

Task 2

1. acceleration: “a vector quantity that is defined as the rate at which an object changes its velocity. An object is accelerating if it is changing its velocity.”

[@<http://www.physicsclassroom.com/class/1DKin/Lesson-1/Acceleration>]

Data: average acceleration consists of an objects change in velocity over (ΔV) time divided by the duration of that period of time (ΔT)

Control: Acceleration is a value used to predict an objects location at some future time

Behavior: Given the average acceleration of a boat or plane expected to travel in a straight line, it's approximate future location can be determined.

2. actuator: “Electrical, hydraulic, or pneumatic device (such as a relay) that controls the flow of material or power. Also called actuation device.” [@<http://www.businessdictionary.com/definition/actuator.html>]

Data: the composition of an actuator differs based upon the type of input used. Common actuators are an electric motor, hydraulic piston, and a pneumatic actuator

Control: actuators work by converting one form of energy into another. For instance, electric motors will take electricity as input and convert it into mechanical torque.

[@<http://en.wikipedia.org/wiki/Actuator>]

Behavior: actuators are used in all manner of mechanical and electronic devices to convert input to output (mostly energy to force).

3. arm: a human upper limb; especially the part between the shoulder and the wrist; or: something like or corresponding to an arm: as... a slender part of a structure, machine, or an instrument projecting from a main part, axis, or fulcrum...” [@<http://www.merriam-webster.com/dictionary/arm>]

Data: an arm is composed of, most importantly, joints, muscles and bones.

Control: arms are connected to other bodies via the joints, which also allow it movement. They are moved by the extension and contraction of muscles. These parts are all connected to the base structure of the arm, the bones.

Behavior: Arms are commonly used to manipulate objects, or to support the main body in some way.

4. axis, directional: The vertical axis passes through an aircraft from top to bottom. Rotation about this axis is called yaw. Yaw changes the direction the aircraft's nose is pointing, left or right.

[@http://en.wikipedia.org/wiki/Flight_control_surfaces]

Data: y-axis on a 3-dimensional coordinate plane

Control: the directional (yaw) axis represents the left/right orientation of an object in 3-d space

Behavior: Planes control their yaw by means of a rudder, which allows the aircraft to orient itself to the left or right.

5. axis, lateral: The lateral axis passes through an aircraft from wingtip to wingtip. Rotation about this axis is called pitch. Pitch changes the vertical direction that the aircraft's nose is pointing.
[http://en.wikipedia.org/wiki/Flight_control_surfaces]

Data: z-axis on a 3-dimensional coordinate plane

Control: the lateral (pitch) axis represents the up/down orientation of an object in 3-d space

Behavior: Planes control their pitch by means of the elevators, which allow the aircraft to orient itself up or down; the ailerons have a secondary effect on pitch.

6. axis, longitudinal: The longitudinal axis passes through the aircraft from nose to tail. Rotation about this axis is called roll. Rolling motion changes the orientation of the aircraft's wings with respect to the downward force of gravity. [http://en.wikipedia.org/wiki/Flight_control_surfaces]

Data: x-axis on a 3-dimensional coordinate plane

Control: the longitudinal (roll) axis represents the orientation of the wings with respect to the downward force of gravity

Behavior: Planes control their roll by means of the ailerons, though the rudder has a secondary effect on bank.

7. backlash: Play that exists between a pair of engaged gears' tooth surfaces. When described as a distance of an arc on the engagement pitch circle, it is called "Circumference Direction Backlash", when described as the shortest distance between two opposing tooth surfaces is called "Normal Line Backlash". [http://www.kuroda-precision.com/products/ball_screws/QandA/BS_QandA_005.htm]

Data: the space left between gear teeth.

Control: theoretically, zero backlash is considered ideal, but in actual practice some backlash must be allowed to prevent jamming.

[http://en.wikipedia.org/wiki/Backlash_%28engineering%29]

Behavior: Reasons for the presence of backlash include allowing for lubrication, manufacturing errors, deflection under load, and thermal expansion.

8. ball-and-socket joint: A joint, as in a mechanical device, that permits rotary movement in all directions through the movement of a ball in a socket. Also called *ball joint*.
[<http://www.thefreedictionary.com/ball-and-socket+joint>]

Data: the joint itself consists of the ball and the socket that it fits into.

Control: a ball-like surface fits into a cup-like depression and the objects connected by the joint may engage in rotary movement.

