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Mechatronics

Dynamical systems approach and theory of holors

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Glossary

Actuator—The component of an open-loop or closed-loop mechatronical control system that connects the electronic control unit (ECU) with the process; the actuator consists of a mechano-electrical (MM) commutation matrixer (MCM) or an electrical commutation matrixer (ECM) AC–AC, AC–DC–AC or DC–AC commutator motor and a final-control unit; positioning electrical signals are converted to mechanical output.

All-electrical vehicle (AEV)—Any ground automotive vehicle whose original source of energy is electrical power, such as an electrical automobile or electrical locomotive.

Angular velocity holor is defined as the rate of change of the angular displacement holor and is a vector quantity (more precisely, a pseudovector) that specifies the angular speed (rotational speed) of an object and the axis about which the object is rotating. The SI unit of angular velocity is radians per second (rad-s^{-1}). Angular velocity holor is usually represented by the symbol omega ($\boldsymbol{\Omega}^{j}$). The sense of direction of the angular velocity holor is perpendicular to the plane of rotation, in a sense of direction that is usually specified by the 'right-hand rule'.

Artificial intelligence (AI) is the synthetic intelligence exhibited by machines or software, and the domain of computer science that develops machines and software with human-like intelligence.

Application specific integrated circuit (ASIC)—An integrated circuit (IC) designed for a custom requirement, frequently a gate array or single-chip microprocessor or programmable logic device.

Application specific integrated matrixer (ASIM)—An integrated matrixer (IM) designed for a custom requirement, frequently a gate array or single-chip static-commutator or electrical commutation matrixer (ECM) AC–AC, AC–DC–AC, AC–DC/DC–AC or DC–DC commutator.

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Cartesian dualism—Developed by René Descartes, this states that there are two basic forms of substance: mental and material. According to Descartes's philosophy, the mental does not have extension in space, and the material cannot think. Also called substance dualism, it is credited with giving rise to much thought concerning the well-known mind-body dilemma.

Cartesian reductionism—The idea of reductionism has existed since the ancient Greeks, while René Descartes, the 17th-century French philosopher, was the first to formally state the concept. He stated that the world is like a machine composed of many smaller parts, and that it can be understood by taking apart and studying the parts before learning how they all fit into the whole.

Chemo-electrical/electro-chemical storage battery (ChE/ECh)Self-contained ChE/ECh cell/cells or an accumulator system that converts chemical energy into electrical energy in a reversible process.

Complexity is the property of a real-world dynamical hypersystem that is perceptible in the inability of any one formalism to denote all its properties. It necessitates that one finds different means of interacting with physical heterogeneous continuous dynamical hypersystems. Different in the sense that when one formulates adequate physical and mathematical models, the formal physical heterogeneous continuous dynamical hypersystems required to describe each particular aspect are not derivable from each other.

Computer-aided systems engineering (CASE)—A tool designed to help a systems analyst complete development tasks.

Connecting rod—Any straight link that transmits motion or power from one linkage to another within a mechanism, especially linear to rotary (LM–RM), as in a reciprocating internal combustion engine (ICE) or mechano-pneumatic (MP) compressor.

Constraint—A restriction on the natural degrees of freedom (DoF) of a physical heterogeneous continuous dynamical hypersystem, the number of constraints is the difference between the number of natural DoF and the number of actual DoF.

Cost function—Can refer to: in mathematical optimisation, the loss function, a function to be minimised; in artificial neural networks, the function to return a number representing how well the neural network performed to map training examples to correct output.

Crankshaft—A shaft about which a crank rotates.

Current holor—A current holor, also known as an electrical energy-transfer holor, is a flow of electrical charge. In electrical commutation matrixers (ECM) this charge is often carried by moving electrons in wires, i.e. ECM rows and columns. It can also be carried by ions in an electrolyte, or by both ions and electrons, as in a plasma. The SI unit for measuring a current is the ampere (A), which is the flow of electrical charges through a surface at the rate of one coulomb per second ($C\ s^{-1}$).

Cybernetics is the study of human/machine interaction guided by the principle that numerous different types of systems can be studied according to the principles of feedback, control and communication. The field has a quantitative component, inherited from feedback control and information theory, but it is primarily a qualitative, analytical tool—one might even say a philosophy of technology. Cybernetics is characterized by a tendency to universalise the notion of feedback, seeing it as the underlying principle of the technological world. The study of systems that are open to energy but closed to information and control systems that are tight is called cybernetics. Cybernetics takes as its domain the design or discovery and application of the principles of regulation and communication. Cybernetics does not treat things, but rather ways of behaving.

Cyber-physical heterogeneous continuous complex and/or simple dynamical hypersystems have collections of various cyber-physical dynamical systems, hyposystems and components so connected or related as to perform a particular function not performable by the cyber-physical dynamical systems, hyposystems and components alone, and they must encompass computational (i.e. hardware and software) and physical homogeneous dynamical systems, hyposystems and components, seamlessly integrated and interacting closely to sense the changing state of the real world. These cyber-physical heterogeneous dynamical hypersystems combine distributed sensing, monitoring, actuation and control networks.

d'Alambert principle—The principle that the resultant of the external forces and the kinetic reaction acting on a body equals zero.

Darcy's Law—The law that the rate at which a fluid flows through a permeable substance per unit area is equal to the permeability, which is only a property of the substance through which the fluid is flowing, times the pressure drop per unit length of flow, divided by the viscosity of the fluid.

Deterministic mathematical model of the physical heterogeneous continuous dynamical hypersystem is a model whose description is possible in the form of the function relationships between the inputs and outputs of the physical heterogeneous continuous dynamical hypersystem.

