

D. K. Singh

Dictionary of Mechanical Engineering

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*Dedicated to my parents, my wife Alka and
my daughters Shivangi and Shalvi.*

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I hope this book will prove to be very useful for all the readers in the field of Mechanical Engineering.

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3PL An *Operations Management* term; see **Third-Party Logistics**.

4PL An *Operations Management* term; see **Fourth-Party Logistics**.

5S An *Operations Management* term; see **Five S**.

6 σ An *Operations Management* term related to *quality*; see **Six Sigma Approach**.

80/20 Rule An *Operations Management* term; see **Pareto Analysis**.

α -Particle A *Physics* term; see **Alpha Particle**.

β -Particle A *Physics* term; see **Beta Particle**.

γ -Alloy A *Materials Engineering* term; see **Gamma-Alloy**.

ABC Analysis An *Operations Management* term related to *inventory*; a selective inventory control technique which uses *Pareto principle* to classify the inventories into three categories: *A*, *B*, and *C* class items based on the value of consumption of items; *A group inventories* include high-valued items in small volume, represent about 10–20% of the total inventory items but account for about 70–80% of the total inventory cost (e.g. *finished goods*, the most expensive items); *B group inventories* include medium-valued items in moderate volume, represent about 30% of the total inventory items but account for about 15–25% of the total cost (e.g. *semi-finished goods*); *C group inventories* include low-valued items in large volume, represent about 50–60% of the total inventory items but account for only 5% of the total cost (e.g. *spare parts*, the least expensive items); this analysis helps in identifying the few items which are very expensive and require careful watch, scrutiny and follow-up.

ABMA American Bearing Manufacturers Association; an *American* professional body.

Abraham Harold Maslow (1908–1970) A prominent humanistic psychologist who proposed the famous '*Need-hierarchy theory*' of motivation which is based on a hierarchy of five human needs, namely *physiological*, *safety*, *social*, *esteem*, and *self-actualization*.

Abrasion A *Manufacturing* term; a process in which surfaces of a material are subjected to continuous grinding, rubbing or gouging action due to the presence of a foreign material.

Abrasive Water Jet Machining A *Nonconventional Machining* term, abbreviated as **AWJM**; a nonconventional machining process which uses a high-pressure *abrasive-mixed water jet* to remove materials from a workpiece; offers high material removal rate as compared to water jet machining (WJM); can cut metallic, non-metallic, and advanced composite materials of various thicknesses; particularly suitable for *heat sensitive materials*, hence is widely used in *aerospace, automotive, and electronic industries*.

Abrasive Wear A *Manufacturing* term; a type of wear which occurs when a rough, hard surface slides on a softer surface; appears in the form of grooves on the softer surface; see also **Adhesive Wear** and **Corrosive Wear**.

Absolute Coefficient of Viscosity A *Fluid Mechanics* term; see **Dynamic Viscosity**.

Absolute Entropy A *Thermodynamics* term; the entropy determined relative to the absolute zero temperature (0 K).

Absolute Error A *Metrology* term; the magnitude of the difference between the arithmetic mean and the individual measured value of a physical quantity; given as:

$$\begin{aligned}
|\Delta a_1| &= a_m - a_1 \\
|\Delta a_2| &= a_m - a_2 \\
&\dots\dots\dots \\
|\Delta a_n| &= a_m - a_n
\end{aligned}$$

where $a_1, a_2, \dots a_n$ are the measured values of a physical quantity and a_m is their arithmetic mean, given as:

$$\begin{aligned}
a_m &= \frac{a_1 + a_2 + \dots + a_n}{n} \\
&= \frac{1}{n} \sum_{i=1}^{i=n} a_i; \text{ see also } \mathbf{Mean Absolute Error}.
\end{aligned}$$

Absolute Humidity A *Thermodynamics* term related to *psychrometry*; see **Specific Humidity**.

Absolute Pressure A *Fluid Mechanics* term; the total pressure exerted on a system including atmospheric pressure; equals to the sum of gauge pressure and atmospheric pressure; see also **Gauge Pressure** and **Vacuum**.

Absolute Temperature A *Thermodynamics* term; the temperature measured on the Kelvin scale; based on a hypothetical absolute zero temperature at which matter is devoid of all thermal energy.

Absolute Viscosity A *Fluid Mechanics* term; see **Dynamic Viscosity**.

Absolute Zero Temperature A *Thermodynamics* term; see **Absolute Zero**.

Absolute Zero A *Thermodynamics* term; also called **Absolute Zero Temperature**; a temperature of zero on the Kelvin scale (0 K); the temperature at which all the molecular motion ceases, according to the kinetic theory of gases; the lowest conceivable temperature, and the temperatures lower than this are not defined.

Absorption Dynamometer A *Theory of Machines* term; a type of dynamometer in which work done by a prime mover under test is converted into heat by friction and gets absorbed during measurement; particularly useful for measuring *power* or *torque* developed by *power sources* such as *engines* or *electric motors*; examples include *Prony brake dynamometer* and *rope brake dynamometer*; see also **Transmission Dynamometer**.

Absorption A *Thermodynamics* term; a process to absorb, especially heat; the transfer of one or more constituents from a gaseous mixture to a liquid, where the absorbed material may dissolve physically or react chemically; see also **Adsorption**.

Absorptivity A *Heat Transfer* term; a *radiation property* of the surface of a body which enables it to absorb a fraction of the radiation energy incident on it; depends on the temperature and the wavelength of the radiation; denoted by α (alpha); its value lies between 0 and 1; see also **Emissivity**.

AC An *Electrical* term; see **Alternating Current**.

Acceleration due to Gravity A *Physics* term; the force of gravity which acts on unit mass of a body placed on or near the surface of the earth; the acceleration set up in a body when it falls freely under the effect of gravity alone; a vector quantity which acts towards the centre of the earth; independent of shape, size, and mass of a body, but depends upon mass and radius of the earth; for example, two bodies of different masses, when allowed to fall from the same height in vacuum, will reach the earth at the same time; has maximum value at the surface of the earth (9.81 ms^{-2}), and becomes zero at the centre of the earth; decreases with both *height* and *depth* (the rate of decrease with height is twice as compared to that with depth); denoted by g ; given as:

$$g = \frac{GM}{R^2}$$

where

G = universal gravitational constant = $6.67 \times 10^{-11} \text{ N.m}^2.\text{kg}^{-2}$

M = mass of the earth

R = radius of the earth.