Behavior: Joints of this type are commonly used in mounting the front wheels of automobiles, allowing these wheels movement sufficient for steering. In this application they are usually called ball joints. [<http://www.infoplease.com/encyclopedia/science/ball-and-socket-joint.html>]

9. bearing: A bearing is a machine element that constrains relative motion and reduces friction between moving parts to only the desired motion. [http://en.wikipedia.org/wiki/Bearing_%28mechanical%29]

Data: bearings consist of, at least, a bearing surface and the part which it bears. Ball bearings are another common application and would also include balls and two races (the bearing surfaces that contain the balls between them).

Control: bearings may *prevent* a motion by controlling the vectors of normal forces that bear on the moving parts, or *facilitate* the desired motion as much as possible, such as by minimizing friction.

Behavior: used to facilitate motions like axial rotation (e.g. shaft rotation), linear motion (e.g. drawer), spherical rotation (e.g. ball and socket joint), hinge motion (e.g. door, elbow, knee).

10. bellcrank: a type of crank that changes motion through an angle. The angle can be any angle from 0 to 360 degrees, but 90 degrees and 180 degrees are most common. [<http://en.wikipedia.org/wiki/Bellcrank>]

Data: Crank fashioned at the necessary angle, pivot bar, and cables.

Control: the crank is attached to two cables. When one cable is tensioned, it rotates the crank, pulling the other cable.

Behavior: Bellcranks are used in aircraft to control the rudder, where each rudder peddle is attached to one of the cables.

11. control horn: an extension to the control surface which projects ahead of the hinge. The air striking the horn assists the pilot to deflect the control surface. Horns are usually provided on elevators and rudders. [http://www.pilotfriend.com/training/flight_training/fxd_wing/primary.htm]

Data: The control surface and the control horn

Control: The control horn extends off of the control surface in order to assist in moving the control surface

Behavior: Used on airplanes to help move the elevators and rudders.

12. control system, closed loop: A Closed-loop Control System, also known as a feedback control system is a control system which uses the concept of an open loop system as its forward path but has one or more feedback loops (hence its name) or paths between its output and its input. [<http://www.electronics-tutorials.ws/systems/closed-loop-system.html>]

Data: consists of at least an input, a controller, an object being controlled, and a sensor to check the output.

Control: The controller translates the input to the object which does its work. The sensor checks the result of the work and gives this result to the controller which will make any necessary adjustments.

Behavior: Such a system is used in thermostats to keep a constant temperature.

13. control system, open loop: an Open-loop system, also referred to as non-feedback system, is a type of continuous control system in which the output has no influence or effect on the control action of the input signal. [<http://www.electronics-tutorials.ws/systems/open-loop-system.html>]

Data: consists of at least an input, a controller, an object being controlled, and its output

Control: The controller translates the input to the object which does its work.

Behavior: a timer will use such a system. The time is set at the controller and the timer will count down until the input time has elapsed, and then it will produce whatever output it is designed to.

14. coordinate, absolute: Absolute coordinates are based on the origin (0,0), which is the intersection of the X and Y axes. Use absolute coordinates when you know the precise X and Y values of the point. [<http://knowledge.autodesk.com/support/autocad-lt/getting-started/caas/CloudHelp/cloudhelp/2015/ENU/AutoCAD-LT/files/GUID-F64F8008-E1C0-49CC-A268-A6B8C6E9B566-htm.html>]

Data: a Cartesian plane, an origin, and an ordered pair.

Control: the origin represents an “actual” point in space and is used to locate the location of the ordered pair

Behavior: Used to determine the location of a point based on a predefined origin.

15. coordinate, Cartesian: a coordinate system that specifies each point uniquely in a plane by a pair of numerical coordinates, which are the signed distances from the point to two fixed perpendicular directed lines, measured in the same unit of length. [http://en.wikipedia.org/wiki/Cartesian_coordinate_system]

Data: plane, coordinate axes (usually x and y), and any specified coordinate pairs.

Control: coordinate pairs (ordered pairs) are determined by measuring the signed distance along each of the coordinate axes from the origin.

Behavior: often used to the change of some value over time or to plot where objects exist in some space.

16. coordinate, polar: the polar coordinate system is a two-dimensional coordinate system in which each point on a plane is determined by a distance from a fixed point and an angle from a fixed direction. [http://en.wikipedia.org/wiki/Polar_coordinate_system]

Data: a fixed point (origin), a polar axis, and a plane. Any points will contain a radius and an azimuth (i.e. polar angle).

Control: Any point on the plane has its distance (radius) measured from the fixed point and its azimuth measured from the polar axis to determine its location.

Behavior: the polar coordinate system is commonly used in navigation and for models displaying radial symmetry.