Developmental systems approach is a perspective that has been adopted by increasing numbers of scientists and engineers since it emerged in the twentieth century. Developmental systems approach into the methodology of physical models of the physical heterogeneous continuous dynamical hypersystems, in addition to the dynamical systems approach has met with indifference not only from some theorists on the research side of mathematical models, but also some practitioners making experimental studies. It still omnipotently predominates in the excellence as well the physical model, as the modelled existing or projected physical heterogeneous continuous dynamical hypersystem, the dynamical systems approach in the methodology of a formulation of mathematical models, creating in researchers who are occupied in analytical studies the illusion of also steering the physical models. The developmental systems approach in the methodology of the excellence of physical models did not bring about the panacea on the routine for creating the physical model. This requires a considerably *stronger* impulse for the creation of the macro-conditions for computerised analytical studies of mathematical models. If the theorists—systems scientists and engineers—and researchers of mathematical models are interested in their computerised analytical studies as well as their verification (checking) while taking into account the feedback of an algorithm for the formulation of a mathematical model, then sooner or later, they must look towards having a repertoire of methods to improve their physical models. This is an opportunity to recognise the developmental systems approach in the methodology for improving physical models—the idea of improving the physical model, and the comprehensive trouble-shooting processes for dynamical and static problems, which are of interest to researchers. What, therefore, is this idea, and what might be the terms of its usefulness? The basic concept in a glossary of the developmental systems approach in the methodology to create excellent physical models is 'change'. Mathematical models continuously improve due to the effect of the alteration of physical models. Lack of alteration means they are inadequate and unfit. Changes to physical models are therefore in the world of mathematical models, and are important functions of the control of their adequacy.

Dynamical systems approach—Offers a holistic from whole to local approach for describing physical reality; produces a comprehensive image of physical reality; produces accurate predictions with straightforward mathematics and clear logic.

Dynamical universe (DU) theory is a holistic description of observable physical reality. It is a unifying theory converting space–time in variable coordinates into dynamic space in absolute coordinates. The dynamic universe (DU) theory relies on an overall zero-energy balance in space and the conservation of the total energy in interactions in space. *The whole in the DU is not composed of the sum of the elementary units—the multiplicity of elementary units is a result of the diversification of the whole*. Many physical processes in the Universe are highly nonlinear and coupled in a complex way. A deep understanding of the DU often requires detailed numerical simulations, coupled with sophisticated data analysis and visualisation.

Electrical commutation matrixer (ECM) AC–DC commutator—This commutator is an ECM AC–DC rectifier for a rotary or transversal AC–DC commutator generator, the commutator electronically commutes (switches) the armature windings so that the resultant induced source AC armature phase-voltages always act with the same sense of voltage polarisation; this requires a reversal of the armature winding connection every π rad; the induced source AC armature phase-voltages are mechanically rectified to the induced source DC armature voltage via bipolar electrical valves, e.g. diodes, MOS-FETs, IGBTs or MCTs.

Electrical commutation matrixer (ECM) DC–AC commutator—This commutator is an ECM DC–AC inverter for a rotary or transversal DC–AC commutator motor or actuator, the commutator electronically commutes (switches) the armature windings so that the resultant torque or force always acts in the same sense of rotary or transverse direction, respectively; this requires a reversal of the armature winding connection every π rad; the DC armature supply is via bipolar electrical valves, e.g. MOSFETs, IGBTs or MCTs.

Electrical capacitance is the ability of a body to store an electrical charge. Any object that can be electrically charged exhibits capacitance. A common form of energy storage device is the parallel-plate capacitor. In a parallel plate capacitor, capacitance is directly proportional to the surface area of the conductor plates and inversely proportional to the separation distance between the plates.

Electrical conductance—The inverse quantity of electrical resistance is electrical conductance, the ease with which an electric current passes. The SI unit of electrical conductance is measured in siemens (S) or mhos (℧).

Electrical inductance—In electromagnetism and electronics, inductance is the property of a conductor by which a change in current flowing through it 'induces' (generates) an electromotive force (induced voltage) in both the conductor itself (self-inductance) and in any nearby conductors (mutual inductance).

Electrical resistance is the repulsion of a current within an electrical homogeneous continuous electrical system. It explains the relationship between voltage (the amount of electrical pressure) and the current (flow of electricity), e.g. the electrical resistance of an electrical conductor is the opposition to the passage of an electric current through that conductor. Electrical resistance shares some conceptual parallels with the mechanical notion of friction. The SI unit of electrical resistance is the ohm (Ω).

Electrics is the technology that generally deals with the application of electricity, electronics and electromagnetism. This branch of physics first became distinct in the latter half of the 19th century, after the introduction of the electrical telegraph, the telephone and electrical power distribution and use. Subsequently, broadcasting and recording media made electronics part of everyday life.

Electro-mechanical (EM)—Pertaining to an electro-mechanical (EM) motor or actuator or device, EM heterogeneous continuous dynamical hypersystem, or EM process that is electromagnetically or electrostatically actuated or controlled.

Engine—A machine in which power is applied to do work by the conversion of various forms of energy into mechanical torque, force and motion.

Enthalpy—The sum of the internal energy of a thermal homogeneous continuous dynamical system plus the product of the system's volume multiplied by the pressure exerted on the system by its surroundings. Also known as heat content, sensible heat or total heat.

Entropy—Function of the state of a thermal homogeneous continuous dynamical system whose change in any differential reversible process is equal to the heat absorbed by the system from its surroundings divided by the absolute temperature of the system. Also known as thermal charge.