Acceleration A *Physics* term; the time rate of change of velocity; a ratio of the change in velocity to the time taken; a *vector quantity* having the direction of velocity; denoted by a ; given as:

$$a = \frac{\text{Change in Velocity}}{\text{Time interval}} = \frac{dV}{dt}$$

Acceptance Sampling A *Quality Control* term; a statistical quality control technique used to decide the acceptance or rejection of a shipment of input or output.

Accreditation A *Management* term; a certification issued by a duly recognized body regarding the *facilities, capability, competence, and integrity* of any *agency, service or operational group or individual* to provide the specific service(s) or operation(s) needed; *NBA* in India provides accreditation to educational institutions.

Accuracy A *Metrology* term; the closeness of the measured value of a physical quantity with its true value; used in conjunction with *precision*; see also **Precision**.

Acetone A *Chemistry* term; a liquid chemical having the chemical formula $\text{CH}_3\text{—CO—CH}_3$ (dimethyl ketone); has the property of absorbing or dissolving many times of its own volume of acetylene.

Acetylene A *Chemistry* term; a triple-bonded *unsaturated hydrocarbon* discovered by *Edmund Davy* (1785–1857) in the beginning of the nineteenth century; has the chemical formula C_2H_2 ; the most widely used of all the fuel gases; finds extensive applications in *oxyacetylene welding, heating, and cutting*; produced by the chemical reaction between *calcium carbide* (CaC_2) and hot water (H_2O).

Acheson Process A *Chemistry* term; a chemical process used to produce *graphite* artificially in large amounts; involves strong heating of a mixture of *silica* (SiO_2) and *powdered anthracite* (or coke) in an electric furnace continuously for 24–30 hr., which results in the formation of *silicon carbide* (SiC) which decomposes into *graphite* and *silicon*, the latter volatilizes off leaving behind graphite.

Acidic Flux A *Chemistry* and a *Welding* term; a flux used to remove basic impurities like *lime* (CaO) or *metallic oxides* (FeO , MnO , etc.) present in an ore; a few examples include *silica* (SiO_2) and *borax* ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$); see also **Basic Flux**.

Acidic Refractories A *Materials Engineering* term; refractories which readily combine with bases; *silica* is their main constituent; a few examples include *quartz, sand, and silica brick*; see also **Basic Refractories** and **Neutral Refractories**.

Acoustic Velocity A *Fluid Mechanics* term; see **Sonic Velocity**.

Acoustic-Emission Inspection A *Materials Engineering* term; see **Acoustic-Emission Testing**.

Acoustic-Emission Testing A *Materials Engineering* term; also called **Acoustic-Emission Inspection**; a *nondestructive testing* in which defects are monitored as a result of ultrasonic emissions caused by stressing the flawed material.

Acquisition Cost An *Operations Management* term; the cost of purchasing or producing a unit of a material or product.

Activated Alumina A *Materials Engineering* term; also called **Gamma-Al₂O₃** (γ -Al₂O₃); an oxide of *aluminium* (Al₂O₃); one of the two common anhydrous forms of alumina in which it exists in nature; readily dissolves in acids; finds use in *column chromatography*; see also **Corundum**.

Activated Charcoal A *Chemistry* term; an *amorphous* allotropic and active form of carbon; obtained by heating all other forms of charcoal at 1000 °C in a current of superheated steam to eliminate their pores which contain impurities such as residual hydrocarbons, oxygen, etc., thus making the resulting charcoal more active.

Active Pressure A *Civil Engineering* term; a *horizontal earth pressure* exerted by a soil mass against some restraining structures such as a *basement wall* or a *retaining wall*; see also **Passive Pressure**.

Activity Chart A *Motion Study* term; also called **Man–Machine Chart** or **Worker–Machine Chart** or **Operator–Machine Chart**; a chart used to study and improve the utilization of an operator (worker) and a machine or some combinations of operators (a crew) and machines; helpful for minimizing worker and machine delay and for determining the optimal number of machines assigned per worker.

Activity List A *Project Management* term; a list which contains all the activities in a project.

Activity A *Project Management* term; indicates the smallest unit of a work which consumes time, labour and material resources for its completion; see also **Event**.

Activity-on-Arc Network A *Project Management* term; see **AOA Network**.

Activity-on-Arrow Network A *Project Management* term; see **AOA Network**.

Activity-on-Node Network A *Project Management* term; see **AON Network**.

Actuator A *Mechatronics* term; a device used to transfer electrical, pneumatic or hydraulic energy into mechanical energy that moves or displaces something; a device which converts fluid pressure into mechanical motion for the purpose of moving a load.

Acute Triangle A *Mathematics* term; also called **Acute-Angled Triangle**; a triangle whose all the angles are acute, that is, less than 90°; see also **Obtuse Triangle**.

Acute-Angled Triangle A *Mathematics* term; see **Acute Triangle**.

Adam Smith A famous economist who introduced the '*division of labour*' in his book 'The Wealth of Nations' in 1776 to enhance a worker's productivity, which later became part of scientific management.

Adaptive Forecasting An *Operations Management* term related to *forecasting*; see **Exponential Smoothing Method**.

Addendum Circle A *Theory of Machines* term related to *gear*; a circle passing through the *tips* of all the gear teeth; its standard diameter equals to the pitch circle diameter plus 2 modules; see also **Dedendum Circle**.

Addendum A *Theory of Machines* term related to *gear*; the radial distance between the top land and the pitch circle of the gear or the height of a gear tooth *above the pitch circle*; has the standard value of *one module*; see also **Dedendum**.

Addition Polymerization A *Chemistry* term; also called **Chain-Growth Polymerization**; a polymerization process in which the molecules of the same or different monomers add together to form a large polymer molecule; unsaturated organic compounds undergo addition polymerization; a few examples include the formation of *polyethylene from ethylene* and the formation of *polyvinyl chloride (pvc) from vinyl chloride*; see also **Condensation Polymerization**.

