier using expansion engine: Made possible liquefaction of helium without liquid H_2 precooling.	4.2
1946	Collins	U.S.	Developed commercial helium liquefier: used expansion engines and counterflow heat exchangers.	2.0
1956	Simon & Kurti	England	First nuclear experiments: used adiabatic demagnetization of nuclear stage of a paramagnetic salt.	10^{-5}
1960	Kurti	England	Reached lowest temperature so far: Nuclear cooling methods.	10^{-6}

Cooling Agents

First constituent	Second constituent	Lowest temperature, °C
NH_4Cl	Ice	-15.4
NaCl (1 part)	Ice(2parts)	-21
Alcohol	Ice	-30
$CaCl_2 \cdot 6H_2O$(4parts)	Ice(3parts)	-55
Alcohol	Solid CO_2	-72
Ether	Solid CO_2	-77
Liquid Oxygen	----	-183
Liquid Nitrogen	----	-196
Liquid Helium	----	-269

The order of magnitude of various time intervals ranging from the longest to the shortest. The representative intervals are approximate.

6×10^{17} Seconds	Age of universe
2×10^{17}	Age of earth
2×10^{13}	Time of man on earth
2×10^{11}	Age of human civilization
2×10^{9}	Human lifetime
3×10^{7}	One year
9×10^{4}	One day
5×10^{2}	Light travels from sun to earth
8×10^{-1}	Time between heartbeats
1×10^{-5}	Duration of stroke flash
3×10^{-9}	Light travels one meter
2×10^{-16}	Half-life of charged pion
4×10^{-19}	Light crosses atom
2×10^{-23}	Light crosses small nucleus

The order of magnitude of some distances observable in the physical world.

2×10^{26} Meters	"Radius of Universe
2×10^{22}	Distance to nearest galaxy
4×10^{16}	Distance to nearest star
2×10^{11}	Distance to sun
7×10^{8}	Radius of sun
6×10^{6}	Radius of earth
1×10^{4}	Highest mountain
1×10^{2}	Football field
2×10^{0}	Man
1×10^{-4}	Thickness of paper
1×10^{-8}	Small virus
5×10^{-11}	Diameter of atom
1×10^{-15}	"Radius of proton

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Some Temperatures
(°K)

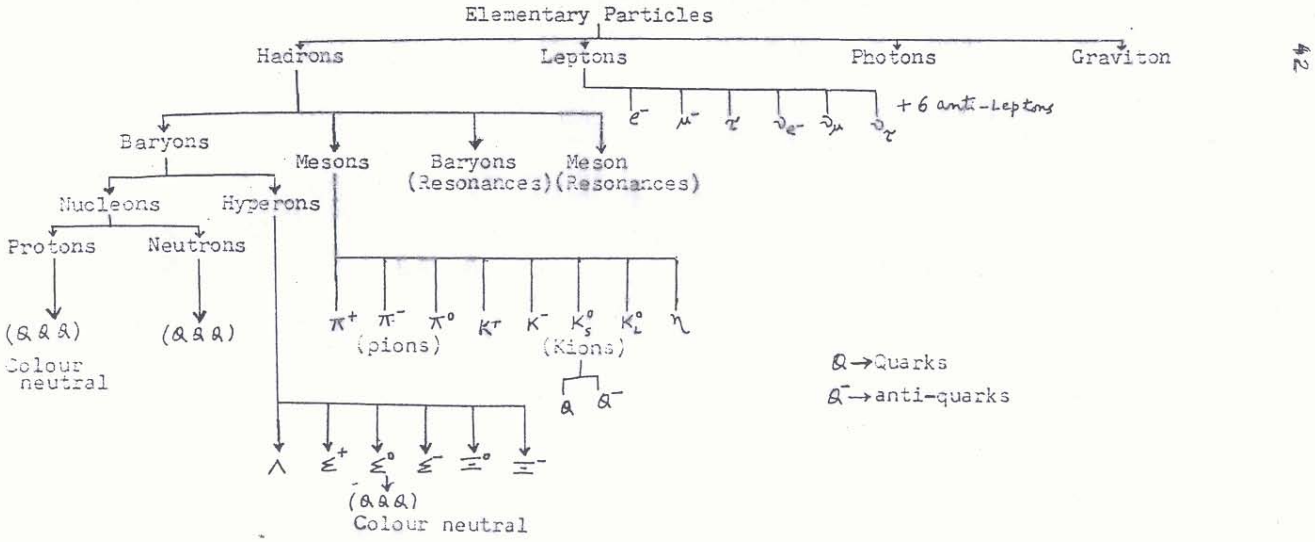
Carbon thermonuclear reaction	5×10^{8}
Helium thermonuclear reaction	10^{8}
Solar interior	10^{7}
Solar corona	10^{6}
Shock wave in air at Mach 20	2.5×10^{4}
Luminous nebulae	10^{4}
Solar surface	6×10^{3}
Tungsten melts	3.6×10^{3}
Lead melts	6.0×10^{2}
Water freezes	2.7×10^{2}
Oxygen boils (1 atm)	9.0×10^{1}
Hydrogen boils (1 atm)	2.0×10^{1}
Helium (He^{4}) boils at 1 atm	4.2
He^{3} boils at attainable low pressure	3.0×10^{-1}
Adiabat. demag. of paramag. salts	10^{-3}
Adiabatic demagnetization of nuclei	10^{-6}

Elementary Particles

Particle Name	Symbol	Mass (GeV)	Mass (electron masses)	Electric charge	Mean life (sec.)
BARYONS					
Proton	p	0.93826	1,836	+1	stable ($>2.5\times10^{38}$)
Neutron	n	0.93955	1,837	0	1.01×10^{3}
Lambda Hyperon	Λ°	1.1156	2,180	0	2.5×10^{-10}
Sigma Hyperon	Σ^{+}	1.1974	2,300	-1	0.8×10^{-10}
Sigma Hyperon	Σ°	1.1926	2,290	0	less than 10^{-14}
Sigma Hyperon	Σ^{-}	1.1974	2,300	-1	1.65×10^{-10}
Xi Hyperon	Ξ°	1.315	2,590	0	3×10^{-10}
Xi Hyperon	Ξ^{-1}	1.321	2,600	-1	1.7×10^{-10}
MESONS					
Pi meson (Pion)	$\pi^{\pm}$	0.13958	273	+1	2.61×10^{-8}
Pi meson	π°	0.13497	264	0	0.9×10^{-16}
Kappa meson (Kion)	$K^{\pm}$	0.4938	920-960	±1	1.23×10^{-8}
Kion short lived	K_s°	0.4978	974	0	0.87×10^{-10}
Kion long lived	K_L°	0.4978	974	0	5.2×10^{-8}
Eta meson	η	0.5486	1070	0	———
Theta meson	θ°		965	0	1.5×10^{-10}
Theta meson	$\theta^{\pm}$		955	±1	10^{-9}
LEPTONS		Mass at rest $\{ MeV/c^2 \}$			
Electron neutrino	ν_e	about 0		0	stable
Electron	e or e^-	0.511		-1	stable
Muon neutrino	ν_μ	about		0	stable
Muon	μ or μ^-	106.6		-1	2.2×10^{-6}
Tau neutrino	ν_τ	less than 164		0	stable
Tau	τ or τ^-	1,784		-1	
QUARKS		Mass/GeV			
Up	u	0.35	310	$+\frac{2}{3}$	
Down	d	0.35	310	-1/3	
Charm	c	1.5	1,500	+2/3	
Strange	s	0.5	505	-1/3	
Top/Truth	t	30-50	>22,500 Hypothetical particle	$+\frac{2}{3}$	
Bottom/Beauty	b	4.7	about 5,000	-1/3	