Eulerian coordinates—Any system of coordinates in which the properties of a fluid are assigned to points in space at each given time, without an attempt to identify individual fluid parcels from one time to the next; a sequence of synoptic charts is a Eulerian representation of the data.

Eulerian correlation—The correlation between the properties of a flow at various points in space at a single instant of time. Also known as synoptical correlation.

Eulerian equation—A mathematical representation of the motions of a fluid in which the behaviour and the properties of the fluid are described at fixed points in a coordinate system.

Euler method—A method of studying fluid motion and the mechanics of deformable bodies in which one considers volume elements at fixed locations in space, across which material flows, the Euler method is in contrast to the Lagrangian method.

Extended finite element method (XFEM) is a numerical technique based on the generalized finite element method (GFEM) and the partition of unity method (PUM). It extends the classical finite element method (FEM) approach by enriching the solution space for solutions to differential equations with discontinuous functions.

External combustion engine (ECE)—An engine that operates by the energy of external combustion of a fuel.

External energy-potential-difference holor—An energy-potential-difference holor exerted on a physical heterogeneous continuous dynamical hypersystem or on some physical homogeneous continuous dynamical systems, hyposystems and components by an agency outside the physical heterogeneous continuous dynamical hypersystem.

External work—The work done by a physical heterogeneous continuous dynamical hypersystem in expanding against energy-potential-difference holors exerted from outside.

Final-control unit—The second or last stage of an actuator to control mechanical output.

Finite elements method (FEM) is a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. It uses the subdivision of a whole problem domain into simpler parts, called finite elements, and variational methods from the calculus of variations to solve the problem by minimising an associated error function.

Flow—The forward continuous movement of a fluid, such as gases, vapours, or liquids, through closed or open channels or conduits.

Flow-rate—Also known as the rate of flow holor. (i) Time necessitated for a given quantity of flowable material to flow a measured distance. (ii) Weight or volume of flowable material flowing per unit time.

Flow resistance—Any factor within a conduit or channel that impedes the flow of fluid, such as surface roughness or sudden bends, contractions, or expansions. Also known as viscosity.

Friction flow—Fluid flow in which a significant amount of mechanical energy is dissipated into heat by the action of viscosity.

Friction torque—The torque that is produced by frictional forces and opposes rotational motion, such as that associated with journal or sleeve bearings in machines.

Fluid is a substance (a continuum) that continuously deforms the application of a shear, no matter how small the shear stress may be, and includes both liquids and gases. A fluid cannot sustain a shear when at rest. Liquids are nearly incompressible, but gases are highly compressible. Liquids are distinguished from gases by orders of magnitude differences in their density, absolute viscosity and bulk modulus.

Fluid density—The mass of a fluid per unit volume.

Fluid dynamics—The science of fluids in motion.

Fluid mechanics—The science concerned with fluids, either at rest or in motion, and dealing with pressures, velocities and accelerations in the fluid, including fluid deformation and compression or expansion.

Fluid statics—The determination of the pressure intensities and forces exerted by fluids at rest.

Fluidic capacitance—The volume of fluid in a channel can change just because of a change in pressure: this is either due to fluid compressibility or channel elasticity. Fluidic capacitors are one of two types of fluidic energy storing dynamical components in fluidic homogeneous continuous dynamical systems. Capacitance in a fluidic homogeneous continuous dynamical system comes from continuous fluido-fluidic (FF) accumulators, but also from the fluid itself if it is compliant. It is essential to consider fluid compliance in pneumatic homogeneous continuous dynamical systems, but it generally does not play a significant role in the physical models of hydraulic homogeneous continuous dynamical systems unless there is significant trapped air causing spongy behaviour. The capacitance of the fluid is captured by its bulk modulus property. The idea of the capacitance of fluid trapped in a cylinder can be expanded to estimate the capacitance of a plug of fluid in a hose or pipe, which in turn can be used in a dynamic model. One application of a physical model involving fluid compression is to understand the hydro-mechanical (HM) hammer, which is impact loading caused by sudden changes in flow, such as when a fluidic valve is commuted (switched) from on to off. One has already seen that a fluid itself, whether a liquid or gas, exhibits fluid compliance due to its compressibility. Certain fluidic machines or devices may also introduce flow compliance into a fluidic homogeneous continuous dynamical system, even if the fluids are absolutely incompressible.

Fluidic equation of motion—One of the set of fluido-dynamic equations representing the application of Newton's second law (NSL) of motion to a fluidic homogeneous continuous dynamical system, the total acceleration of an individual fluid particle is equated to the sum of the forces acting on the particle within the fluid.

Fluidic inertance or inductance—The second type of energy-storing dynamical component is fluidic inertance or inductance. In mechanical homogeneous continuous dynamical systems, mass and rotary inertia often dominate dynamical-system behavior and must be physically and mathematically modelled. In fluidic homogeneous continuous dynamical systems, the inertia of the fluid is generally insignificant and it is usually ignored in dynamical system physical models. This is because in hydraulic homogeneous continuous dynamical systems, the pressures are so high that inertial forces can be neglected, and in pneumatic homogeneous continuous dynamical systems, the mass of air is so low that inertial forces can also be neglected. When analysing the high-frequency behaviour of a fluidic homogeneous continuous dynamical system, for example, with the sudden on–off commutation (switching) of fluidic valves that causes transients in fluid flow, fluidic inertance should be included in the physical model.