Additive A *Materials Engineering* term; a material added to a polymer or other material to provide specific characteristics.

Adhesive Bonding A *Joining* term; a process of joining materials by means of an *adhesive*; the bond is due to molecular attraction between adhesive and the workpiece; useful to join *metals* with *non-metals*, *plastics*, or *composites*.

Adhesive Force A *Physics* term; also called **Force of Adhesion**; the *intermolecular force* acting between *molecules of different substances*; does not obey the inverse square law of forces; increases rapidly with decrease in distance between the molecules (varies inversely as the seventh power of the distance between the molecules); a few examples include *wetting of the surface of a glass container by water*, *writing impression left over by a lead pencil (graphite) on a paper*, and *glueing of two surfaces with the use of fevicol, cement*, etc.; see also **Cohesive Force**.

Adhesive Wear A *Manufacturing* term; a type of wear which occurs when *two smooth surfaces* slide over each other and the fragments are pulled off from one surface and adhere to another; see also **Abrasive Wear** and **Corrosive Wear**.

Adhesive A *Chemistry* term; a *polymeric material* used to join *polymers*, *metals*, *ceramics*, *composites* or combinations of these materials; finds applications in areas such as *automotive*, *aerospace*, *appliance*, *electronics*, *construction*, and *sporting equipment*.

Adiabatic Compression A *Thermodynamics* term; a compression process which does not involve any heat transfer; see also **Isentropic Compression**.

Adiabatic Expansion A *Thermodynamics* term; an expansion process which does not involve any heat transfer; see also **Isentropic Expansion**.

Adiabatic Process A *Thermodynamics* term; a thermodynamic process which does not allow heat transfer through a system (neither heat addition nor heat rejection); see also **Isentropic Process**.

Adiabatic Wall A *Thermodynamics* term; a wall which does not allow the flow of heat across it; see also **Diathermal Wall**.

Adjacent Sides A *Mathematics* term; any two sides starting or originating from the same initial point, (called *vertex*); see also **Opposite Sides**.

Adsorption A *Thermodynamics* term; the removal of impurities from a gas stream by concentration on the surface of a solid or liquid, where the substance that concentrates at the surface is termed adsorbate and the material on the surface of which the adsorption takes place is called adsorbent; see also Absorption.

Aerodynamics A *Fluid Mechanics* term; the study of the effect of air flow on bodies; finds extensive applications in the design of an aircraft.

Aerofoil A *Fluid Mechanics* term; a streamlined body that is designed to produce a streamlined flow pattern, when placed in the free stream of a fluid.

Aerosol A *Chemistry* term; a *colloidal system* in which the dispersion medium is a gas and the dispersed phase is a solid or liquid which is usually smaller than 50 micron in size.

AEV An *Electric Vehicle* term; see **Battery Electric Vehicle**.

AF An *IC Engine* term; see **Air–Fuel Ratio**.

Agate A *Chemistry* term; one of the three *naturally occurring amorphous forms* of silica (SiO_2), other two include *Jasper* and *Onyx*.

Aggregate Plan An *Operations Management* term; a statement which shows the production rates, the work-force levels, and the inventory holdings based on the estimates of customer requirements and capacity limitations of a production system.

Aggregate Planning An *Operations Management* term; see **Aggregate Production Planning**.

Aggregate Production Planning An *Operations Management* term, abbreviated as **APP**; also called simply **Aggregate Planning**; a production plan which helps to arrive at the quantity and timing of resources to be made available to a production system to ensure continuous flow of goods and services to customers; serves the critical role of translating the business plans and strategic intent to operational decisions.

AGMA The short form of *American Gear Manufacturers Association*; an *American* professional body which is the responsible authority for the dissemination of knowledge pertaining to the design and analysis of gearing.

AGV A *Manufacturing* term; see **Automatic Guided Vehicle**.

AI See **Artificial Intelligence**.

Air Preheater A *Power Plant* term related to a *boiler*; an important *boiler accessory* used to extract (absorb) heat from the hot flue gases in the furnace (going as waste) and use it to preheat the air required for combustion; increases the overall boiler efficiency by 5–10%.

Air Standard Cycle A *Thermodynamics* term; a theoretical thermodynamic cycle used in the analysis of internal combustion engines such as petrol, diesel and semi-diesel engines or gas turbine engines; a closed cycle which uses *air* as the working fluid (treated as an ideal gas), and all the processes used in the cycle are reversible; a few examples include *Otto*, *Diesel*, *Dual*, and *Brayton* cycles.

Air-Cooled Condenser A *Power Plant* term; a condenser which uses air as the condensing medium; see also **Water-Cooled Condenser** and **Evaporative Condenser**.

Air-Dried Moulding A *Casting* term; a moulding method in which the surface of a sand mould is dried by leaving the mould in the air.

Air–Fuel Ratio An *IC Engine* term; abbreviated as **AF**; a ratio of the *mass of air* to the *mass of fuel*; see also **Fuel–Air Ratio**.

AISI Short form of American Iron and Steel Institute; an *American* Professional body.

Alclad A *Materials Engineering* term; an alloy of *aluminium* (Al) formed of a thin layer coating (approx. 5% of the thickness) of *pure aluminium* or copper-free aluminium alloys over *duralumin*; produced by *Alcoa* in the form of *sheets* and *plates*; has high corrosion resistant.

All-Electric Vehicle An *Electric Vehicle* term, abbreviated as *AEV*; see **Battery Electric Vehicle**.

Allotropy A *Chemistry* term; the phenomenon of existence of an element in two or more forms which have different *physical properties*, but *identical chemical properties*; for example, carbon (C) exists in both crystalline and amorphous allotropic forms, where carbon's crystalline allotropic forms include *diamond*, *graphite*, and *fullerene*, whereas its amorphous allotropic forms include *coke*, *charcoal*, and *lamp black*.

Allowance Time A *Time Study* term; also called **Fraction Time**: the fraction of time added to the normal time for a job to calculate its standard time; factors such as *worker's fatigue, rest periods* or *unavoidable delays* during working period are included in allowance time, and each is about 20–30% of normal time.

