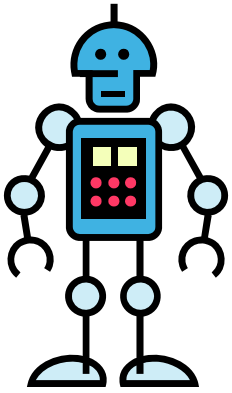
Boulder Valley School District
Excellence and Equity

Middle School Robotics Curriculum Essentials Document



Boulder Valley School District
Department of Curriculum and Instruction
May 2012

Boulder Valley School District Technology – An Introduction to The Curriculum Essentials Document

Background

* This BVSD Curriculum Essentials Document incorporates the International Society for Technology in Education's (ISTE) National Educational Technology Standards for Students (NETS) and the integrated essentials from the Colorado Academic Standards for 21st Century Learning Skills. The NETS for Students from ISTE do not delineate how courses should be created or taught. Each teacher must determine appropriate lesson planning. As technology rapidly evolves with new dynamic tools, there is no set of prescribed software, tools, or technologies that students and teachers may adopt to achieve these rigorous and robust standards. It is with experience, trust, and teacher consensus in ISTE that the Technology Teachers and Educational Technology Department at BVSD adopted these same NETS for our Boulder Valley students. The writing teams took the ISTE NETS for Students and carefully and thoughtfully divided them into courses for the creation of the 2011 BVSD Educational Technology Curriculum Essentials Documents (CED).

The ISTE 2007 Standards

The expectations in these documents are based on mastery of the topics at specific grade levels with the understanding that the standards, themes and big ideas reoccur throughout PK-12 at varying degrees of difficulty, requiring different levels of mastery. The Standards are:

1. Creativity and innovation

Students demonstrate creative thinking, construct knowledge, and develop innovative products and process using technology.

Students:

a. Apply existing knowledge to generate new ideas, products, and processes

b. Create original works as a means of personal or group expressions

c. Use models and simulations to explore complex systems and issues

d. Identify trends and forecast possibilities

2. Communication and Collaboration

Students use digital media and environments to communicate and work collaboratively to support individual learning and contribute to the learning of others. Students:

a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media

b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats

c. Develop cultural understanding and global awareness by engaging with learners of other cultures

d. Contribute to project teams to produce original works or solve problems

3. Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information. Students:

a. Plan strategies to guide inquiry

b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media

c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks

d. Process data and report results

4. Critical Thinking, Problem Solving, and Decision Making

Students use critical thinking skills to plan and conduct research, manage projects, solve problems and make informed decisions using appropriate digital tools and resources.

Students:

a. Identify and define authentic problems and significant questions for investigation

b. Plan and manage activities to develop a solution or complete a project

c. Collect and analyze data to identify solutions and/or make informed decisions

d. Use multiple processes and diverse perspectives to explore alternative solutions

5. Digital Citizenship

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students:
a. Advocate and practice safe, legal, and responsible use of information and technology
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity
c. Demonstrate personal responsibility for lifelong learning
d. Exhibit leadership for digital citizenship

6. Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students:
a. Understand and use technology systems
b. Select and use applications effectively and productively
c. Troubleshoot systems and applications
d. Transfer current knowledge to learning of new technologies

Components of the Curriculum Essentials Document

The CED for each grade level and course include the following:
 An At-A-Glance page containing:
o approximately ten key skills or topics that students will master during the year
o the general big ideas of the grade/course
o the Standards of Technology Practices
o assessment tools allow teachers to continuously monitor student progress for planning and pacing needs
o Description of Technology at that level
 The Grade Level Expectations (GLE) pages.
 The Grade Level Glossary of Academic Terms lists all of the terms with which *teachers should be familiar and comfortable using during instruction. It is not a comprehensive list of vocabulary for student use*