Fluidic resistance—The force exerted by a gas or liquid opposing the motion of a body through it. Like mechanical friction and electrical resistance, this fluidic dynamical component performs an energy-dissipation function. The dissipation of fluidic energy into thermal energy (heat) occurs in all fluidic machines (FM motors, MF pumps and compressors) or devices to some extent. Thus, fluidic resistors are any dynamical component that resists flow. Another way of looking at fluidic resistors is: any dynamical component that causes a pressure drop when fluid flows through the component. Fluidic resistors include fluidic valves, filters, hoses, pipes and fittings.

Fluidic friction—Conversion of mechanical energy in fluid flow into thermal energy.

Fluidics is the technology of using the flow characteristics of liquid or gas to operate a fluidic homogeneous continuous dynamical system. One of the newest of the control technologies, fluidics has in recent years come to compete with mechanical and electrical homogeneous continuous dynamical systems.

Fluido-mechanical (FM)—Pertaining to a fluido-mechanical (FM) motor or actuator or device, FM heterogeneous continuous dynamical hypersystem, or FM process that is fluido-dynamically or fluido-statically actuated or controlled.

Force holor—That influence on a mechanical homogeneous continuous dynamical system that causes it to accelerate, quantitatively it is a mechanical energy-potential-difference holor, equal to the mechanical homogeneous continuous dynamical system's rate of change of momentum holor.

Fuzzy-logic (FL)—Software design based upon a reasoning node rather than a fixed mathematical algorithm, a fuzzy logic design allows the mechatronic engineer to participate in the software design because the fuzzy language is linguistic and built upon easy-to-comprehend fundamentals.

Generalised admittance holor is a measure of how easily a physical heterogeneous continuous dynamical hypersystem will allow an energy-transfer holor to flow. It is defined as the holor inverse of generalized impedance holor, that is the holor reciprocal of the generalised impedance holor. Thus, the generalised admittance holor is the energy-transfer holor-to-energy-potential-difference holor ratio, and it conventionally carries SI units of siemens (S), formerly called mhos (℧).

Generalised coordinates—A set of variables used to specify the positional orientation of a physical heterogeneous continuous dynamical hypersystem, in principle defined in terms of the Cartesian coordinates of the physical heterogeneous continuous dynamical hyposystem's particles and of the time to some convenient manner, the number of such coordinates equals the number of degrees of freedom (DoF) of the physical heterogeneous continuous dynamical hyposystem. Also known as Lagrangian coordinates.

Generalised equation of motion—Equation that specifies the coordinates of particles as functions of time. Also known as a differential equation of dynamics, or one of several such equations, from which the coordinates of particles as functions of time can be obtained if the initial positions and velocities of the particles are known.

Generalised energy-potential-difference holor—The generalised energy-potential-difference holor corresponding to a generalised coordinate is the ratio of the virtual work done in an infinitesimal virtual displacement, which alters those coordinates and no others.

Generalised energy-transfer holor—The derivative with respect to time of one of the generalised coordinates of a particle. Also known as the Lagrangian generalised energy-transfer holor.

Generalised finite element method (GFEM) is a direct extension of the standard finite element method (SFEM, or FEM), which makes it possible to attain the accurate solution of physical and engineering problems in complex domains that might be practically impossible to solve using the FEM.

Generalised impedance holor is the measure of the opposition that a physical heterogeneous continuous dynamical hypersystem presents to an energy-transfer holor when an energy-potential-difference holor is applied. In quantitative terms, it is the holor ratio of the energy-potential-difference holor to the energy-transfer holor in a physical heterogeneous continuous dynamical hypersystem. The impedance holor extends the concept of the resistance holor to physical heterogeneous continuous dynamical hypersystems, and possesses both magnitude and phase, unlike the resistance holor, which only has magnitude. When a physical heterogeneous discrete dynamical hypersystem is driven with a step function, there is no distinction between the impedance holor and the resistance holor; the latter can be thought of as an impedance holor with a zero phase angle. The magnitude of the impedance holor is the holor ratio of the energy-potential-difference holor amplitude to the energy-transfer holor amplitude. The phase of the impedance is the phase shift by which the energy-transfer holor lags the energy-potential difference holor. In general, the generalised impedance will be a holor, with the same SI units as the physical resistance holor, for which the SI unit is the ohm (Ω).

Generalised momentum—If q_j ($j = 1, 2, 3, \ldots$) are the generalised coordinates of a classical physical heterogeneous continuous dynamical hypersystem, and $\mathcal{L}$ is its Lagrangian, the momentum conjugate to q_j is $p_j = \partial\mathcal{L}/\partial q_j$. Also known as canonical momentum or conjugate momentum.

Graphene is a remarkable substance with a multitude of astonishing properties that have repeatedly earned it the title of 'wonder material'. Graphene is the thinnest material known to man at one atom thick, and it is also incredibly strong—about 200 times stronger than steel. On top of that, graphene is an excellent conductor of heat and electricity and has interesting light-absorption abilities. It is truly a material that could change the world, with unlimited potential for integration in almost any industry.

Hamilton–Ostrogradsky principle—A variational principle that states that the path of a conservative physical heterogeneous continuous dynamical hypersystem in configuration space between two configurations is such that the integral of the Lagrangian function over time is a minimum or maximum relative to near paths between the same end points and taking the same time.

Hamilton's equations of motion—A set of first-order, highly symmetrical equations describing the motion of a classical dynamical system, namely $\dot{q}_j = \partial H/\partial p_j \,.\, p_j = -\partial H/\partial p_j$, where q_j ($j = 1, 2, \ldots$) are the generalised coordinates of the system, p_j is the momentum conjugate to q_j and H is the Hamiltonian. Also known as canonical equations of motion.