Allowance A *Design* term; the minimum stated clearance or the maximum stated interference for the mating parts; see also **Clearance** and **Interference**.

Alloy Steel A *Materials Engineering* term; a *ferrous* material which contains alloying elements in substantial amounts other than carbon to modify its properties substantially; addition of alloying elements not only overcomes the deficiencies and limitations of plain carbon steels, but also improves their other properties so as to make them extremely useful for industrial applications; classified into *low alloy* and *high alloy* steels, depending upon less than or more than 10% alloy content; a typical example includes *stainless steel*.

Alloy A *Chemistry* term; a material made of two or more elements, one of which is a *metal*; has properties different from its constituents; has metallic characteristics; *steel* is an alloy of *iron* (Fe) and *carbon* (C).

Alloyed Cast Iron A *Materials Engineering* term; the cast iron obtained by adding alloying elements such as *chromium, copper, nickel, and molybdenum* in various proportions.

Alpha Error A *Quality Control* term; see **Type I Error**.

Alpha Particle A *Physics* term, abbreviated as **α -Particle**; consists of a large number of *helium ions* (He^{+2}), each having two units of positive charge and 4 times heavier than *hydrogen* (H) atoms; see also **Beta Particle**.

Alpha Ray A *Physics* term; an *electromagnetic radiation* discovered by *Ernest Rutherford* (1871–1937), a New Zealand physicist who is known as the ‘*father of nuclear physics*’; emitted by radioactive substances such as *uranium* (U), *plutonium* (Pu), and *thorium* (Th); consist of *helium* (He) particles each having two units of positive charge (He^{+2}) and is 4 times as heavy as *hydrogen* (H) atom; moves with a very high velocity of over 16,000 km/s; can ionize the gas through which it passes; see also **Beta Ray** and **Gamma Ray**.

Alpha- Al_2O_3 ($\alpha\text{-Al}_2\text{O}_3$) A *Materials Engineering* term; see **Corundum**.

Alternating Current An *Electrical* term, abbreviated as **AC**; a type of electrical current whose polarity changes in a fixed interval of time and has positive and negative values alternatively; flows in *one direction* during any half cycle and in reversed direction during the next half cycle; see also **Direct Current**.

Altitude In *triangle* terms, the perpendicular drawn from any vertex of a triangle to its opposite side; in *mechanics* terms, the height of an object from the earth’s surface.

Alumina (Al₂O₃) A *Chemistry* term; an *oxide of aluminium* produced by heating aluminium in oxygen; a white or nearly colourless crystalline substance used as a starting material for smelting of aluminium metal; two common forms of anhydrous alumina include α -Al₂O₃ (also called **Corundum**) and γ -Al₂O₃ (also called **Activated Alumina**).

Aluminium Bronze A *Chemistry* term; a heat-treatable *copper-base* alloy containing up to 12% aluminium (Al) along with *copper* (Cu); has *better strength* and *improved corrosion resistance* over brass.

Aluminum A *Chemistry* term; a *metallic element* having symbol *Al* with atomic number 13; a bluish-white *nonferrous metal* having a brilliant lustre which is soon destroyed due to formation of an oxide layer; the most abundant (approx. 8.3% by mass) metal in the earth's crust, and also the third most abundant element in the earth's crust after oxygen (46.6%) and silicon (27.7%); very weak and soft in pure form, but when mixed with small amounts of other alloying elements, its tensile strength, yield strength and hardness can be increased; its principal alloying elements include copper, silicon, manganese, magnesium, and occasionally zinc, nickel and chromium; a very light metal (specific gravity 2.7 as compared to iron's specific gravity of 7.86, thus making it *lighter than iron by one-third for an equivalent volume*); melts at 659 °C and boils at 2450 °C; a malleable and ductile metal which can be rolled into sheets, foils and wires; its important ores include bauxite (Al₂O₃.H₂O), cryolite (Na₃AlF₆), and corundum (Al₂O₃), but is generally extracted from *bauxite*; *pure aluminium is not affected by pure water*, but impure form is readily corroded by water containing salts; being lighter in weight, it finds use in making household *utensils*, *aeroplane parts*, and *precision and surgical instruments*; also used extensively in *paint as a paint pigment* and for *transporting nitric acid* (HNO₃) as it is not attacked by nitric acid; generally replaces steel and cast iron, where there is a strong need for light weight, corrosion resistance, low maintenance cost or high thermal and electrical conductivity; also used in making body parts, engine blocks, pistons, manifolds and transmission cases in modern motor vehicles in order to ensure fuel economy because of its low weight; its important alloys include *duralumin*, *alclad*, and *γ -alloy*.

Ambient Temperature A *Thermodynamics* term; also called **Sink Temperature**; the temperature (usually of the air) surrounding an operating system; the lowest temperature in the surroundings.

Amethyst A *Chemistry* term; a coloured (purple) *variety of quartz used as a gem*; see also **Jasper** and **Opal**.

Ammonia A *Chemistry* term; also called **Azane**; an inorganic compound of *nitrogen* and *hydrogen* having molecular formula NH₃; industrially produced by *Haber process*; a colourless gas with a characteristic pungent smell and is both caustic and hazardous; extensively used in the manufacture of HNO₃ and important fertilizers such as *ammonium sulphate*, *urea*, *calcium ammonium nitrate*, *ammonium calcium phosphate*; also used as a *cleaning agent*; a widely used *refrigerant* for industrial applications in *ice plants*, *large cold storage*, and *skating rinks*.

Amorphous Materials A *Materials Engineering* term; also called **Noncrystalline Materials**; the materials which do not have a regular periodic arrangement of constituent atoms; for example, *glass* and *clay*; see also **Crystalline Materials**.

Amorphous A *Chemistry* term; an atomic structure in which atoms are not orderly arranged; similar to *noncrystalline structure*.

Amplifier An *Electronics* term; a device used to increase electrical current.

Amplitude A *Physics* term; the distance between the equilibrium position (the mean position) and an extreme position of an oscillation which represents the maximum displacement.

amu A *Chemistry* term; see **Atomic Mass Unit**.