17. coordinate, relative: Relative coordinates are based on some other point on the plane. Use relative coordinates when you know the location of a point in relation to the previous point. [<http://knowledge.autodesk.com/support/autocad-lt/getting-started/caas/CloudHelp/cloudhelp/2015/ENU/AutoCAD-LT/files/GUID-F64F8008-E1C0-49CC-A268-A6B8C6E9B566-htm.html>]

started/caas/CloudHelp/cloudhelp/2015/ENU/AutoCAD-LT/files/GUID-F64F8008-E1C0-49CC-A268-A6B8C6E9B566-htm.html]

Data: A Cartesian plane and at least two points.

Control: Any distance measured between the points is a relative distance since it cannot tell you where either exists relative to the origin, but only relative to one another.

Behavior: Used when you need to the distance between two objects without respect to the origin.

18. degree of freedom: the degree of freedom (DOF) of a mechanical system is the number of independent parameters that define its configuration.

[@http://en.wikipedia.org/wiki/Degrees_of_freedom_%28mechanics%29]

Data: modes of translation and modes of rotation

Control: The number of degrees of freedom of any object is determined by ways it can move given its engineering and environmental constraints. A car can translate forward and back, slide left and right, and turn left and right, so it has two translations and one rotation for three degrees of freedom.

Behavior: The degrees of freedom must be understood in order to properly engineer an efficient system. Though boats are only able to move forward and backward and pivot left and right by design, their environment causes them to move in other undersigned ways. These must be understood in order that the boat can be designed to not roll over or sink.

19. dynamics: is a branch of physics (specifically classical mechanics) concerned with the study of forces and torques and their effect on motion, as opposed to kinematics, which studies the motion of objects without reference to its causes. [@http://en.wikipedia.org/wiki/Dynamics_%28mechanics%29]

Data: Bodies, forces, and motion.

Control: (1)First law: If there is no net force on an object, then its velocity is constant. The object is either at rest (if its velocity is equal to zero), or it moves with constant speed in a single direction. (2) Second law: The rate of change of linear momentum P of an object is equal to the net force F_{net} , i.e., $dP/dt = F_{net}$. (3) Third law: When a first body exerts a force F_1 on a second body, the second body simultaneously exerts a force $F_2 = -F_1$ on the first body. This means that F_1 and F_2 are equal in magnitude and opposite in direction.

Behavior: dynamics is essential to the field of engineering where machines are designed to translate energy to force or vice versa to achieve a variety of goals.

20. energy, kinetic: Kinetic energy is energy of motion. The kinetic energy of an object is the energy it possesses because of its motion. [@<http://hyperphysics.phy-astr.gsu.edu/hbase/ke.html>]

Data: Kinetic energy is determined by an objects mass and velocity.

Control: kinetic energy is equal to $\frac{1}{2}$ mass * velocity squared.

Behavior: Kinetic energy is utilized by many inventions including rollercoasters, which have gathered a significant amount of kinetic energy at the bottom of their path which is then converted into gravitational potential energy as it rises again.

21. energy, potential: An object can store energy as the result of its position. For example, the heavy ball of a demolition machine is storing energy when it is held at an elevated position. This stored energy

of position is referred to as potential energy.

[<http://www.physicsclassroom.com/class/energy/Lesson-1/Potential-Energy>]

Data: The data will change depending on what potential energy is being considered, but will concern the object storing the energy and the phenomenon against which the energy is stored. For instance, gravitational potential energy concerns the mass of an object, the gravitational field strength, and the height of the object.

Control: the potential gravitational energy of an object is equal to its mass multiplied by its height multiplied by the gravitational field.

Behavior: Using the example of the roller coaster, when it rises to the apex of its path, it has gathered gravitational potential energy by virtue of its height and mass, which will propel it downward.

22. equations of motion: are equations that describe the behavior of a physical system in terms of its motion as a function of time. [http://en.wikipedia.org/wiki/Equations_of_motion]

Data: dynamic variables like special coordinates and time.

Control: Equations of motion concern how a physical system changes over time.

Behavior: Acceleration is an example of a physical system that has an associated equation of motion.

23. Euler angle: three angles introduced by Leonhard Euler to describe the orientation of a rigid body. [http://en.wikipedia.org/wiki/Euler_angles]

Data: three axes x, y, and z with three corresponding rotations α , β , and γ

Control: Any target orientation can be reached, starting from a known reference orientation, using a specific sequence of intrinsic rotations, whose magnitudes are the Euler angles of the target orientation.

Behavior: Gyroscopes use gimbals to measure Euler angles and determine the orientation of a vehicle based on the results.

24. failure (mechanical): reason for failure in engineering component can be attributed to design deficiencies, poor selection of materials, manufacturing defects, exceeding design limits and overloading, inadequate maintenance etc. [http://www.springer.com/cda/content/document/cda_downloaddocument/9789814560375-c2.pdf?SGWID=0-0-45-1433632-p175459859]

Data: the engineering component in question and its design specifications, fault tolerance, material attributes, and method of use.