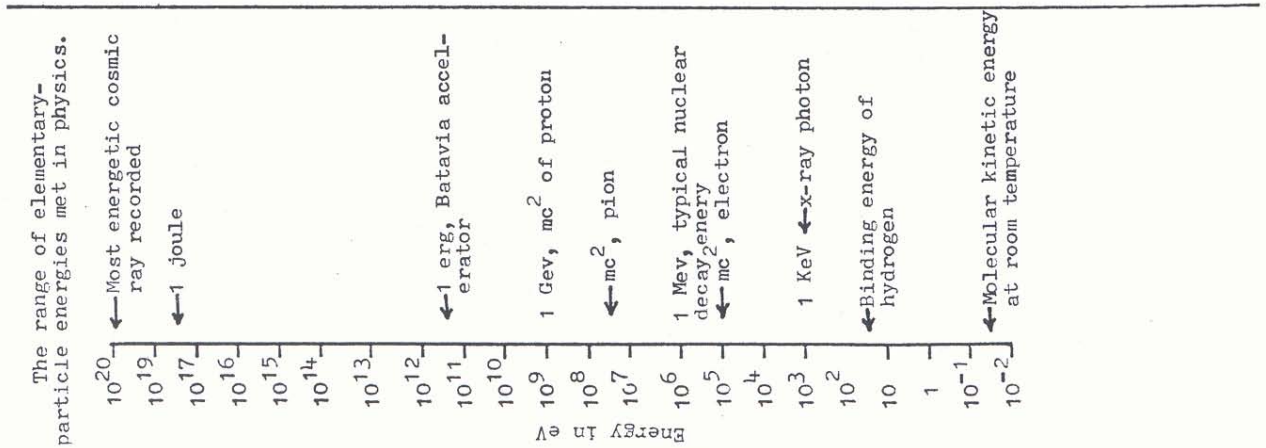
Fundamental Forces

Name of the force	Range	Strength at 10^{-13} cm in comparison with the strong force	Source	Name of carrier	Mass at rest (GeV/c^2)	Spin	Electric charge	Life time (sec.)	Remarks
Gravity	Infinite	10^{-38}	Mass	Graviton	0	2	0	—	Hypothetical or Conjectu
Electro-magnetism	Infinite	10^{-2}	Electric charge	Photon	0	1	0	10^{-20}	Observed directly
Weak force	$<10^{-16}$cm	10^{-13}	"Weak charge"	Intermediate Boson: W^+	81	1	+1	10^{-8}	All three observed directly
				W^-	81	1	-1		
				Z°	93	1	0		
Strong force	$<10^{-13}$cm	1	"Colour charge"	Gluons	0	1	0	10^{-21}	Permanent confinec



Planets of Solar System

Planet	Distance from the Sun $x10^9$ m	Equatorial radius in proportion to the Earth	Volume in proport. to Earth	Period of revolution	Period of rotation
Mercury	46-70	0.38	0.05	88 days	58.6 days
Venus	107-109	0.95	0.89	224.7 days	243.17 days
Earth	147-152	1.00	1.00	365.25 days	23.93 hours
Mars	207-249	0.53	0.15	1 year, 321 days	24.62 hours
Jupiter	741-816	10.77	1,300.00	11 years, 314.13 days	9.94 hours
Saturn	1347-1507	9.01	750.00	29 years, 168 days	10.33 hours
Uranus	2734-3004	3.93	55.00	84 years, 3.66 days	10.83 hours
Neptune	4462-4534	3.87	47.00	164 years, 288.56 days	15.82 hours
Pluto	4431-7369	0.31	0.03	248 years, 157 days	6.38 days



Fundamental Constants

Velocity of light, c and radio waves	$= 2.9979 \times 10^{8} ms^{-1} = 186{,}000$ miles/s
Elementary charge, e	$= 1.6021 \times 10^{-19} C$
Electron rest mass, m_e	$= 9.1091 \times 10^{-31} kg$
Proton rest mass, m_p	$= 1.6725 \times 10^{-27} kg = 1.008$ amu $= 1836$ electron masses
Neutron rest mass, m_n	$= 1.6748 \times 10^{-27} kg = 1837$ electron masses
Planck's constant, h	$= 6.6256 \times 10^{-34}$ J.s.
e/m for electron, e/m_e	$= 1.7588 \times 10^{11} kg^{-1} C$
Rydberg constant, R	$= 1.0974 \times 10^{7} m^{-1}$
Avogadro constant, N_o, No. of molecules/gm-mol.	$= 6.0225 \times 10^{23} mol^{-1}$
Boltzmann constant, $k=R/N_o$	$= 1.3805 \times 10^{-23} J\ K^{o-1}$
Universal gas constant, R	$= 8.3143\ J\ K^{o-1} mol^{-1}$
Vacuum permittivity, ϵ_o	$= 8.8544 \times 10^{-12}\ N^{-1} m^{-2} C^{2}$
Vacuum permeability,	$= 1.3566 \times 10^{-6}\ m\ kg\ C^{-2}$
Acceleration of gravity, g	$= 9.7805\ ms^{-2}$
Gravitational constant, G	$= 6.673 \times 10^{-11}\ N\text{-}m^{2}/kg^{2}$
The Faraday, F	$= 96{,}520\ C\ gm^{-1} mol^{-1}$
One atomic mass unit $(c^2)\mu$	$= 1.66 \times 10^{-27} kg = 931$ Mev $= 1.49 \times 10^{-10}$ J
Heat of fusion of ice	$= 336000\ J\ kg^{-1}$
Heat of vaporization of water	$= 2263800\ J\ kg^{-1}$
1 electron volt	$= 1.501 \times 10^{-12}$ erg
Ratio of proton mass to electron mass, m_p/m_e	$= 1836.14$
Radius of the Earth	$= 6.4 \times 10^{6} m = 3959$ miles
Mass of the Earth	$= 6 \times 10^{24} kg$
Stefan-Boltzmann const.	$= 5.6697 \times 10^{-8}\ W\ m^{-2} K^{o-4}$
Mean orbital speed of earth	$= 29{,}770$ m/sec $= 18.50$ miles/sec
Mean angular speed of rotation of earth	$= 7.29 \times 10^{-5}$ radians/sec
Bohr magneton, $\mu_B = eh/2m_e$	$= 9.274 \times 10^{-24}\ J\ T^{-1}$
nuclear magneton, $\mu_N = \frac{eh}{2m_p}$	$= 5.051 \times 10^{-27} JT^{-1}$
neutron-hydrogen atom mass difference $m_n - M_H$	$= 0.782\ MeV/c^{2}$

Standard Prefixes

Multiple and Submultiple units; as a result of the Eleventh General Conference on Weights and Measures (1960), as amended in 1962 by the Executive Board.