Analog-to-Digital Converter An *Electrical* term, abbreviated as ADC; the conversion of an analog signal to a digital quantity such as binary; see also **Digital-to-Analog Converter**.

Andon An *Operations Management* term; a *warning light system* installed at each assembly line of the workstation; used as a *visible control technique* in *total quality control* (TQC); uses different colours to signify the different types of assistance and support required at the workstation; for example, green colour indicates that the assembly line has no problem, red colour indicates the machine breakdown, white colour indicates the end of a production run, blue colour indicates about a defective unit, and yellow colour indicates about the requirement of a set-up; when an *Andon* light glows, the nearby operators quickly move to assist and solve the problem.

Aneroid Barometer A *Fluid Mechanics* term; a mechanical device used to measure *relatively low pressures* using the elastic deformation of a corrugated diaphragm; see also **Bourdon Gauge**.

Angle of Action A *Cam and Follower* term; the sum of the angle of ascent, angle of descent, and angle of dwell; see also **Angle of Ascent**, **Angle of Dwell**, and **Angle of Descent**.

Angle of Ascent A *Cam and Follower* term; the angle moved by the cam from the instant the follower begins to rise till it reaches its highest position; see also **Angle of Descent**, **Angle of Dwell**, and **Angle of Action**.

Angle of Contact A *Fluid Mechanics* term; the angle made inside a liquid between the tangent to the solid surface and the tangent to the liquid surface at the point of contact between solid and liquid; its value for contact between *pure water* and *clean glass* is zero, for contact between *ordinary water* and *glass* is about 8° , for contact between *water* and *silver* is 90° and for contact between *mercury* and *glass* is 135° .

Angle of Descent A *Cam and Follower* term; the angle moved by the cam during which the follower returns to its initial position; see also **Angle of Ascent**, **Angle of Dwell**, and **Angle of Action**.

Angle of Dwell A *Cam and Follower* term; the angle moved by the cam during which the follower remains in the highest position; see also **Angle of Ascent**, **Angle of Descent**, and **Angle of Action**.

Angle of Friction A *Physics* term; the angle which the resultant of the force of limiting friction and the normal reaction between any two surfaces in contact makes with the direction of normal reaction; equals to the *angle of repose*; its tangent is equal to the coefficient of static friction; see also **Angle of Repose**.

Angle of Obliquity A *Theory of Machines* term related to *gear*; see **Pressure Angle**.

Angle of Repose A *Physics* term; also called **Angle of Sliding**; the minimum angle of inclination of a plane with the horizontal, such that a body placed over it just begins to slide down; equals to the *angle of friction*; its tangent is equal to the coefficient of static friction; see also **Angle of Friction**.

Angle of Sliding A *Physics* term; see **Angle of Repose**.

Angle Section A *Strength of Materials* term; one of the most commonly used cross sections of structural members; resembles the capital English alphabet *L*.

Angle A *Mathematics* term; a geometrical figure formed by two line segments originating from the same initial point, called *vertex* of the angle; a ratio of the arc length to the radius of a circular sector; denoted by the symbols such as θ (theta), φ (phi), ψ (psi), α (alpha), β (beta), γ (gamma), δ (delta), and others; usually measured in degree; has no unit.

Angular Acceleration A *Physics* term; the time rate of change of angular velocity of a body; a *vector quantity* denoted by α (alpha); the SI unit is rad/s^2 ; the relationship between linear acceleration (a) and angular acceleration (α) is given as:

$$a = \alpha \cdot r$$

where

r = radius of the circular path.

Angular Deformation A *Strength of Materials* term; the deformation related to change in the angular position of a solid body on being subjected to an external force; see also **Linear Deformation** and **Lateral Deformation**.

Angular Displacement A *Physics* term; the angle traced by the radius vector of a body moving around a circular path at its centre in a given time; a *vector quantity* whose direction depends upon the sense of rotation of the body, and is given by the right-hand rule; usually denoted by (*theta*), and is expressed in *radian (rad)*.

Angular Distortion A *Strength of Materials* term; see **Shearing Strain**.

Angular Frequency A *Physics* term; also called **Circular Frequency**; the frequency connected to the rotation of a body; the product of cyclic frequency (n) of oscillation of a body executing periodic motion with a factor 2π ($2\pi n$) or $\frac{2\pi}{T}$ (where T is the time period of oscillation); denoted by ω (Omega); the SI unit is rad/s; see also **Cyclic Frequency**.

Angular Momentum A *Physics* term; also called **Moment of Momentum** or **Rotational Momentum**; a property of a rotating body; the rotational analog of linear momentum; equals to the product of moment of inertia (I) and the angular velocity (ω) of a rigid body about the axis of rotation; a *vector quantity* whose direction is given by the right-handed screw rule or the right hand thumb rule; see also **Linear Momentum**.

Angular Velocity A *Physics* term; the *time rate* (dt) of change of *angular displacement* ($d\theta$) of a body; a *vector quantity* whose direction is same as that of $d\theta$; the SI unit is rad/s; denoted by omega (ω); given as:

$$\omega = \frac{d\theta}{dt}$$

Animal Charcoal A *Chemistry* term; also called **Bone Black**; an *amorphous* allotropic form of carbon obtained by destructive distillation of animal bones which involves strong heating in the absence of air; consists of approximately 10% of *carbon* and remaining *calcium phosphate*.

Anion A *Chemistry* term; a *negatively charged ion* which results due to addition of an electron to a neutral atom or molecule; a few examples include *chlorine ion* (Cl^{-1}), *oxygen ion* (O^{-2}), and *carbonate ion* (CO_3^{-2}); see also **Cation**.

Anisotropic Material A *Materials Engineering* term; also called **Non-Isotropic Material**; does not exhibit uniform properties in all directions; see also **Isotropic Material**.

Anisotropic A *Materials Engineering* term; the characteristics of having properties (of a material) varying with direction; for example, materials which are single crystals or in which many grains are oriented along a certain direction (occurring naturally or deliberately) have *anisotropic mechanical, optical, magnetic, and dielectric* properties; see also **Isotropic**.