Hamiltonian function—A function of the generalised coordinates and momenta of a physical heterogeneous continuous dynamical hypersystem, equal in value to the sum over the coordinates of the product of the generalised momentum corresponding to the coordinate, and the coordinate's time derivative, minus the Lagrangian of the physical heterogeneous continuous dynamical hypersystem; it is numerically equal to the total energy of the Lagrangian and does not depend on time explicitly, the equations of motion of the physical heterogeneous continuous dynamical hypersystem are determined by the functional dependence of the Hamiltonian on the generalised coordinates and momenta.

Heat—Thermal energy is transmitted due to a temperature difference between the source from which the energy is coming and a sink towards which the energy is going, other types of energy in transit are called work.

Heat conduction—The flow of thermal energy through a substance from a higher to a lower temperature region. Also known as heat diffusion.

Heat convection—The transfer of thermal energy by actual physical movement from one location to another of a substance to which thermal energy is stored. Also known as thermal convection.

Heat flow—Heat thought of as thermal energy flowing from one substance to another, quantitatively, the amount of heat transferred in a unit time. Also known as heat transmission.

Heat radiation—Also known as thermal radiation, this is electromagnetic radiation generated by the thermal motion of charged particles in matter. All matter with a temperature greater than absolute zero emits thermal radiation. When the temperature of the body is greater than absolute zero, interatomic collisions cause the kinetic energy of the atoms or molecules to change. Thermal radiation is one of the fundamental mechanisms of heat transfer. Heat transfer through radiation takes place in the form of electromagnetic waves that are mainly in the infrared region. Radiation emitted by a body is a consequence of the thermal agitation of its composing molecules.

Heat transfer describes the exchange of thermal energy between physical heterogeneous continuous dynamical hypersystems, depending on the temperature and pressure, by dissipating heat. Thermal homogeneous discrete dynamical systems which are not isolated may decrease in entropy. Most objects emit infrared thermal radiation near room temperature. The fundamental modes of heat transfer are conduction or diffusion, convection, advection and radiation.

Holism—Asserts that everything exists in relationship, in a context of connection and meaning—and that any change or event causes realignment, however slight, throughout the entire pattern. The whole is greater than the sum of its parts and this means that the whole comprises a pattern of relationships that are not contained by the parts, but ultimately define them. Holism stands in stark opposition to the method of reductionism, which holds that analysis, dissection and strict definition are the tools for understanding reality. Holism asserts that phenomena can never be fully understood in isolation; it asserts that reductionism can only give us a partial view of anything it dissects. Holism is difficult to pin down precisely, because by its very nature it embraces paradox, mystery and contradiction. The holistic world view has its roots in the new physics, systems thinking and ecology, holism and perennial philosophy.

Holonomic constraints—An integrable set of differential equations of dynamics which describe the restrictions on the motion of a physical heterogeneous continuous dynamical hypersystem, a function relating several variables in the form $f(x_1, \ldots x_n) = 0$, in the optimisation of physical problems.

Holonomic physical heterogeneous continuous dynamical hypersystem—A physical heterogeneous continuous dynamical hypersystem in which the constraints are such that the original coordinates can be expressed in terms of independent coordinates and possibly also time.

Holor—A holor (hoʊlər; Greek ὅλος *whole*) is a mathematical entity that is made up of one or more independent quantities ('merates', as they are called in the theory of holors). Complex numbers, scalars, vectors, matrices, tensors, quaternions and other hypercomplex numbers are kinds of holor.

Hybrid-electrical vehicle (HEV) an automotive vehicle that uses two or more distinct power sources. However, one of them ought to be a secondary power source with the possibility of energy storage. The term most commonly refers to hybrid electrical vehicles (HEVs), which combine an internal combustion engine (ICE) or external combustion engine (ECE) and one or more electro-mechanical/ mechano-electrical (EM/ME) dynamotors. However, other mechanisms to capture and utilise energy are included. A hybridisation of a conventional automotive vehicle and an electrical vehicle combines an ICE or ECE propulsion system with an electrical propulsion system. The presence of the electrical power train is intended to achieve either better specific fuel consumption (SFC) than a conventional automotive vehicle or better performance.

Internal combustion engine (ICE)—A prime mover in which the fuel is burned within the engine and the products of combustion serve as thermodynamic fluid, as with gasoline and diesel engines. An engine that operates by the energy of internal combustion of a fuel.

Kinetic energy—The energy which a physical heterogeneous continuous dynamical hypersystem possesses because of the motion in classical physics equal to one-half of the physical heterogeneous continuous dynamical hypersystem's mass and/or capacitance times the square of its energy-transfer variable.

Kirchhoff's first law (KFL)—This law is also known as Kirchhoff's point rule, or Kirchhoff's junction rule (or nodal rule). The principle of conservation of electrical charge implies that at any commutation node (junction) in an electrical commutation matrixer (ECM), the holor sum of the current holors flowing into that commutation node is equal to the holor sum of the current holors flowing out of that commutation node, or the holor sum of the current holors in an ECM of conductors (rows and columns) meeting at a point is zero.

Kirchhoff's second law (KSL)—This law is also known as Kirchhoff's loop rule, Kirchhoff's mesh rule, or Kirchhoff's second rule. The principle of conservation of energy implies that the holor sum of the electrical energy-potential-difference holors (voltage holors) around any closed electrical commutation matrixer (ECM) is zero, or, more simply, the holor sum of the electromotive force (emf) holors in any closed loop is equivalent to the holor sum of the potential-drop holors in that loop, or the holor sum of the products of the resistances of the ECM conductors (rows and columns) and the current holors in them in a closed loop is equal to the total emf holor available in that loop.