Prefix	Symbol	Multiplication Factor
atto	a	10^{-18}
femto	f	10^{-15}
pico (or micromicro)		10^{-12}
nano (or millimicro)	n, m	10^{-9}
micro		10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}
'no prefix'	----	1
deka	da	10
hecto	h	10^{2}
kilo	k	10^{3}
mega	M	10^{6}
giga (or kilomega)	G	10^{9}
tera (or megamega)	T, MM	10^{12}
peta	P	10^{15}
exa	E	10^{18}

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fermi = 1×10^{-15} m

angstrom, A° = 1×10^{-10} m

Beaufort scale

A wind scale introduced by Admiral Sir Francis Beaufort (1774-1857) in which numbers represent the wind velocity. The scale is first mentioned in the admiral's diary in January 1806 and its general use was suggested in an article in the *Nautical Magazine* in 1832. The Navy adopted the scale in 1838 and the Board of Trade have used it since 1862.

The scale is given in the following Table.

The Beaufort wind scale

Number	Description	Wind speed (miles / hour)
0	Calm	< 1
1	Light air	1 - 3
2	Light breeze	4 - 7
3	Gentle breeze	8 - 12
4	Moderate breeze	13 – 18
5	Fresh breeze	19 – 24
6	Strong breeze	25 – 31
7	Moderate gale	32 – 38
8	Fresh gale	39 – 46
9	Strong gale	47 – 54
10	Whole gale	55 – 63
11	Storm	64 – 72
12	Hurricane	> 72

The number on the Beaufort scale is someties called the Beaufort number B and is related to the wind velocity V in miles per hour by the empirical formula

$V = 1.87\, B^{3/2}$.

THE EARTH

Variation of properties with depth

Zone	Depth(km)	Density(kg m^{-1})	g(m S^{-2})
	0	2600	9.82
	60	3390	9.85
	150	3400	9.88
	350	3580	9.95
Mantle	500	3830	9.98
	1000	4560	9.96
	1500	4825	9.92
	2000	5080	10.01
	2886	⌈ 5520	10.74
	//	⌊ 9900	//
	3500	10680	9.32
	4000	11410	7.96
Core	4500	11850	6.64
	5000	12200	4.80
	5150	⌈ 12280	4.62
Inner	//	⌊ 13000	//
Core	6371	13500	0

Other physical constants

Land	area	1.49×10^{14} m^2 (29.2 % of Earth's surface)
	mean height	840 m
	greatest height	8840 m
Oceans:	area	3.61×10^{14} m^2 (70.8 % of Earth's surface)
	mean depth	3800 m
	greatest depth	10550 m
Atmosphere:	mass	5.27×10^{18} kg (10^{-6} of Earth's mass)

Areas and depths of the oceans

Oceans	Area($mile^2$)	Greatest depth (ft)
Pacific	86,634,000	30,000
Atlantic	41,324,000	27,365
Indian	29,340,000	18,582
Antarctic	7,500,000	25,200
Arctic	4,000,000	9,000

Composition of the atmosphere

(Parts in 10^6 of dry air by volume)

N_2	O_2	A	Co_2	Ne	He	CH_4	Kr
780900	209500	9300	300	18	5.2	1.5	1.14
N_2O	H_2	O_3	Xe				
0.5	0.5	0.4	0.086				

Some Gravity Base Stations*

Some gravity base stations established by the Geological Survey of Pakistan up to 1963 are listed in the table below. Karachi Air Port gravity Station has been tied to Teddington and Washington Pendulum Stations (Woolard, 1950). They have started laying out gravity base lines connected to gravity value of 978.9630 cm/sec^2 at Karachi Air Port. It is taken for base connections in Pakistan, in order to affect the projected schedule of preparing regional gravity maps of the country. It is an extension work carried out by Survey of Pakistan, the Geophysical Institute and Punjab University.

Measurements were made with a temperature controlled Worden Gravimeter, Master Model No. 551. The calibration factor of 0.2547 milli-gals/scale [gals = cm/sec^2] division was determined by the manufacturers using their standard practice on pendulum bases near Houston (U.S.A.).

Station (place)	'g'(cm/sec^2)	Station (place)	'g'(cm/sec^2)
Bahawalpur (CMH)	979.2021	Malakwal (Railway Station)	979.4743
Bannu (Mission Bungalow)	979.3470	Mandi Bahauddin(// //)	979.4012
Bhalwal (Civil Rest House)	979.4225	Mansehra (Dak Bungalow)	979.2452
Chiniot (PWD bungalow)	979.4617	Multan (Air Port)	979.2553
Dera Ghazi Khan(// //)	979.1976	Muree (Survey of Pakistan)	979.0440
Dinga(Islamia High School)	979.3938	Peshawar(Air Port)	979.3950
Ghotki (Railway Station)	978.1502	Rabwah (Railway Station)	979.4733
Gujar Khan (// //)	979.3329	Islamabad (Air Port)	979.3501
Hyderabad (// //)	979.9750	Sadiqabad(at 264.29 elev)	979.1510
Jhang(Police Line Compound)	979.3719	Sargodha (Air Port)	979.4680
Jhelum(B.M.in Cantt. Church)	979.3828	Sahiwal (Railway Station)	979.3254
Kabir Wala(Dak Bungalow)	979.2847	Burewala (obs-g-)	979.2802
Lahore(Air Port)	979.3920	Kharian (Forest Office)	979.3781
Mangla(Dam Rest House)	979.3718	Jalalpur Jattan(obs-g-)	979.3688

To find 'actual value' of *g* at your place :

1) By repeated method: i.e. take repeated readings by the freefall or the simple pendulum method , then take their average value.
2) Make a standard reading: i.e. take average reading of many efficient students of your lab constituting many months back.
3) By Gravimeter: Arrange to bring some standard gravimeter from a Geophysicists and take the precise value of 'g' at your place.