Control: The causes of mechanical failure are analyzed so that future instances can be avoided.

Behavior: Causes of mechanical failure include:

- Misuse or abuse
- Assembly errors

- Manufacturing defects
- Improper or inadequate maintenance
- Design errors or design deficiencies
- Improper material or poor selection of materials
- Improper heat treatments
- Unforeseen operating conditions
- Inadequate quality assurance
- Inadequate environmental protection/control
- Casting discontinuities.

25. fatigue: the weakening of a material caused by repeatedly applied loads. It is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading.
[http://en.wikipedia.org/wiki/Fatigue_%28material%29#Characteristics_of_fatigue]

Data: Engineering material, material attributes, load applied to material

Control: Over time, as a material is continually subject to bearing loads, it will break down. Visible cracks or warping are indicators of fatigue in metal alloys.

Behavior: Material fatigue must be monitored so that it may be replaced before catastrophic failure.

26. force (general): In physics, a force is any interaction which tends to change the motion of an object.
[<http://en.wikipedia.org/wiki/Force>]

Data: Force has both magnitude and direction

Control: Force is equal to an objects mass multiplied by its acceleration

Behavior: All forces in nature derive from the fundamental forces: gravitational force, weak force, electromagnetic force, and strong force. One example of a non-fundamental force is normal force; Normal force is due to repulsive forces of interaction between atoms at close contact.

27. force, compressive: the application of balanced inward ("pushing") forces to different points on a material or structure, that is, forces with no net sum or torque directed so as to reduce its size in one or more directions. [http://en.wikipedia.org/wiki/Compression_%28physics%29]

Data: torque, materials, direction, stress, axial force

Control: compressive can be a component of design as when used to compress gasses, or a byproduct of design as with heavy structures. In the latter case, the fatigue of the material must be monitored.

Behavior: compressive force is used with gasses in order to save space, increase efficiency of reactions, or create a cushioning counter force.

28. force, sheer: are unaligned forces pushing one part of a body in one direction, and another part of the body in the opposite direction. When the forces are aligned into each other, they are called compression forces. [http://en.wikipedia.org/wiki/Shear_force]

Data: material, degree of shearing forces, and where these forces are being applied

Control: Shearing force is a force that must be designed against rather than one that is utilized. It occurs when two forces are at odds with one another and leads to material fatigue

Behavior: an example is when wind blows at the side of a peaked roof of a home - the side walls experience a force at their top pushing in the direction of the wind, and their bottom in the opposite direction, from the ground or foundation

29. force, tension: describes the pulling force exerted by each end of a string, cable, chain, or similar one-dimensional continuous object, or by each end of a rod, truss member, or similar three dimensional object. [http://en.wikipedia.org/wiki/Tension_%28physics%29]

Data: one-dimensional continuous object, level of tension being applied, and objects tolerance to tension

Control: At the atomic level, tension is produced when atoms or molecules are pulled apart from each other and gain electromagnetic potential energy. Each end of a string or rod under tension will pull on the object it is attached to, to restore the string/rod to its relaxed length.

Behavior: In a catapult, the bucket is pulled down, creating tension. When the lock is released, the tension forces the bucket back to its state of equilibrium, causing it to fling its ammunition.

30. friction: the force resisting the relative motion of solid surfaces, fluid layers, and material elements sliding against each other. [<http://en.wikipedia.org/wiki/Friction>]

Data: In the case of dry friction, material properties' friction coefficient, and normal force (object mass and gravity) are the data

Control: Also as regards dry friction: force of friction is less-than-or-equal-to the friction coefficient times the normal force

Behavior: Friction can be used to create kinetic or static energies. It can also be a design obstacle when materials must slide against one another.

31. geometry: a branch of mathematics concerned with questions of shape, size, relative position of figures, and the properties of space. [<http://en.wikipedia.org/wiki/Geometry>]

Data: lengths, areas, volumes, shapes, axioms, etc.

Control: Geometric data operate together according to geometric axioms (logical relations) to produce calculations based on that data.

Behavior: Geometry is used in geographical, surveying, astronomy, and construction, to name a few fields, but is widely applicable elsewhere as well.

32. hydraulic cylinder: a mechanical actuator that is used to give a unidirectional force through a unidirectional stroke. [http://en.wikipedia.org/wiki/Hydraulic_cylinder]

Data: the main parts of an hydraulic cylinder are the cylinder barrel, cylinder base or cap, cylinder head, piston, piston rod, seal gland, and seals.

Control: can move back and forth along one axis.