Lagrange–Hamilton theory—The formalised study of continuous systems in terms of field variables where a Lagrangian density function and a Hamiltonian density function are introduced to produce equations of motion.

Lagrange's equations—Equation of dynamics of a physical heterogeneous continuous dynamical hypersystem for which a classical (non-quantum mechanical) physical description is possible, and which relates the kinetic energy of the physical heterogeneous continuous dynamical hypersystem to the generalised coordinates, the generalised energy-potential-difference variables and the time. Also known as the Lagrangian equations of dynamics.

Lagrangian—The difference between the kinetic energy and the potential energy of a physical heterogeneous continuous dynamical hypersystem, expressed as a function of generalised coordinates and energy-transfer variables from which Lagrange's equations can be derived. Also known as the kinetic potential Lagrange function.

Lagrangian density—For a dynamical system of fields or continuous media, a function of the fields, of their time and space derivatives, and the coordination and time, whose integral over space is the Lagrangian.

Lagrangian function—The function which measures the difference between the kinetic and the potential energy of a physical heterogeneous continuous dynamical hypersystem.

Lagrangian method—A method of studying of fluid motion and the mechanics of deformable bodies in which one considers volume elements which are carried along with the fluid or body, and across whose boundaries material does not flow, in contrast to the Euler method.

Machine—A combination of rigid or resistant bodies that have definite motions and are capable of performing useful work.

Magnetic reluctance is a concept used in the analysis of magnetic homogenous continuous dynamical systems. It is analogous to electrical resistance in an electrical homogeneous continuous dynamical system, but rather than dissipating electrical energy it stores magnetic energy. In likeness to the way an electrical field causes an electrical current to follow the path of least resistance, a magnetic field causes magnetic flux to follow the path of least magnetic reluctance. It is a scalar, extensive quantity, akin to electrical resistance. The units for magnetic reluctance are inverse henries (H^{-1}). Also known as magnetic resistance.

Magnetic resistance—See magnetic reluctance.

Magnetomotive force—In physics, the magnetomotive force (mmf), is a quantity appearing in the equation for the magnetic flux in a magnetic homogeneous continuous dynamical system, sometimes known as Hopkinson's law: $M = R\,\Phi$, where Φ is the magnetic flux and R is the magnetic reluctance of the homogeneous continuous dynamical system. It can be seen that the mmf plays a role in this equation that is analogous to that of the voltage V in Ohm's law: $V = R\ I$. The mmf is analogous to electromotive force (emf), i.e. the difference in electrical potential, or voltage, between the terminals of a source of electricity, e.g. a ChE/ECh storage battery from which no current is being drawn, since it is the cause of magnetic flux in a magnetic homogeneous continuous dynamical system, i.e. (i) $M = N\ I$, where N is the number of turns in the coil and I is the electrical current through the magnetic homogeneous continuous dynamical system, and (ii) $M = R\ \Phi$, where Φ is the magnetic flux and R is the magnetic reluctance, and (iii) $M = H\ l$, where H is the magnetising force (the strength of the magnetising field) and l is the mean length of a solenoid or the circumference of a toroid.

Mass-flow holor—Also known as the mass-transfer holor and bulk-flow holor, it is the measure of the movement of material matter. In physics, mass flow occurs in open fluidic homogeneous continuous dynamical systems and is often measured as occurring when moving across a certain boundary characterised by its cross-sectional area and a flow-rate holor. In fluidics it may also be a flow of fluids in a tube or vessel of a certain diameter. A bulk transfer of particles of matter in a characterised type of flow is also known as bulk flow.

Mass-velocity holor—The mass flow-rate holor of a fluid divided by the cross-sectional area of the enclosing chamber or conduit, The SI unit is kilogram per second and square metres (kg s^{-1} m^2).

Mathematical model of the physical heterogeneous continuous dynamical hypersystem is adequate to a physical process, functional and structural homogeneous continuous dynamical systems, hyposystems and components and superimposed constraints.

Mechanical commutation matrixer (MCM) AC–DC commutator—This commutator is a mechano-electrical commutation matrixer (MCM) AC–DC rectifier for a rotary AC–DC commutator generator, the commutator mechano-electrically (ME) commutes (switches) the armature windings so that the resultant induced source AC armature phase-voltages always act with the same sense of voltage polarisation; this requires a reversal of the armature winding connection every π rad; the induced source AC armature phase-voltages are mechano-electronically rectified to the induced source DC armature voltage via bipolar mechano-electrical valves, i.e. commutator segments that contact the carbon brushes.

Mechanical commutation matrixer (MCM) DC–AC commutator—This commutator is a mechano-electrical commutation matrixer (MCM) DC–AC inverter for a rotary DC–AC commutator motor or actuator, the commutator mechano-electrically commutes (switches) the armature windings so that the resultant torque always acts in the same sense of rotary direction; this requires a reversal of the armature winding connection every π rad; the DC armature supply is via bipolar mechano-electrical valves, i.e. carbon brushes that contact the commutator segments.

Mechanics (Greek μηχανική) is concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effects of the bodies on their environment. It is a branch of classical physics that deals with particles that are either at rest or are moving at velocities significantly less than the speed of light. It can also be defined as a branch of science that deals with the motion of and forces on objects.

Mechanism—The part of a machine which contains two or more pieces so arranged that the motion of one compels the motion of the others.

Mechano-electrical (ME)—Pertaining to a mechano-electrical (ME) generator or device, ME heterogeneous continuous dynamical hypersystem, or ME process that is mechanically driven or controlled.