* Special Courtesies to Russell Nazir Ullah, Director, Geological Survey of Pakistan, Quetta, who helped to get reach the records of Geological Survey of Pakistan, (Vol. XI, Part 2).

THE 24 NEAREST STARS

Name	Distance light-years	Transverse velocity km/sec	Absolute magnitude
Sun			+4.8
α Centauri	4.3	23	4.7
Barnard's star	6.0	90	13.2
Wolf 359	7.7	54	16.6
Luyten 726-8	7.9	38	15.6
Lalande 21185	8.2	57	10.5
Sirus	8.7	16	11.6
Ross 154	9.3	9	13.3
Ross 248	10.3	23	14.7
∈ Eri	10.8	15	6.2
Ross 128	10.9	22	13.5
61 Cyg	11.1	84	7.9
Luyten 789-6	11.2	53	14.5
Procyon	11.3	20	13.1
∈ Indi	11.4	77	7.0
Σ 2398	11.6	38	11.1
Groombr. 34	11.7	49	10.3
τ Cet	11.8	33	5.8
Lacaille 9352	11.9	118	9.4
+5° 1668	12.4	67	12.0
Lacaille 8760	12.8	64	8.6
Kapertyn's star	13.0	166	11.2
Ross 614	13.1	18	13.1
Kruger 60	13.1	16	13.4

Important Space Probes

Name	Launch date	Comments
Pioneer 5	March 11, 1959	First deep-space probe; magnetic fields and cosmic rays
Mariner 2	August 26, 1962	Venus probe
Mariner 4	Nov 28, 1964	Mars encounter, photography, magnetic fields, cosmic rays
Luna 9	Jan 31, 1966	First photographs of lunar surface
Surveyor 1	May 30, 1966	Soft landing on moon; environmental data and photography
Mariner 5	June 14, 1967	Venus probe; atmospheric and magnetospheric data
Mariner 6	Feb 25, 1969	Photography and analysis of surface and atmosphere of Mars
Venera 7	Aug 17, 1970	Lander capsule transmitted 23 min from surface of Venus
Luna 16	Sept 12, 1970	Reentered Sept 24, uncrewed Moon lander touched down on Sea of Fertility Sept 20, returned lunar soil samples
Mars 2	May 19, 1971	First Soviet Mars landing
Luna 20	Feb 14, 1972	Recovered Feb 25, returned lunar sample
Pioneer 10	March 2, 1972	Jupiter encounter; transjovian interplanetary probe
Venera 8	March 27, 1972	Venus landing July 22, 1972
Mariner 10	Nov 3, 1973	Venus and Mercury encounter
Helios	Dec 10, 1974	Close solar probe
Viking 2	Sep 9, 1975	Mars lander and orbiter
Voyoger 2	Aug 20, 1977	Continuing to Uranus and Neptune…
Voyager 1	Sep 5, 1977	Returned encounter information concerning Jupiter, Saturn, and their satellites and rings
Pioneer Venus Multi-Probe Bus	Aug 8, 1978	Penetration of Venus atmosphere by four probes, returned atmospheric data

The American astronaut Ed Aldrin, pilot of the Apollo 11 expedition, the first to land men on the Moon on 21 July 1969, photographed by his colleague Neil Armstrong in front of the American flag planted in the lunar soil.

The most important manned spaceflights

mission	date	crew	details of the flight
VOSTOK-VOSKHOD PROGRAMME (RUSSIAN)			
Vostok 1	12 April 1961	Y. Gagarin	Oribital flight of 1 h 48 min; first man sent into space.
Vostok 6	16-19 June 1963	V. Tereshkova	First and only woman astronaut to date.
Voskhod 2	18-19 March 1965	P. Belyaev, A. Leonov	Multi-manned space capsule; first space walk by an astronaut(Leonov) for about 10 min.
MERCURY PROGRAMME (AMERICAN)			
Mercury 6	20 February 1962	J. Glenn	Oribital flight; First American astronaut; lasted 4 h 55 min.
GEMINI PROGRAMME (AMERICAN)			
Gemini 3	23 March 1965	V. Grissom, J. Young	First American multi-manned capsule.
Gemini 4	3-7 June 1965	J. McDivitt, E. White	White left capsule for 20 min; tests of guidance and navigation systems.
Gemini 8	16-17 March 1966	N. Armstrong, D. Scott	First docking in orbit with a rocket (Agena).
APOLLO PROGRAMME (AMERICAN)			
Appollo 8	21-27 December1968	F. Borman, J. Lovell, W. Anders	Manned oribital test flight around the Moon, experiments in changing lunar orbits.
Appollo 11	16-24 July 1969	N. Armstrong, E. Aldrin M. Collins	First Moon landing on 21 July; Moon walk by Armstrong and Aldrin; samples of lunar rocks taken.
Appollo 17	7-19 December1972	E. Cernan, R. Evans, H. Schmitt	Landing of Cernan and Schmitt on the Moon; stayed for 75 h;exploration and collection of many rock samples; installation of instruments to measure seismic phenomena and radiation.
DOCKING APPOLLO 18-SOYUZ	15-22July 1975	V. Brand, D. Slayton, T. Stafford	Joint American and Soviet Appollo-Soyuz programme: Apollo caught up and docked with Soyuz which was already in oribit on 17 July; exchange of equipment and joint work; separated on 19 July.
SOYUZ PROGRAMME (RUSSIAN)			
Soyuz 6	11-16 October 1969	G. Shonin, V.	The three spacecraft, after meeting in oribit, were used for experiments; electric welding expts conducted first time in space.
Soyuz 7	12-17 October 1969	Kubasov, A.Filipchenko, Volk,	
Soyuz 8	13-18 October 1969	Gorbat, Yeli.	
Soyuz 35	8 April-11 October 1980	L. Popov, V. Ryumin	The spacecraft docked with oribital station Salyut 6; crew remained for 185 days without a break.

Crewed space flights 1961–1981* (cont.)