Behavior: used most notably in construction equipment to manipulate heavy objects like steel arms and shovels.

33. hydraulic motor: a mechanical actuator that converts hydraulic pressure and flow into torque and angular displacement (rotation). [http://en.wikipedia.org/wiki/Hydraulic_motor]

Data: For a gear motor: driven gear, shaft, idler gear, housing, and oil.

Control: the gears are turned by the oil which produces kinetic energies (torque and rotation).

Behavior: have many applications including being used in winches and crane drives, wheel motors, self-driven cranes and excavators.

34. hydraulics: a topic in applied science and engineering dealing with the mechanical properties of liquids. [[@http://en.wikipedia.org/wiki/Hydraulics](http://en.wikipedia.org/wiki/Hydraulics)]

Data: liquids, pressure, mechanisms

Control: used for the generation, control, and transmission of power by the use of pressurized liquids.

Behavior: covers concepts such as pipe flow, dam design, fluidics and fluid control circuitry, pumps, turbines, and hydropower

35. inertia: the resistance of any physical object to any change in its state of motion, including changes to its speed and direction. It is the tendency of objects to keep moving in a straight line at constant velocity. [[@http://en.wikipedia.org/wiki/Inertia](http://en.wikipedia.org/wiki/Inertia)]

Data: Force, mass, acceleration, and resistance

Control: the greater the mass of an object the more force is required change its velocity and direction.

Behavior: inertia is an important consideration when designing breaks, since the inertia of a massive object will require much more resistance to stop than a smaller object.

36. inertial measurement unit: an electronic device that measures and reports a craft's velocity, orientation, and gravitational forces, using a combination of accelerometers and gyroscopes, sometimes also magnetometers. [[@http://en.wikipedia.org/wiki/Inertial_measurement_unit](http://en.wikipedia.org/wiki/Inertial_measurement_unit)]

Data: accelerometers, gyroscopes, and magnetometers.

Control: detect the current rate of acceleration, changes in rotational attributes like pitch, roll and yaw, and some also include a magnetometer to assist calibrate against orientation drift.

Behavior: IMUs are typically used to maneuver aircraft, including unmanned aerial vehicles (UAVs), among many others, and spacecraft, including satellites and landers.

37. jerk: the rate of change of acceleration; that is, the derivative of acceleration with respect to time, and as such the second derivative of velocity, or the third derivative of position. [[@http://en.wikipedia.org/wiki/Jerk_%28physics%29](http://en.wikipedia.org/wiki/Jerk_%28physics%29)]

Data: magnitude, and direction, and time.

Control: In general, engineering designs must limit jerk since it has adverse effects on human operators and the parts of the device.

Behavior: Jerk must be accounted for in design of objects like railroad tracks and rollercoasters, where acute change in direction could produce a noticeable jerk if improperly designed. In engineering, quick changes of acceleration in tools could cause great wear if unaccounted for.

38. kinematics: the branch of classical mechanics which describes the motion of points, bodies (objects) and systems of bodies (groups of objects) without consideration of the causes of motion; often referred to as the *geometry of motion*. [<http://en.wikipedia.org/wiki/Kinematics>]. The process of calculating the position in space of the end of a linked structure, given the angles of all the joints [http://freespace.virgin.net/hugo.elias/models/m_ik.htm]

Data: trajectories, points, lines, geometric objects, velocity, and acceleration

Control: used to describe the motion of celestial bodies, jointed parts, components of a mechanical system, and ranges of motion of mechanical systems.

Behavior: Kinematics is used in astrophysics to describe the motion of celestial bodies and systems, and in mechanical engineering, robotics and biomechanics to describe the motion of systems composed of joined parts (multi-link systems) such as an engine, a robotic arm or the skeleton of the human body.

39. kinematics, inverse: refers to the use of the kinematics equations of a robot to determine the joint parameters that provide a desired position of the end-effector. [http://en.wikipedia.org/wiki/Inverse_kinematics]

Data: position, joints, joint range of motion, motion plan, end effector

Control: Used to transform the motion plan into joint actuator trajectories for the robot.

Behavior: Used in the design of robotic limbs and 3d animation.

40. kinetics: deals with the effects of forces upon the motions of material bodies or with changes in a physical or chemical system [<http://www.merriam-webster.com/dictionary/kinetics>]

[http://en.wikipedia.org/wiki/Kinetics_%28physics%29]

Data: force, torque, mass, and kinematics

Control: used to determine the force or torque created by motion

Behavior: examined in a variety of fields, including physics, engineering, and chemistry, to determine and harness the forces of movement of physical or chemical bodies.