Annealing A *Manufacturing* term related to *heat treatment*; a process of heating a metal above the critical temperature and leaving it in the furnace to cool slowly; offers many changes in the metal like *removes stresses, induces softness* for better machining properties, *refines crystalline structure*, and *changes ductility, toughness* or *electrical, magnetic* or other *physical properties* of the metal.

Anode An *Electrical* term; the negative terminal of a power source (battery) and the positive terminal of an electrolytic cell; see also **Cathode**.

Anodic Reaction A *Chemistry* term; the oxidation reaction which occurs at the *anode* in an electrochemical cell; see also **Cathodic Reaction**.

Anthracite Coal A *Chemistry* term; the *purest type of coal* which contains about 95% of carbon; used as a reducing agent in metallurgical processes and for the manufacture of graphite.

Anticipation Inventory An *Operations Management* term; the inventory which is in demand at some specific periods of time and not required throughout the year, and its demand is accordingly anticipated and met; a few examples include inventory of *fans, air conditioners, and air-coolers* before the start of summer; see also **Buffer Inventory, Cycle Inventory, and Movement Inventory**.

Anticlockwise Moment A *Physics* term; see **Counterclockwise Moment**.

Anti-Friction Bearing A *Design* term; also called **Rolling Contact Bearing**; a bearing which offers very little friction, much less than the sliding friction; consists of rolling elements such as *balls, cylinders or cones* placed between an inner race and an outer race, and has a separator that prevents the rolling elements from rubbing up against one another; involves *rolling friction* between the moving components; the most commonly employed bearing used in *bicycle wheels, robotic joints, and automobile transmissions*; see also **Journal Bearing**.

Antoine Chezy (1718–1798) A *French* engineer who is known for the *Chezy equation*, one of the oldest equations used in the area of fluid mechanics; designed a canal for the *Paris water supply system*; formulated *similarity parameter* for predicting flow characteristics of one channel from measurements on another.

Anvil A *Manufacturing* term; the most commonly used *forging tool* used to support a workpiece during its shaping; usually supported on a wooden block or a cast iron stand; made of *wrought iron or cast steel*.

AOA Network A *Project Management* term which stands for **Activity-on-Arc Network** or **Activity-on-Arrow Network**; an *event-oriented* network diagram approach in which activities are shown on the *arcs* (or arrows) between two *nodes* (or circles) which represent activity's start or completion time; used in *program evaluation and review technique (PERT)*; see also **AON Network**.

AON Network A *Project Management* term which stands for **Activity-on-Node Network**; an *activity-oriented* network diagram approach in which activities and activity times are represented by *nodes* (circles) and the *arrows* (also called branches) between the nodes indicate the precedence relationships between activities; used in *critical path method (CPM)*; see also **AOA Network**.

AOQ A *Quality Control* term; see **Average Outgoing Quality**.

AOQL A *Quality Control* term; see **Average Outgoing Quality Limit**.

APF A *Materials Engineering* term; see **Atomic Packing Factor**.

APICS The short form of American Production and Inventory Control Society; an *American* professional body.

APP An *Operations Management* term; see **Aggregate Production Planning**.

Apparent Viscosity A *Fluid Mechanics* term; the viscosity of a fluid which depends on the shear rate; for example, most non-Newtonian fluids have apparent viscosities; relatively high as compared to the viscosity of water.

Appraisal Cost A *Quality Management* term; a part of *cost of quality* associated with evaluation of quality; includes costs of *inspection*, *testing*, and other related tasks to ensure that the products or processes are acceptable; see also **Prevention Cost**.

Apron A *Lathe* term; a principal part of a lathe which houses the gears and controls for the carriage and feed mechanism.

Arc Voltage A *Welding* term; the voltage generated between the electrode and the workpiece during a welding operation.

Arc Welding A *Welding* term; a *fusion welding process* which uses heat of an arc produced between two electrodes or between the workpiece and an electrode for joining the parts; the temperature produced may be 6000–7000 °C; produces stronger joints because of higher temperatures involved, and hence finds extensive applications; classified into *shielded metal arc*, *submerged arc*, *electroslag*, *electrogas*, and *atomic hydrogen welding processes*; see also **Gas Welding**.

Arc A *Welding* term; see **Electric Arc**.

Archimedes (287–212 B.C.) A *Greek* mathematician and inventor who established elementary principles of *buoyancy* and *floatation* used in *fluid mechanics*.

Archimedes Principle A *Fluid Mechanics* term; named after the *Greek* mathematician and philosopher *Archimedes* (287–212 BC) who discovered and formulated the *principle of buoyancy* in the third century BC; states that a solid body when immersed wholly or partially in a fluid, experiences an upward buoyancy force equal to the weight of the fluid displaced by the body; explains why a floating or sink body appears lighter in weight, while it is under a fluid.

Area Moment of Inertia A *Strength of Materials* term; see **Second Moment of Area**.

Area A *Mathematics* term; a measure of the two-dimensional space that is enclosed by a shape.

Area-Moment Method A *Strength of Materials* term related to *deflection*; see **Moment-Area Method**.

Arithmetic Mean A *Statistics* term; also called simply **Mean**; the most common form of average which takes into account all the numbers, but is affected by extreme values; may not be a whole number even though each item is a whole number; the mean of n numbers from x_1 to x_n can be mathematically expressed as:

$$\begin{aligned} a_a &= \frac{\text{Total of all items}}{\text{Number of items}} \\ &= \frac{x_1 + x_2 + \cdots + x_n}{n} \\ &= \frac{\sum_{r=1}^n x_r}{n} \end{aligned}$$

Arthur M. Wahl A person who introduced the *curvature correction factor for helical springs*; famous for his book '*Mechanical Springs*' considered as the *bible* of spring design.

Artificial Diamond A *Chemistry* term; also called **Synthetic Diamond**; a diamond first made artificially in 1955; one of its methods of manufacturing is to subject graphite to a hydrostatic pressure of 14 GPa and a temperature of 3000 °C; has superior properties over natural diamond as it does not contain impurities; used extensively as *abrasives* for *grinding* and *polishing* for industrial applications; *gem-quality synthetic diamond has electrical conductivity 50 times higher than that of natural diamond, and is 10 times more resistant to laser damages*; its possible applications are as heat sinks for computers, in telecommunications, in the integrated circuit (IC) industries and as windows for high-power lasers; see also **Diamond**.