Dates launched and recovered	Designation and crew	Weight, lb	Revolutions	Max. distance from Earth, mi	Duration	Remarks
1978 (cont.)						
June 27–July 5	*Soyuz 30* Pyotr I. Klimuk Mirosiav Hermaszewski	14,400	125	225	7 days 22 h 4 min	Crew transferred to *Salyut 6* to join *Soyuz 29* crew. Second non-Soviet cosmonaut Hermaszewski (Poland).
Aug. 26–Nov. 2	*Soyuz 31* Valery F. Bykovsky Sigmund Jaehn	14,400	1070	221	67 days 20 h 14 min Crew duration: 7 days 20 hr 49 min	Crew transferred to *Salyut 6* to join *Soyuz 29* crew. Third non-Soviet cosmonaut: Jaehn (East Germany). Crew returned with *Soyuz 29* spacecraft.
1979						
Feb. 25–June 13	*Soyuz 32* Vladimir Lyakhov Valery Ryumin	14,400	1711	232	108 days 4 h 24 min Crew duration: 175 days	Crew transferred to *Salyut 6* to establish new endurance record (175 days). Returned on Aug. 19 with *Soyuz 34*. *Soyuz 32* returned uncrewed. Resupplied by *Progress 5* (launched Mar. 12) and *Progress 6* (launched May 13).
Apr. 10–12	*Soyuz 33* Nikolai Rukavishnikov Georgi Ivanov	14,400	31	221	1 day 23 h 1 min	Docking with *Salyut 6* failed. Crew returned to Earth. Fourth non-Soviet cosmonaut: Ivanov (Bulgaria).
June 6–Aug. 19	*Soyuz 34*	14,400	1152	257	73 days 18 h 17 min	Launched uncrewed and docked to *Salyut 6*. Returned *Soyuz 32* crew. Resupplied by *Progress 7* (launched June 28). New type of uncrewed Soyuz (*Soyuz T1*) launched Dec. 16 on flight test to dock with *Salyut 6*.
1980						
Apr. 9–June 3	*Soyuz 35* Leonid Popov Valery Ryumin	14,400	869	220	55 days 22 min Crew duration: 184 days 20 h 12 min	Crew transferred to *Salyut 6* for record-duration mission (184 days). Returned Oct. 11 with *Soyuz 37* spacecraft. Resupplied by: *Progress 8* (launched Mar. 27), *Progress 9* (launched Apr. 27), *Progress 10* (launched June 29), *Progress 11* (launched Sept. 28).
May 26–July 31	*Soyuz 36* Valery Kubasov Bertalan Farkas	14,400	1040	220	65 days 20 h 54 min	Crew transferred to *Salyut 6* to join with *Soyuz 35* crew. Returned June 3 with *Soyuz 35* spacecraft. Fifth non-Soviet cosmonaut: Farkas (Hungary).
June 5–9	*Soyuz T2* Yuriy Malyshev Vladimir Aksenov	14,400	62	220	3 days 22 h 41 min	First crewed test of new type spacecraft. Crew transferred to *Salyut 6* on June 6. Tenth crewed visit to *Salyut 6*.
July 23–Oct. 11	*Soyuz 37* Viktor V. Gorbatko Pham Tuan	14,400	1258	220	79 days 15 h 17 min Crew duration: 7 days 20 h 42 min	Crew transferred to *Salyut 6* on July 25 to join with *Soyuz 35* crew. Returned July 31 with *Soyuz 36* spacecraft. Sixth non-Soviet cosmonaut: Pham Tuan (Vietnam).
Sept. 18–26	*Soyuz 38* Yuri Romanenko Arnaldo T. Mendez	14,400	124	220	7 days 20 h 43 min	Crew transferred to *Salyut 6* to joint with *Soyuz 35* crew. Returned Sept. 26 with *Soyuz 38* spacecraft. Seventh non-Soviet cosmonaut: Mendez (Cuba).
Nov. 27–Dec. 10	*Soyuz T3* Leonid Kizim Oleg G. Makarov Gennady Strekalov	14,400	202	220	12 days 19 h 8 min	Crew transferred to *Salyut 6*. Thirteenth crewed visit to *Salyut 6*. First three-person mission since ill-fated *Soyuz 11* in 1971. Returned Dec. 10. *Salyut 6* resupplied by *Progress 12* (launched Jan. 24).
1981						
Mar. 12–May 26	*Soyuz T4* Vladimir Kovalyonok Viktor Savinykh	14,400	1183	220	75 days	Crew transferred to *Salyut 6* on Mar. 14. Savinykh became 100th human to go into space (43 U.S. astronauts, 57 East-bloc cosmonauts).
Mar. 22–30	*Soyuz 39* Vladimir Dzhanibekov J. Gurragcha	14,400	125	220	7 days 20 h 43 min	Crew transferred to *Salyut 6* on Mar. 23 to join with *Soyuz T4* crew. Returned on Mar. 30 with *Soyuz 39*. Eighth non-Soviet cosmonaut: Gurragcha (Mongolia).
Apr. 12–14	STS-1 John Young Robert Crippen	205,000	36	172	2 days 6 h 20 min 52 s	First crewed orbital test flight of the U.S. space shuttle *Columbia*. After a two-day delay due to an on-board computer anomaly, mission launched at 7 a.m. EST for a full, successful orbital check of the revolutionary reusable spacecraft and its many subsystems. Return to Earth, featuring atmospheric entry at Mach 25, hypersonic/supersonic maneuvering flight and subsonic unpowered landing at Edwards AFB, California, was celebrated by millions around the world. Time of landing on Apr. 14: 1:20 p.m. EST.
May 14–22	*Soyuz 40* Leonid Popov Dumitru Prunariu	14,400	124	220	7 days 20 h 41 min	Crew transferred to *Salyut 6* on May 15 to join with *Soyuz T4* crew. Returned May 22 with *Soyuz 40*. Ninth non-Soviet cosmonaut: Prunariu (Romania).

*1 lb = 0.45 kg. 1 mi = 1.6 km. 1 ft = 0.3 m. 1 yd = 0.9 m. 1 fathom = 1.8 m. 1 psi = 6.9 kilopascals.

Mathematical signs and symbols

$<$ less than
$>$ greater than
$\leq$ less than or equal to
$\geq$ greater than or equal to
$=$ equals
$\equiv$ identical with
$\approx$ approximately equals
$\sim$ similar to
$\equiv$ congruent
$\neq$ not equal to
$\rightarrow$ approaches
$\propto$ proportionate
∞ infinity
$||$ parallel to
( ) parenthese
{ } brackets
[ ] braces
Π pi = 3.142
$\angle$ angle
Δ (delta) difference
∇ del or nabla, vector differential operator
∇^2 Laplacian operator
5! factorial 5 = 5x4x3x2x1

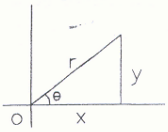
Number
% percentage
Δx increment of x
dx/dt derivative of x w.r.t. to t
$\partial x/\partial t$ partial derivative of x w.r.t. t
$\int$ integral of
$\int_b^a$ absolute integral between a & b
$f(x)$ function of x
e^x exponential of x
$\in$ belongs to
$\notin$ not belongs to
$\wedge$ average of
$\Rightarrow$ implies that
$\sqrt{}$ square root of
$\forall$ for all
$\therefore$ therefore
$\log_{10} u$ logarithm of u to the base 10
ln u natural logarithm of u (to the base e)