41. lever: a machine consisting of a beam or rigid rod pivoted at a fixed hinge, or fulcrum. It is one of the six simple machines identified by Renaissance scientists. [<http://en.wikipedia.org/wiki/Lever>]

Data: a beam or rigid rod pivoted at a fixed hinge, or fulcrum

Control: amplifies an input force to provide a greater output force, which is said to provide leverage.

Behavior: Used extensively in all manner of human tools ranging from crowbars to large construction equipment to assist in moving greater weight than human muscles can move on their own.

42. linkage, mechanical: an assembly of bodies connected to manage forces and movement.

Data: links, joints

Control: Mechanical linkages are usually designed to transform a given input force and movement into a desired output force and movement. The ratio of the output force to the input force is known as the mechanical advantage of the linkage, while the ratio of the input speed to the output speed is known as the speed ratio.

Behavior: Levers, cranks, and all manner of complex machines are, in essence, mechanical linkages.

43. mass: a property of a physical body which determines resistance to being accelerated by a force and the strength of its mutual gravitational attraction with other bodies. [[@http://en.wikipedia.org/wiki/Mass](http://en.wikipedia.org/wiki/Mass)]

Data: matter in an object

Control: determines resistance to acceleration and strength of gravitational attraction to other bodies

Behavior: As a primary property of physical bodies, mass is used in all manner of calculations in physics and its myriad sub-sciences.

44. mechanics (general): area of science concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effects of the bodies on their environment. [[@http://en.wikipedia.org/wiki/Mechanics](http://en.wikipedia.org/wiki/Mechanics)]

Data: properties of physical bodies, forces, effects of physical bodies manipulated by forces

Control: Produces data which allow people to better understand how objects interact with one another and the environment.

Behavior: Mechanical data is harnessed by scientists to create all manner of machines

45. mechanics of materials: a subject which deals with the behavior of solid objects subject to stresses and strains. [[@http://en.wikipedia.org/wiki/Strength_of_materials](http://en.wikipedia.org/wiki/Strength_of_materials)]

Data: materials, integrity, stresses, strains, loads

Control: produces data concerning the load bearing capabilities of materials.

Behavior: Used extensively in engineering to help design structures that can withstand loads under both normal and adverse conditions.

46. mechanics, applied: examines the response of bodies (solids and fluids) or systems of bodies to external forces. [[@http://en.wikipedia.org/wiki/Applied_mechanics](http://en.wikipedia.org/wiki/Applied_mechanics)]

Data: bodies (solids and liquids) and forces

Control: useful in formulating new ideas and theories, discovering and interpreting phenomena, and developing experimental and computational tools.

Behavior: used in many fields of engineering, especially mechanical engineering

47. moment: a combination of a physical quantity and a distance. Moments are usually defined with respect to a fixed reference point [[@http://en.wikipedia.org/wiki/Moment_%28physics%29](http://en.wikipedia.org/wiki/Moment_%28physics%29)]

Data: distance, force, mass, electric charge distributions

Control: The Moment of a force is a measure of its tendency to cause a body to rotate about a specific point or axis. [http://web.mit.edu/4.441/1_lectures/1_lecture5/1_lecture5.html]

Behavior: Torque is an example of a moment and measures how much force must be applied at various lengths from an axis to rotate the axis.

48. momentum: the product of the mass and velocity of an object.
[<http://en.wikipedia.org/wiki/Momentum>]

Data: mass and velocity.

Control: Momentum measures the forward force of an object.

Behavior: In pool, the momentum of the cue-ball is transferred to the other balls as it hits them, causing them to move.

49. motion, axial: rotary motion of an object around its own axis
[<http://www.thefreedictionary.com/axial+motion>]

Data: axis, object

Control: Spinning around an axis

Behavior: Wheels and propellers have an axial motion when they spin.

50. motion, hinge: only the component of the torque vector along the axis has effect on the rotation, other forces and torques are compensated by the structure.
[http://en.wikipedia.org/wiki/Rotation_around_a_fixed_axis]

Data: Hinge, structure,

Control: A jointed or flexible device that allows the turning or pivoting of a part on a stationary frame. [<http://www.thefreedictionary.com/hinge>]

Behavior: Doors and lids operate with hinge motion.

51. motion, linear: motion along a straight line (one dimension). The linear motion can be of two types: uniform linear motion with constant velocity or zero acceleration; or non-uniform linear motion with variable velocity or non-zero acceleration. [http://en.wikipedia.org/wiki/Linear_motion]

Data: axis, velocity, acceleration, force

Control: an object will move at a constant velocity in one direction unless acted upon by an outside force

Behavior: An object in space will follow this trend, but understanding other forces like gravity, air resistance, and friction help us to understand why objects do come to a stop in Earth's atmosphere.