Mechano-fluidic (MF)—Pertaining to a mechano-fluidic (MF) pump or compressor or device, MF heterogeneous continuous dynamical hypersystem, or MF process that is fluidically driven or controlled.

Microcomputer unit (MCU)—A semiconductor device that has a central processing unit (CPU), memory and input/output (I/O) capability on the same chip.

Motion—A continuous change of position of a body.

Mechano-fluidic (MF) pump—A machine that draws a fluid into itself through an entrance port and forces the fluid out through an exhaust port.

Mechano-pneumatic (MP) compressor—A mechano-pneumatic (MP) machine that increases the pressure of a gas or vapour by increasing the gas density and delivering the gas or vapour against the connected pneumatic homogeneous continuous dynamical system resistance.

Newtonian mechanics—A mechanical homogeneous continuous dynamical system based upon Newton's laws of motion in which mass and energy are considered as separate, conservative, mechanical properties, in contrast to their treatment in relativistic mechanics.

Newton's first law—The law that a particle not subjected to external forces remains at rest or moves with constant velocity in a straight line. Also known as the first law of motion, or Galileo's law of inertia.

Newtonian paradigm—Newton gave us three 'laws of motion', which were intended to describe the motion of the planets. It turned out that these laws could be applied in a seemingly perfectly general way. This broader application has been the foundation of the modern scientific method and will be referred to here as the Newtonian paradigm. At the centre of this paradigm is 'dynamics'. Dynamics is the way the laws of motion get applied.

Newton's second law—The law that the acceleration of a particle is directly proportional to the resultant external force acting on the particle and is inversely proportional to the mass of the particle. Also known as the second law of motion.

Newton's third law—The law that, if two particles interact, the force exerted by the first particle on the second particle (called the action force) is equal in magnitude and opposite in sense of direction to the force exerted by the second particle on the first particle (called the reaction force). Also known as the law of action and reaction, or the third law of motion.

Partition of unity method (PUM)—Can be regarded as a generalisation of the classic finite element methods (FEM). Instead of a mesh, the construction of a global approximation space and the evaluation of the discretisation use a much more versatile set of patches, the so-called cover. The method enables the inclusion of arbitrary local function spaces and is particularly well suited for adaptive refinements with respect to spatial resolution and reproducing the quality of the function space.

Physical heterogeneous continuous complex andlor simple dynamical hypersystems—Have collections of various physical dynamical systems, hyposystems and components so connected or related as to perform a particular function not performable by the dynamical systems, hyposystems and components alone.

Physical model of the physical heterogeneous continuous dynamical hypersystem is a model in which passing physical processes are equivalent to each other when being described by mathematical relationships.

Pneumatics—Fluid statics and behaviour in closed pneumatic homogeneous continuous dynamical systems when the fluid is a gas.

Potential energy—The capacity to do the work that a physical heterogeneous continuous dynamical hypersystem has by virtue of its position or configuration.

Pressure-drop holor—The difference in pressure holor between two points in a fluidic homogeneous continuous dynamical system, usually caused by frictional resistance to a fluid flowing through a conduit, filter media, or other flow-conducting, fluidic homogeneous continuous dynamical system.

Pressure holor—A type of stress which is exerted uniformly in all senses of directions; its measure is the force holor exerted on per unit area.

Prime mover—The component of a power plant that transforms energy from the thermal or the fluidic form to the mechanical form.

Principle of virtual work—The principle that the total work done by all energy-potential-difference variables acting on a physical heterogeneous continuous dynamical hypersystem in static equilibrium is zero for any infinitesimal generalised coordinate from equilibrium that is consistent with the constraints of the physical heterogeneous continuous dynamical hypersystem. Also known as the virtual work principle.

Protocol—The rules governing the exchange of information (data) between networked elements.

Pulse-width modulation (PWM)—The precise and timely creation of negative and positive waveform edges to achieve a waveform with a specific frequency and duty cycle.

Ratchet—A wheel operating with a catch or a pawl so as to rotate in only a single sense of direction.

Ratchet coupling—A coupling between two shafts that uses a ratchet to allow the driven shaft to be turned in one sense of direction only and also to permit the driven shaft to overrun the driving shaft.

Semicustom MCU—A microcontroller unit (MCU) that incorporates normal MCU elements plus application-specific peripheral devices, such as higher-power port outputs, special times units, etc; mixed semiconductor technologies, such as high-density CMOS (HCMOS) and bipolar analogues, are available in a semicustom MCU, generally the HCMOS is limited to 10 V_{DC}, whereas the bipolar-analogue is suitable to 60 V_{DC}.

Specific fuel consumption (SFC)—The mass flow rate of fuel required to produce a unit of power or thrust, e.g. kilograms per kilowatt-hour (kg kWh^{-1}).

Statistical mathematical model of the physical heterogeneous continuous dynamical hypersystem is a model that is formulated by taking into consideration the statistical parameters and the probability expansion function.

Statistical mechanics—Statistical mechanics is a branch of physics that uses probability theory to study the average behaviour of a mechanical homogeneous continuous dynamical system where the state of the system is uncertain. Statistical mechanics is a collection of mathematical tools that are used to fill this disconnection between the laws of mechanics and the practical experience of incomplete knowledge.