Greek Alphabets

A	α	alpha
B	β	beta
Γ	γ	gamma
Δ	δ	delta
E	ϵ	epsilon
Z	ζ	zeta
H	η	eta
Θ	θ	theta
I	ι	iota
K	κ	kappa
Λ	λ	lambda
M	μ	mu
N	ν	nu
Ξ	ξ	xi
O	o	omicron
Π	π	pi
P	ρ	rho
Σ	σ	sigma
T	τ	tau
Υ	υ	upsilon
Φ	ϕ φ	phi
X	χ	chi
Ψ	ψ	psi
Ω	ω	omega

Trigonometry

Special Definitions:



$\sin\theta$ = opposite / hypotenuse = y / r

$\cos\theta$ = base / hypotenuse = x / r

$\tan\theta$ = opposite / base = y /x

for circular functions:

$\sin\theta = (e^{t\theta} - e^{-t\theta}) / 2t$ $\quad\quad$ $\cos\theta = (e^{t\theta} + e^{-t\theta}) / 2$

$\tan\theta = \sin\theta / \cos\theta$

$\sin\theta = \theta - \theta^3/3! + \theta^5/5! - \theta^7/7! + \ldots$

$\cos\theta = 1 - \theta^2/2! + \theta^4/4! - \theta^6/6! + \ldots$

$\tan\theta = \theta + \theta^3/3! + (2/15)\theta^6 + \ldots$

Few Identities:

$\sin^2\theta + \cos^2\theta = 1$ $\quad\quad$ $\sin 2\alpha = 2\sin\alpha\cos\alpha$

$\tan\theta = \sin\theta / \cos\theta$ $\quad\quad$ $2\sin^2\theta/2 = 1 - \cos\theta$

Relations :

$\sin(\alpha + \beta) = \sin\alpha\cos\beta + \cos\alpha\sin\beta$

$\sin(\alpha - \beta) = \sin\alpha\cos\beta - \cos\alpha\sin\beta$

$\cos(\alpha + \beta) = \cos\alpha\cos\beta - \sin\alpha\sin\beta$

$\cos(\alpha - \beta) = \cos\alpha\cos\beta + \sin\alpha\sin\beta$

$\sin(-\theta) = -\sin\theta$ $\quad\quad$ $\cos(-\theta) = \cos\theta$ $\quad\quad$ $\tan(-\theta) = -\tan\theta$

The Four Quadrants:

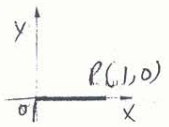
The two axes of the rectangular coordinate system divide the plane into four parts.

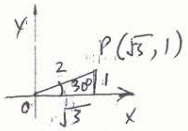
Y	
Second Quadrant	First Quadrant
X	
Third Quadrant	Fourth Quadrant

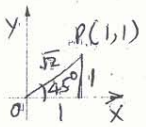
Signs of Trigonometric Functions:

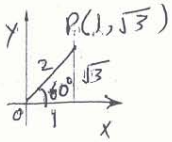
II Sin θ + ve Cosec θ + ve	I All Positive
III Tan θ + ve Cot θ +ve	IV Cos θ + ve Sec θ + ve

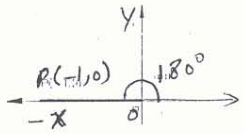
Functions of 0° , 30° , 45° , 60° , 90° , 180°











$\sin 0^\circ = 0/1 = 0$	$\cos 0^\circ = 1/1 = 1$	$\tan 0^\circ = 0/1 = 0$
$\sin 30^\circ = 1/2$	$\cos 30^\circ = \sqrt{3}/2$	$\tan 30^\circ = 1/\sqrt{3}$
$\sin 45^\circ = 1/\sqrt{2}$	$\cos 45^\circ = 1/\sqrt{2}$	$\tan 45^\circ = 1/1 = 1$
$\sin 60^\circ = \sqrt{3}/2$	$\cos 60^\circ = 1/2$	$\tan 60^\circ = \sqrt{3}/1 = \sqrt{3}$
$\sin 90^\circ = 1/1 = 1$	$\cos 90^\circ = 0/1 = 0$	$\tan 90^\circ$ is not defined
$\sin 180^\circ = 0/-1 = 1$	$\cos 180^\circ = -1/1 = -1$	$\tan 180^\circ = 0/1 = 0$

Exponential Function

Consider a function f(x) given by the infinite series

$$1 + x + x^2/2! + x^3/3! + x^4/4! + x^5/5! + \ldots \quad (1)$$

for x = 1, the value of the above function is

$$1 + 1 + 1/2! + 1/3! + 1/4! + 1/5! + \ldots \quad (2)$$

we use the symbol e to denote the sum of the series (2),

$$e = 1 + 1 + 1/2 + 1/3.2 + 1/4.3.2 + \ldots\ldots$$
$$= 1 + 1 + 0.5 + 0.16667 + 0.04167 + 0.00833 + \ldots.$$
$$= 2.718 \text{ approximately}$$

we can have

$$e^x = 1 + x + x^2/2! + x^3/3! + x^4/4! + \ldots\ldots \quad (3)$$

Just as the number Π is expected to make its appearance whenever we make calculations involving circles or allied curves, in the same manner we expect the exponential function to be presented in the study of those natural phenomena where the rate of change of a quantity is proportional to the quantity itself. Examples of the latter are the bacterial growth, decomposition of a radioactive substance, and motion when resistance is proportional to the velocity.

Logarithm:

The logarithm of a number x to the base a is the exponent y that the base must raised to produce the number.

For example ,

$$\log_{10}(10^4) = 4$$

Equations,

$$\log_e x = y$$
$$x = e^y$$

Illustration:

Consider

$$(1, 10, 100, 1000, 10{,}000)$$
or $$1, 10^1, 10^2, 10^3, 10^4$$

the logs of the above elements are

$$0, 1, 2, 3, 4$$

Example:

Our ear works on logarithmic scale. For example, a sound of 10 times larger intensity will be just twice of first intensity, similarly, 1000 time larger will be just three times of its first intensity.

Calculus

Calculus: *Branch of mathematics that permits the manipulation of continuously varying quantities, applicable to practical problems.*

Integral Calculus: *The branch of calculus making use of the processes of summation of infinitesimally small elements.*

Differential Calculus: *A branch of pure mathematics that deals with continuously varying quantities.*

Differential Calculus is based on the purely arithmetical ideas of number and the theory of limits. Its main object is to estimate the rate of growth of changing quantities.

If $y = f(x)$ be a function of x, then

$$Lt_{\delta x \to 0} \frac{f(x + \delta x) - f(x)}{\delta x}$$

is called the differential coefficient of f(x) and is denoted by dy /dx. It is also called the derivative of the function $y = f(x)$. Thus the derivative of $y = f(x)$ is given by,

$$dy/dx = d/dx\,[f(x)] = Lt_{\delta x \to 0} \frac{f(x + \delta x) - f(x)}{\delta x}$$

Employing this process in determining the derivative of a function, means, finding the derivative from definition, or first principles, or ab-initio.