Artificial Intelligence Abbreviated as **AI**; a process which uses machines and computers to replace human intelligence; useful in making decisions which optimize operations and minimize costs.

Artificial Satellite A *Physics* term; a *man-made satellite* which revolves in an orbit around the earth or any other planet; see also **Natural Satellite**.

AS 9100 A *Quality Management* term; a quality standard system which stipulates the requirements for suppliers to an *aerospace industry*; earlier known as AS 9000.

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers; an *American* professional body.

ASME American Society of Mechanical Engineers; an *American* professional body.

ASRS An *Operations Management* term; see **Automated Storage and Retrieval System**.

Assemble-to-Order An *Operations Management* term; also called **Build-to-Order**; a manufacturing approach or strategy in which products and services are produced in standard modules to which options are added according to customer

specifications; the components are made-to-stock and then assembled to order after the customer order comes; has the flexibility of varying the components of the final assembly; no final product inventory exists as in case of make-to-stock and the customer has limited input into the design of the product; a few examples include *computer systems*, *corporate training*, and *industrial equipment*; see also **Make-to-Stock** and **Make-to-Order**.

Assembly Chart An *Operations Management* term; the chart or table which shows the various parts or components of a final product requiring assembly while shaping the product.

Assembly Drawing A *Machine Drawing* term; the *complete drawing* of a given machinery which indicates the relative positions of various component parts assembled together; should not be overcrowded with dimensions and dotted lines.

Assembly Line Technology An *Operations Management* term; a process technology suitable for a narrow range of standardized products in high volume (mass production); uses the product layout.

Assembly Line An *Operations Management* term related to *facilities planning*; see **Product Layout**.

Assembly A *Design* term; a group of machined or handmade parts that fit together to form one unit.

Assignable Variation A *Statistics* term; also called **Special Cause Variation**; arises from external sources which are not inherent in the process, appears sporadically and disrupts the random pattern of common causes; can be traced to a specific reason and hence can be explained or understood and can be eliminated; the potential sources of assignable variations include *machine wear*, *misadjusted equipment*, *fatigued or untrained workers*, or *new batches of raw materials*; see also **Natural Variation**.

Assignment Method An *Operations Research* term; a *linear programming solution method* used to assign jobs or personnel to machines or departments.

Assignment Problem An *Operations Research* term; a special case and a completely degenerate form of transportation problem in which the objective is to assign a number of sources to the equal number of destinations at a minimum cost.

Assumptions Applied for Simple Bending A *Strength of Materials* term; include the following:

- Beam's material is *isotropic* and *homogeneous*.
- Transverse section of the beam remains flat before and after bending.
- Beam material's modulus of elasticity remains the same in tension and compression.
- Radius of curvature of the bent beam is very large as compared to its cross-sectional dimensions.

- No resultant push or pull acts on the beam's cross section.
- Load on the beam acts in the plane of bending.

ASTM American Society of Testing Materials; an *American* professional body.

Asymmetric Bending A *Strength of Materials* term; see **Unsymmetrical Bending**.

Atkinson Cycle A *Thermodynamics* term; named after a *British* engineer *James Atkinson* (1846–1914) who invented in 1882; an air-standard cycle which consists of four *reversible processes*, namely *isentropic compression*, *constant volume heat addition*, *isentropic expansion*, and *constant pressure heat rejection*; uses *variable engine strokes* (*shorter compression stroke and longer expansion stroke*) from a complex crankshaft; has greater thermal efficiency than conventional engines.

Atmospheric Air A *Thermodynamics* term; a mixture of dry air and water vapour.

Atmospheric Pressure A *Physics* term; the normal pressure exerted by atmospheric air upon all surfaces in contact; equals to a force of 10.13 N exerted by the gases on each square cm, which is considered as 1 atmosphere pressure, equivalent to 760 mm of Hg; varies with altitude; pressure at a higher altitude is less, as air becomes rarer; the atmospheric pressure is measured by a *barometer*; the standard atmospheric pressure can be expressed in various units as given below:

$$\begin{aligned}
 1 \text{ standard atmospheric pressure} &= 760 \text{ mm of Hg} \\
 &= 76 \text{ cm of Hg} \\
 &= 10.3 \text{ m of water} \\
 &= 1.01325 \text{ bar} \\
 &= 1.01325 \times 10^5 \text{ Pa} \\
 &= 1.0332 \text{ kgf/cm}^2.
 \end{aligned}$$

Atom A *Chemistry* term; the smallest as well as a basic unit of a chemical element which takes part in a chemical reaction; has a spherical shape with a radius of 10–8 cm; composed of three fundamental particles, namely *electrons* (negatively charged), *protons* (positively charged) and *neutrons* (no charge); mass of an atom is entirely due to the presence of protons and neutrons which are present in its nucleus, whereas electrons move around the nucleus in different orbits and are held in position by an electrostatic attraction; a few examples include *hydrogen* (H), *nitrogen* (N), *iron* (Fe), and *copper* (Cu); an atom is *electrically neutral* as it contains equal number of electrons and protons.

Atomic Disintegration A *Chemistry* term related to *radioactivity*; a process of disintegration of an atom of a radioactive element; the rate of decay is independent of temperature, pressure, or any external conditions; the whole of the substance never disintegrates completely, although its actual amount may become too small to be measured; the time of complete disintegration of all radioactive elements is thus

infinity and does not carry any meaning; a half-life period is commonly used to refer to a time span during which the radioactivity of the element reduces to one-half of its original value.

Atomic Hydrogen Welding A *Welding* term; a fundamentally different *arc welding process* which uses two nonconsumable tungsten electrodes to produce the arc; the heat of the arc is not directly used for welding as it happens in conventional arc welding processes, but is used to break the molecules of hydrogen (H₂) into atoms of hydrogen (H), which recombine after coming out of the arc, producing large amount of heat (temperature around 6000 °C) to be used for welding purpose; does not require shielding atmosphere, as hydrogen itself provides a shielding medium.