Systems thinking approach involves shifting one's attention from the dynamical parts to the whole, from objects to relationships, from structures to processes, from hierarchies to networks. It also includes shifts of emphasis from the rational to the intuitive, from analysis to synthesis, from linear to nonlinear thinking. By contrast to reductionism, systems thinking is a style of thought and reasoning that seeks to understand a whole dynamical hypersystem by examining the physical heterogeneous continuous dynamical hypersystem as a whole instead of disassembling and studying the dynamical parts, i.e. the physical homogeneous continuous dynamical systems, hyposystems and components. While some scientists prefer to use one of the two styles of thinking to the exclusion of the other, it is more common to use whichever style fits a given situation. Quite simply, some situations call for systems thinking, while others require a closer look at the dynamical parts of the physical heterogeneous continuous dynamical hypersystem and are better suited to reductionism. Summing up, systems thinking is an approach to integration that is based on the belief that the dynamical parts, i.e. the physical homogeneous continuous dynamical systems, hyposystems and components of a physical heterogeneous continuous dynamical hypersystem, will act differently when isolated from the hypersystem's environment or other parts of the hypersystem. Standing in contrast to positivist and reductionist thinking, systems thinking sets out to view physical heterogeneous continuous dynamical hypersystems in a holistic manner. Consistent with systems philosophy, systems thinking concerns an understanding of a physical heterogeneous continuous dynamical hypersystem by examining the linkages and interactions between the physical homogeneous continuous dynamical systems, hyposystems and components that comprise the whole of the physical heterogeneous continuous dynamical hypersystem. When one encounters situations that are complex and messy, then systems thinking can help one to understand the situation systemically. This helps one to see the full-size image from which one may identify multiple leverage points that can be addressed to support constructive change. It also helps one to see the connectivity between physical homogeneous continuous dynamical systems, hyposystems and components in the situation, so as to support joined-up actions.

Theoretical reductionism states that all theories in a field are part of a larger theory with a broader scope. In theory, this supports the idea of the existence of a 'grand unified theory' of physics that combines quantum physics with other observed phenomena.

Thermal capacitance—The ratio of the entropy added to a body to the resulting rise in temperature.

Thermal conductance—The amount of heat transmitted by a material divided by the difference in temperature of the surfaces of the material.

Thermal conductivity—The heat flow through a surface per unit area per unit time, divided by the negative of the rate of change of temperature with distance to a direction perpendicular to the surface. Also known as heat conductivity.

Thermal inductance—The product of temperature difference and time divided by entropy flow.

Thermal energy potential difference is the difference between the thermodynamic temperatures of two points.

Thermal resistance—A measure of a body's ability to prevent heat from flowing through it, equal to the difference between the temperatures of opposite faces of the body divided by the rate of heat flow. Also known as heat resistance.

Thermal resistivity—The reciprocal of thermal conductivity.

Thermics—Also known as thermal physics, this is the combined study of thermodynamics, statistical mechanics and kinetic theory. This umbrella-subject is typically designed for physics students and functions to provide a general introduction to each of the three core heat-related subjects. Others, however, define thermics loosely as a summation of thermodynamics and statistical mechanics.

Thermodynamics is a branch of physics concerned with heat and temperature and their relation to energy and work. It defines the macroscopic variables, such as internal energy, entropy, and pressure, which partly describe a body of matter or radiation. It states that the behaviour of these variables is subject to general constraints that are common to all materials, not the peculiar properties of particular materials. These general constraints are expressed in the four laws of thermodynamics.

Torque holor—(i) For a single force holor, the cross product of a holor from some reference point to the point of application of the force holor with the force holor itself. Also known as the moment of force holor or rotation moment holor. (ii) For several force holors, the holor sum of the torque holors (first definition) associated with each of the force holors.

Transfer-function holor—The mathematical relationship between the output holor of a mechatronical control system and its output holor for a linear system; it is the output holor divided by the input holor under conditions of zero initial energy stored. Also known as the transmittance holor.

Transfer-matrix holor—The generalisation of the concept of a transfer-function holor to a multivariable mechatronical control system; it is the matrix whose product with the vector representing the input holors yields the vector representing the output holors.

Unholonomic physical heterogeneous continuous dynamical hypersystem—A physical heterogeneous continuous dynamical hypersystem that is subject to restraints of such a nature that the physical heterogeneous continuous dynamical hypersystem cannot be described by independent coordinates; examples are generalised commutation matrixer (GCM) commutators, e.g. in mechanical homogeneous continuous dynamical systems are a rolling hoop, or an ice skate which must point along its path.

Vapour is a gas at a temperature below the critical temperature, so that it can be liquefied by compression, without lowering the temperature.

Velocity holor—The time rate of change of position of a body; it is a vector quantity with a sense of direction and magnitude. Also known as the linear velocity holor.

Voltage holor—Also known as the electrical energy-potential-difference holor, electrical tension holor or electrical pressure holor (denoted $\boldsymbol{V_i}$) and measured in SI units of electrical potential: volts (V) or joules per coulomb (J C^{-1}). It is the electrical energy-potential-difference holor between two electrical commutation matrixers' (ECM) separated terminals, i.e. between ECM rows and columns, or the difference in electrical potential energy of a unit charge transported between two ECM separated terminals.

Volumetric flow-rate holor—In fluidics-in particular, fluid dynamics and hydrometry-the volumetric flow-rate holor (also known as the volume flow-rate holor, the rate of fluid-flow holor or the volume velocity holor) is the volume of fluid that passes through a given surface per unit time. The SI unit is cubic meters per second (m^3 s^{-1}). It is usually represented by the symbol Q^j. The volumetric flow-rate holor should not be confused with the volumetric flux holor, as defined by Darcy's law and represented by the symbol q^j, with SI units of m^3/m^2 s, that is, (m s^{-1}). The integration of a flux over an area gives the volumetric flow rate.