Functions of several Independent Variables:

These are common, for instance, the area of a triangle depends upon two variables, viz., the base and the altitude; while the volume of a rectangular box depends upon three variables, viz., its length, breadth, and depth; and it is plain that each of these variables may vary independently of others.

Partial Differential Coefficients:

The partial derivative of $z = f(x,y)$ with respect to x is the ordinary differential coefficient of f(x,y) when y is regarded as a constant. It is written as:

$$\partial z/\partial x \text{ or } \partial f/\partial x \text{ or } f_x$$

Thus $$\partial f/\partial x = Lt_{\delta x \to 0} \frac{f(x + \delta x, y) - f(x,y)}{\delta x}$$

Partial derivatives of higher orders:

We can form partial derivatives of $\partial z/\partial x$ and $\partial z/\partial y$.

Thus we

$$\partial/\partial x(\partial z/\partial x), \quad \partial/\partial y(\partial z/\partial x)$$

which are called the second order partial derivatives of z and are denoted by

$$\partial^2 z/\partial x^2, \quad \partial^2 z/\partial y\,\partial x \text{ or } f_x^2, \quad f_{yx}$$

Laplace's Equation:

The operator $\partial^2/\partial x^2 + \partial^2/\partial y^2 + \partial^2/\partial z^2$ $(\equiv \nabla^2)$ plays a fundamental part in the Higher Physical Analysis.

The equation $\nabla^2 V = 0$ is called Laplace's equation; and any homogeneous function of x, y, z which satisfies it, is called a Spherical Harmonic.

It is customary to denote $x^2 + y^2 + z^2$ by r^2.

The differential operator ∇:

The differential operator ∇ called 'del' was introduced by Sir William Rowan Hamilton

$$\bar{\nabla} = \underline{i}\,\partial/\partial x + \underline{j}\,\partial/\partial y + \underline{k}\,\partial/\partial z$$

Standard Formulae for Differentiation & Integration

$\frac{d(c)}{dx} = 0$ $\qquad \frac{d(x)}{dx} = 1$ $\qquad \int 1.dx = x$ $\qquad \int (0)\,dx = C$

$\frac{d(x^n)}{dx} = n x^{n-1}$ $\qquad \int x^n\,dx = x^{n+1}/(n+1)$

$\frac{d(a^x)}{dx} = a^x \log_e a$ $\qquad \int a^x\,dx = a^x/\log_e a$

$\frac{d(e^x)}{dx} = e^x$ $\qquad \int e^x\,dx = e^x$

$\frac{d(\log_a x)}{dx} = (1/x)\log_a e$ $\qquad \frac{d(\log_e x)}{dx} = 1/x$ $\qquad \int (1/x)\,dx = \log_e x$, or $= \log_a x / \log_a e$

$\frac{d(\sin x)}{dx} = \cos x$ $\qquad \int \cos x\,dx = \sin x$

$\frac{d(\cos x)}{dx} = -\sin x$ $\qquad \int \sin x\,dx = -\cos x$

$\frac{d(\tan x)}{dx} = \sec^2 x$ $\qquad \int \sec^2 x\,dx = \tan x$

$\frac{d(\cot x)}{dx} = -\operatorname{cosec}^2 x$ $\qquad \int \operatorname{cosec}^2 x\,dx = -\cot x$

$\frac{d(\sec x)}{dx} = \sec x \tan x$ $\qquad \int \sec x \tan x\,dx = \sec x$

$\frac{d(\operatorname{cosec} x)}{dx} = -\operatorname{cosec} x \cot x$ $\qquad \int \operatorname{cosec} x \cot x\,dx = -\operatorname{cosec} x$

$\frac{d(\log \sec x)}{dx} = \tan x$ $\qquad \int \tan x\,dx = \log \sec x$

$\frac{d(\log \sin x)}{dx} = \cot x$ $\qquad \int \cot x\,dx = \log \sin x$

$\left.\begin{matrix}\frac{d(\sin^{-1} x/a)}{dx} = 1/\sqrt{(a^2 - x^2)} \\ \frac{d(\cos^{-1} x/a)}{dx} = -1/\sqrt{(a^2 - x^2)}\end{matrix}\right\}$ $\qquad \int dx/\sqrt{(a^2 - x^2)} = \sin^{-1} x/a$ or $-\cos^{-1} x/a$

$\left.\begin{matrix}\frac{d(\tan^{-1} x/a)}{dx} = 1/(a^2 + x^2) \\ \frac{d(\cot^{-1} x/a)}{dx} = -1/(a^2 + x^2)\end{matrix}\right\}$ $\qquad \int dx/(a^2 + x^2) = \tan^{-1} x/a$ or $-\cot^{-1} x/a$

$\left.\begin{matrix}\frac{d(1/a \sec^{-1} x/a)}{dx} = 1/x\sqrt{(x^2 - a^2)} \\ \frac{d(1/a \operatorname{cosec}^{-1} x/a)}{dx} = -1/x\sqrt{(x^2 - a^2)}\end{matrix}\right\}$ $\qquad \int dx/x\sqrt{x^2 - a^2} = (1/a)\sec^{-1} x/a$ or $-(1/a)\operatorname{cosec}^{-1} x/a$

$\frac{d(\operatorname{vers}^{-1} x)}{dx} = 1/\sqrt{(2x - x^2)}$ $\qquad \int dx/\sqrt{2x - x^2} = \operatorname{vers}^{-1} x$

$\frac{d(\operatorname{covers}^{-1} x)}{dx} = -1/\sqrt{(2x - x^2)}$ $\qquad$ or $-\operatorname{covers}^{-1} x$

COMMON LOGARITHMS

N	0	1	2	3	4	5	6	7	8	9
0		0000	0301	0477	0602	0699	0778	0845	0903	0954
1	0000	0414	0792	1139	1461	1761	2041	2304	2553	2788
2	3010	3222	3424	3617	3802	3979	4150	4314	4472	4624
3	4771	4914	5051	5185	5315	5441	5563	5682	5798	5911
4	6021	6128	6232	6335	6435	6532	6628	6721	6812	6902
5	6990	7076	7160	7243	7324	7404	7482	7559	7634	7709
6	7782	7853	7924	7993	8062	8129	8195	8261	8325	8388
7	8451	8513	8573	8633	8692	8751	8808	8865	8921	8976
8	9031	9085	9138	9191	9243	9294	9345	9395	9445	9494
9	9542	9590	9638	9685	9731	9777	9823	9868	9912	9956
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067