Atomic Mass Unit A *Chemistry* term, abbreviated as **amu**; the fundamental unit of *mass of an atom*; approximately equals to the mass of a proton or neutron (1.66×10^{-24} g).

Atomic Mass A *Chemistry* term; the mass of an individual atom expressed in *atomic mass unit* (amu).

Atomic Number A *Chemistry* term: the number of protons in the nucleus of an atom.

Atomic Packing Factor A *Materials Engineering* term, abbreviated as **APF**; a ratio of the *volume of atoms* to the *volume of unit cell* of a crystal; a measure of how dense a metal is; its higher value indicates a denser metal; the *bcc structure* has the APF value of 0.68, the *fcc structure* has the APF value of 0.74, and the *hcp structure* has the APF value of 0.74.

Atomic Radius A *Chemistry* term; the distance of the outermost electron orbital from the atomic nucleus; a parameter used to measure the size of an atom.

Attribute Characteristics A *Statistics* term; also called simply **Attributes**; a product characteristic which can be measured with a discrete response like *yes* or *no*, *good* or *bad*, *success* or *failure*, etc.; see also **Variable Characteristics**.

Attributes A *Statistics* term; see **Attribute Characteristics**.

Audible Wave A *Physics* term; also called **Sound Wave**; the longitudinal wave having frequency varying between 20 and 20,000 Hz, and is audible; produced by vibrating bodies such as vocal cords (human and animal voices), stretched strings (violin, guitar, etc.), stretched membranes (drum, loudspeaker, etc.), air columns (flute, clarinet, etc.), also produced by irregular motion of bodies like doors, tree leaves, etc.; classified into *musical sound waves* and *noise waves* depending on pleasing or irritating effect on the ear.

Audit Findings A *Financial Management* term; the findings or results of the evaluation of the collected audit evidence against audit criteria; can be positive, negative, or neutral.

Audit A *Management* term; a systematic, independent, and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled.

Auditee A *Financial Management* term; a firm (company) which is being audited.

Auditor A *Financial Management* term; an organization or a person with the competence and authorization to conduct an audit.

Augustin Louis de Cauchy (1789–1857) A *French* engineer, mathematician, and hydrodynamicist who contributed to the general field of *theoretical hydrodynamics* and to the *study of wave motion*; well known for the *Cauchy number* (a non-dimensional group) used in the analysis of a *compressible flow*.

Austenite A *Materials Engineering* term; a *solid solution of carbon or iron-carbide* in face-centered cubic *gamma phase* (γ) of *iron or steel*.

Austenitic Stainless Steel A *Materials Engineering* term; also called **Chromium-Nickel Steel**; a corrosion-resistant ferrous alloy which predominantly contains face-centered cubic (γ) phase of iron in which chromium content varies between 16 and 26% and nickel between 3.5 and 22%.

Authority A *Management* term; the right in a position or the right of a person occupying a position to exercise discretion in making decisions affecting others.

Autocratic Leader A *Management* term; a person who commands and expects compliance; he is *dogmatic* and *positive*, and leads by the ability to withhold or give rewards and punishment; see also **Democratic Leader**.

Autocratic Style A *Management* term; a method of functioning which encourages a dictatorial way of doing the work; tends to centralize authority, and limits employee participation.

Autogenous Joining A *Joining* term; see **Autogenous Welding**.

Autogenous Welding A *Joining* term; also called **Autogenous Joining**; a welding process which does not use any filler metal; for example, *solid-state* and *resistance welding processes*; see also **Homogeneous Welding** and **Heterogeneous Welding**.

Autoignition An *IC Engine* term; the premature ignition of a fuel; produces an audible noise, called *engine knock*.

Automated Assembly System An *Operations Management* term related to *automation*; a production system of *automated assembly machines* and *automated materials handling equipment* used to produce major assemblies or completed products.

Automated Storage and Retrieval System An *Operations Management* term related to *automation*; abbreviated as **ASRS**; an automated system of receiving orders for materials, collecting the materials, and delivering them to different workstations for various operations.

Automatic Guided Vehicle A *Manufacturing* term, abbreviated as **AGV**; a material handling system used in a flexible manufacturing system (FMS) to move and transfer materials on different locations of the manufacturing floor.

Automatic Transmission An *Automobile* term; a mechanism used in automobiles to shift gears using a hydraulic torque converter; replaces the clutch pedal found in manual transmission; allows the engine to continue running when the vehicle comes to a stop; currently, in the USA over 84% of the cars have automatic transmission; see also **Manual Transmission**.

Automatic Welding A *Welding* term; a welding process which uses *automatic equipment* to control the entire welding operation including feed, speed, etc. without involving any human intervention.

Automation A *Manufacturing* term; a technological change which involves the replacement of human efforts by mechanical devices; used as a tool to gain competitive advantage through increased productivity and improved quality; see also **Soft Automation** and **Hard Automation**.

Autonomation An *Operations Management* term; the automatic control of defects; the in-built capability of a machine to detect abnormalities or defects in the parts and stop the production line when defects or abnormalities occur; a tool to produce defect-free products and eliminate the need for re-work.

Available Energy A *Thermodynamics* term; also called **Exergy**; the energy which can be converted into work by some means (usually by reversible engines); a few examples include *kinetic energy*, *potential energy*, and *work* itself; *internal energy* and *heat* are partially available energy as they are not convertible into work; see also **Unavailable Energy**.

Average Outgoing Quality Limit A *Quality Control* term, abbreviated as **AOQL**; the maximum average outgoing defectives leaving an inspection process, as the actual percent defectives in lots vary; see also **Average Outgoing Quality**.

Average Outgoing Quality A *Quality Control* term, abbreviated as **AOQ**; the average percentage of outgoing defectives in lots leaving an inspection process; see also **Average Outgoing Quality Limit**.

Average Speed A *Physics* term; a ratio of the total distance travelled by an object to the total time taken by the object.

Avogadro's Hypothesis A *Chemistry* term; see **Avogadro's Law**.

Avogadro's Law A *Chemistry* term; also called **Avogadro's Hypothesis**; named after an Italian scientist *Amedeo Avogadro* (1776–1856); states that equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules; see also **Avogadro's Number**.