52. motion, reciprocating: a repetitive up-and-down or back-and-forth linear motion
[http://en.wikipedia.org/wiki/Reciprocating_motion]

Data: axis, velocity

Control: any object moving back and forth along an axis is reciprocating

Behavior: cranks are used to convert circular motion into reciprocating motion. Pistons in internal combustion engines use reciprocating motion to convert the force caused by combustion into circular motion.

53. motion, spherical: Rotation around a point, or spherical motion, is the motion of a rigid body during which one of its points O remains fixed, while all the other points move along the surface of spheres with their center at point O. [http://www.answers.com/Q/What_is_spherical_motion]

Data: center point, rotating points

Control: A point that moves in spherical patterns around a center point

Behavior: A gyroscope has a spherical motion.

54. pitch: The lateral axis (also called transverse axis) passes through an notional plane from wingtip to wingtips. Rotation about this axis is called **pitch**. [http://en.wikipedia.org/wiki/Aircraft_principal_axes]

Data: lateral axis. Vertical rotation

Control: This represents one of the degrees of freedom among the 6DOF. An object that can pitch can rotate up and down along a lateral axis.

Behavior: Planes use pitch to point their noses up and down.

55. pneumatics: a section of technology that deals with the study and application of pressurized gas to produce mechanical motion. [<http://en.wikipedia.org/wiki/Pneumatics>]

Data: gas, pressure, compressor,

Control: gas is compressed into a denser state. When released, the gas rapidly expands to its uncompressed state, creating pneumatic energy.

Behavior: pneumatics are used extensively in construction in tools like drills and jackhammers, which use the pneumatic energy to move a bit in a rotating or reciprocating motion.

56. power: the rate of doing work. It is equivalent to an amount of energy consumed per unit time. [http://en.wikipedia.org/wiki/Power_%28physics%29]

Data: work and time; force and movement

Control: power is used to change the state of an object, either to accelerate or decelerate motion.

Behavior: Power is used in every application imaginable. Human muscles use chemical power while machinery uses electric, hydraulic, and pneumatic power to name a few.

57. quaternion: In mathematics, the quaternions are a number system that extends the complex numbers. A feature of quaternions is that multiplication of two quaternions is noncommutative. Hamilton defined a quaternion as the quotient of two directed lines in a three-dimensional space or equivalently as the quotient of two vectors. [<http://en.wikipedia.org/wiki/Quaternion>]

Data: numbers, vectors, 3-dimensional coordinates

Control: $i^2 = j^2 = k^2 = ijk = -1$ such that i , j , and k are basis elements of a quaternion H .

Behavior: Used in calculations involving three-dimensional rotation as in computer graphics.

58. roll: The longitudinal axis passes through a notional plane from nose to tail. Roll changes the orientation of the aircraft's wings with respect to the downward force of gravity.

[@http://en.wikipedia.org/wiki/Aircraft_principal_axes]

Data: longitudinal axis, banking rotation

Control: This represents one of the degrees of freedom among the 6DOF. An object that can roll can tilt side to side along a longitudinal axis.

Behavior: Planes use rolls to point their wings up and down in relation to gravity.

59. sensor: a device that detects events or changes in quantities and provides a corresponding output, generally as an electrical or optical signal [a@<http://en.wikipedia.org/wiki/Sensor>]

Data: detection device, events, quantities, output

Control: detects changes in an environment over time.

Behavior: Used in all manner of closed-loop systems that adjust their report on conditions in an environment or change their behavior based on said conditions.

60. statics: the branch of mechanics that is concerned with the analysis of loads (force and torque, or "moment") on physical systems in static equilibrium, that is, in a state where the relative positions of subsystems do not vary over time, or where components and structures are at a constant velocity.

[a@<http://en.wikipedia.org/wiki/Statics>]

Data: particle, force, vector, moment, equilibrium

Control: Concerns the analysis of particles in static equilibrium

Behavior: statics is an important science for engineering as load bearing structures should have force applied at equilibrium to reduce strain and stave off eventual failure

61. strain: describes relative deformation or change in shape and size of elastic, plastic, and fluid materials under applied forces. The deformation, expressed by strain, arises throughout the material as the particles (molecules, atoms, ions) of which the material is composed are slightly displaced from their normal position. [a@<http://www.britannica.com/EBchecked/topic/567922/strain>]

Data: particles, normal position, degree of displacement (deformation), force

Control: Understanding levels of strain helps engineers understand if and when a material is in danger of deformation and collapse.

Behavior: Strain is considered all the time in engineering concerning operation life and structural integrity of designs.