N	0	1	2	3	4	5	6	7	8	9
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996
100	0000	0004	0009	0013	0017	0022	0026	0030	0035	0039

N	0	1	2	3	4	5	6	7	8	9

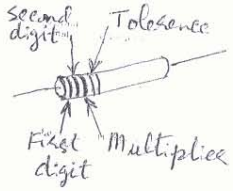
NATURAL TRIGONOMETRIC FUNCTIONS

Angle		Sine	Cosine	Tangent
Degree	Radian			
0°	.000	0.000	1.000	0.000
1°	.017	.017	1.000	.017
2°	.035	.035	0.999	.035
3°	.052	.052	.999	.052
4°	.070	.070	.998	.070
5°	.087	.087	.996	.087
6°	.105	.104	.994	.105
7°	.122	.122	.992	.123
8°	.140	.139	.990	.140
9°	.157	.156	.988	.158
10°	.174	.174	.985	.176
11°	.192	.191	.982	.194
12°	.209	.208	.978	.212
13°	.227	.225	.974	.231
14°	.244	.242	.970	.249
15°	.262	.259	.966	.268
16°	.279	.276	.961	.287
17°	.297	.292	.956	.306
18°	.314	.309	.951	.325
19°	.332	.326	.946	.344
20°	.349	.342	.940	.364
21°	.366	.358	.934	.384
22°	.384	.375	.927	.404
23°	.401	.391	.920	.424
24°	.419	.407	.914	.445
25°	.436	.423	.906	.466
26°	.454	.438	.899	.488
27°	.471	.454	.891	.510
28°	.489	.470	.883	.532
29°	.506	.485	.875	.554
30°	.524	.500	.866	.577
31°	.541	.515	.857	.601
32°	.558	.530	.848	.625
33°	.576	.545	.839	.649
34°	.593	.559	.829	.674
35°	.611	.574	.819	.700
36°	.628	.588	.809	.726
37°	.646	.602	.799	.754
38°	.663	.616	.788	.781
39°	.681	.629	.777	.810
40°	.698	.643	.766	.839
41°	.716	.656	.755	.869
42°	.733	.669	.743	.900
43°	.750	.682	.731	.933
44°	.768	.695	.719	.966
45°	.785	.707	.707	1.000

Angle		Sine	Cosine	Tangent
Degree	Radian			
46°	0.803	0.719	0 695	1.036
47°	.820	.731	.682	1.072
48°	.838	.743	.669	1.111
49°	.855	.755	.656	1.150
50°	.873	.766	.643	1.192
51°	.890	.777	.629	1.235
52°	.908	.788	.616	1.280
53°	.925	.799	.602	1.327
54°	.942	.809	.588	1.376
55°	.960	.819	.574	1.428
56°	.977	.829	.559	1.483
57°	.995	.839	.545	1.540
58°	1.012	.848	.530	1.600
59°	1.030	.857	.515	1.664
60°	1.047	.866	.500	1.732
61°	1.065	.875	.485	1.804
62°	1.082	.883	.470	1.881
63°	1.100	.891	.454	1.963
64°	1.117	.899	.438	2.050
65°	1.134	.906	.423	2.145
66°	1.152	.914	.407	2.246
67°	1.169	.920	.391	2.356
68°	1.187	.927	.375	2.475
69°	1.204	.934	.358	2.605
70°	1.222	.940	.342	2.747
71°	1.239	.946	.326	2.904
72°	1.257	.951	.309	3.078
73°	1.274	.956	.292	3.271
74°	1.292	.961	.276	3.487
75°	1.309	.966	.259	3.732
76°	1.326	.970	.242	4.011
77°	1.344	.974	.225	4.331
78°	1.361	.978	.208	4.705
79°	1.379	.982	.191	5.145
80°	1.396	.985	.174	5.671
81°	1.414	.988	.156	6.314
82°	1.431	.990	.139	7.115
83°	1.449	.992	.122	8.144
84°	1.466	.994	.104	9.514
85°	1.484	.996	.087	11.43
86°	1.501	.998	.070	14.30
87°	1.518	.999	.052	19.08
88°	1.536	.999	.035	28.64
89°	1.553	1.000	.017	57.29
90°	1.571	1.000	.000	∞

Resistor and Capacitor Colour Codes

Coloured bands around the body of a resistor designate the nominal value of its resistance in ohms. Three coloured bands grouped toward one end of the resistor, fig.1, are interpreted as a number having two significant figures and a multiplier factor.



The band nearest the end of the resistor represents the first significant figure according according to the colour code in the able. The second band in the second significant figure, and the third band gives the number of zeros to add to determine the actual resistance. For example, a resistor whose bands are yellow , violet, and orange has a resistance of 47,000 ; green, blue green signifies 5,600,000 , or 5.6 M etc. Resistor values between 1 and 10 are indicated by a gold third band, while a silver third band means the resistance is between 0.1 and 1 .

A fourth band of either gold or silver tells the tolerance, or limit of accuracy, of the resistance value. A gold band indicates the the tolerance is ± 5 percent, which means that the actual resistance may be any value within 5 percent of the nominal value. Similarly, a silver band signifies a tolerance of ±10 percent. If the fourth band is absent, the tolerance is understood to be ± 20 percent.

Table: Resistor Colour Code

Colour	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

Capacitor colour codes are not as universally accepted as is the case for resistors. The codes used differ somewhat among manufacturers and many manufacturers print the numerical value of capacitance on the body of the unit. Nevertheless, the majority of mica and ceramic tubular capacitors used the same colour code as in the Table, to indicate the nominal capacitance value in picofarads, fig.2. For example, red, violet, red signifies 2700 pf or 0.0027 uf; orange, orange, black means 33 pf, etc. Other coloured bands or dots are also used to indicate tolerance, temperature coefficient of capacitance, and other parameters. These also vary from manufacturer to manufacturer.

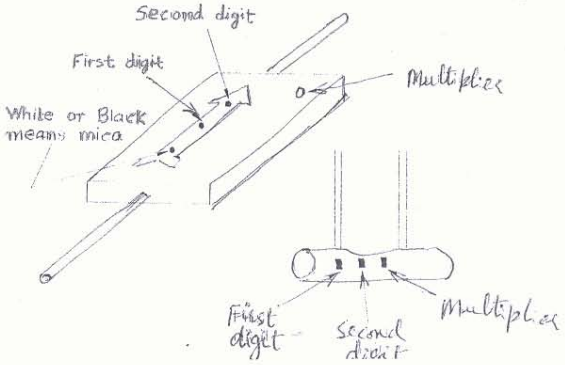


Fig.2:

Colour-code scheme for mica (above) and ceramic (below) capacitors.

List of Abbreviations

DNA	deoxyribonucleic acid
T_c	Transition temperature
Cusec	Cubic feet per second

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