62. strain gauge: a device used to measure strain on an object
[http://en.wikipedia.org/wiki/Strain_gauge]

Data: An insulating flexible backing, metallic foil pattern

Control: as an object that the strain gauge is attached to deforms, the foil in the gauge will deform, causing its electrical resistance to change.

Behavior: attached to physical structures to measure their degree of deformation.

63. stress: a physical quantity that expresses the internal forces that neighboring particles of a continuous material exert on each other [[@http://en.wikipedia.org/wiki/Stress_%28mechanics%29](http://en.wikipedia.org/wiki/Stress_%28mechanics%29)]

Data: force, materials, mass, gravity

Control: Stress is monitored in order to calculate the level of strain on a material structure.

Behavior: engineers monitor stress factors on machines so that they can be designed to counteract these stress factors.

64. torque: the tendency of a force to rotate an object about an axis, fulcrum, or pivot.
[[@http://en.wikipedia.org/wiki/Torque](http://en.wikipedia.org/wiki/Torque)]

Data: force, distance

Control: a torque can be thought of as a twist to an object

Behavior: Torque is part of the basic specification of an engine: the power output of an engine is expressed as its torque multiplied by its rotational speed of the axis. Steam engines and electric motors tend to produce maximum torque close to zero rpm, with the torque diminishing as rotational speed rises (due to increasing friction and other constraints).

65. vector: a geometric object that has magnitude (or length) and direction
[[@http://en.wikipedia.org/wiki/Euclidean_vector](http://en.wikipedia.org/wiki/Euclidean_vector)]

Data: line, length, direction

Control: vectors represent what is needed to carry the original point to the terminal point.

Behavior: vectors are used to represent, for instance, velocity and acceleration of moving objects.

66. velocity: the rate of change of the displacement, the difference between the final and initial position of an object. [[@http://en.wikipedia.org/wiki/Velocity](http://en.wikipedia.org/wiki/Velocity)]

Data: speed, direction

Control: Constant velocity requires a constant speed in a constant direction

Behavior: Velocity is considered when the start and the end point of an object is needed, as in how long it will take a rocket to reach the moon.

67. weight: the force on the object due to gravity. [[@http://en.wikipedia.org/wiki/Weight](http://en.wikipedia.org/wiki/Weight)]

Data: mass, gravity, force

Control: Weight equals mass multiplied by the force of gravity.

Behavior: Weight is important for all kinds of considerations in physics like the amount of stress caused by certain materials acting against one another and the amount of force needed to move a material of a certain weight.

68. work: a force is said to do work if, when acting on a body, there is a displacement of the point of application in the direction of the force. [http://en.wikipedia.org/wiki/Work_%28physics%29]

Data: displacement, direction, force

Control: Work equals force multiplied by a displacement.

Behavior: The principle of work and kinetic energy states that the work done by all forces acting on a particle (the work of the resultant force) equals the change in the kinetic energy of the particle

69. yaw: The yaw axis is defined to be perpendicular to the body of the wings with its origin at the center of gravity and directed towards the bottom of a notional aircraft. A yaw motion is a movement of the nose of the aircraft from side to side. [http://en.wikipedia.org/wiki/Aircraft_principal_axes]

Data: Vertical axis, horizontal rotation

Control: This represents one of the degrees of freedom among the 6DOF. An object that can yaw can turn side to side along a vertical axis.

Behavior: Planes use yaw to point their nose from left to right.

Engineering Terms

- backlash

States

- Failure (mechanical)
- Fatigue

Complex Values

- Weight
- Vector
- Acceleration
- Torque
- Velocity
- Work
- Quaternion

- Force, general
- Force, Compressive
- Force, Sheer
- Force, Tension
- Energy, kinetic
- Energy potential
- Friction
- Moment
- Momentum
- Power
- Stress
- Torque

Directional values

- Motion, axial
- Motion, hinge
- Motion, linear
- Motion, reciprocating
- Motion, spherical
- Pitch
- Yaw
- Roll
- Jerk
- Strain

Primitive

- Mass

Sciences

- Dynamics
- Geometry
- Kinematics
- Inverse Kinematics
- Kinetics
- Mechanics (general)
- Pneumatics
- Statics

Machines

- Actuator
- Arm
- Ball-and-socket joint

- Bearing
- Bellcrank
- Control Horn
- Lever
- Linkage, mechanical
- Sensor
- Strain Gauge

References

- Axis, directional
- Axis, lateral
- Axis, longitudinal
- Coordinate, absolute
- Coordinate, Cartesian
- Coordinate, polar
- Coordinate, relative

Scientific Concepts

- Degree of freedom
- Equations of motion
- Euler angle

Electronics

- Control system, closed loop
- Control system, open loop