8th Grade Overview

Course Description	Topics at a Glance
The Middle Level Robotics course utilizes a hands on approach in designing, building, programming and testing robots. Students engage in a variety of activities that incorporate various engineering principles. Students also learn the value of teamwork and even friendly competition.	• Structural Engineering • Programming Essentials • Rotation Sensor • Ultrasonic Sensor • Touch Sensor • Infrared Sensor • Color Sensors • Mechanical Engineering-Gears
Assessments Written Exams Computer-Based Exams Project-Based Assessments	Achieving these goals may be reached by a variety of projects and/or programs. Use of specific software programs or technology equipment were deliberately not mentioned due to the variation in resources among different schools. **Standards:** The National Education Technology Standards (NETS) for Students were developed in 1998 and updated in 2007 by ISTE, the International Society for Technology in Education. 1. Creativity and innovation 2. Communication and Collaboration 3. Research and Information Fluency 4. Critical Thinking, Problem Solving, and Decision Making 5. Digital Citizenship 6. Technology Operations and Concepts 7. Careers

Content Area: Technology – Middle Level Robotics

Standard 1. Creativity and Innovation: Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.

Prepared Graduates: Apply existing knowledge to generate new ideas, products, or processes. Create original works as a means of personal or group expression. Use models and simulations to explore complex systems and issues. Identify trends and forecast possibilities.

GRADE LEVEL EXPECTATION

Concepts and skills students master:

- Apply existing knowledge to generate new ideas, products, or processes.
- Create original works as a means of personal or group expression.
- Use models and simulations to explore complex systems and issues.
- Identify trends and forecast possibilities.

Evidence Outcomes	21st Century Skills and Readiness Competencies
Students can: • Apply prior learning to develop innovative solutions to problems. • Produce a checklist of design constraints and apply them to a given project. • Test, modify, and retest, solutions to produce and improved final product. • Provide documentation of the process leading to a solution.	**Inquiry Questions:** • How is creativity different from problem solving? • Why are there always tradeoffs in design problems? • What are some of the ethical responsibilities that a designer should consider? **Relevance and Application:** • Technological design involves trade-offs among competing constraints and requirements. **Nature of Discipline:** • Work in a design or engineering team to solve a given problem.

Content Area: Technology – Middle Level Robotics

Standard: 2. Communication and Collaboration: Students work cooperatively to brainstorm possible solutions to multi-faceted problems. Students work together to choose and apply potential solutions. Students will present solutions to peers and teachers.

Prepared Graduates:

Communicate information and ideas effectively to multiple audiences. Contribute to team projects to produce original works or solve problems.

GRADE LEVEL EXPECTATION

Concepts and skills students master:

- Communicate information and ides effectively to multiple audiences.
- Contribute to team projects to produce original works or solve problems.

Evidence Outcomes	21st Century Skills and Readiness Competencies
Students can: • Communicate effectively with others during brainstorming sessions. • Successfully complete group projects and demonstrate cooperation, teamwork, and division of labor to complete the assigned task. • Successfully communicate evidence of projects success by demonstration.	**Inquiry Questions:** • What skills do we need to work effectively with others? • How might people collaborate in the future? • Why is working with others so important?
	Relevance and Application: • Communication and cooperation are necessary in everyday life. These skills will remain necessary in our future careers as well.
	Nature of Discipline: • Having skills to complete tasks and communicate solutions as an individual and as a team member is essential for the 21st Century Graduate.

Content Area: Technology – Middle Level Robotics

Standard: 3. Research and Information Fluency: Students use digital tools to gather, evaluate, and use information

Prepared Graduates:

Plan strategies to guide inquiry. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources. Process Data and report results.

GRADE LEVEL EXPECTATION

Concepts and skills students master:

- Plan strategies to guide inquiry.
- Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources.
- Process Data and report results.

Evidence Outcomes	21st Century Skills and Readiness Competencies
Students can: • Plan design strategies and processes by creating a project management document listing steps in the design process, a timeline for completion, and division of workload. • Locate, analyze, and evaluate design exemplars to devise strategies and formulate design questions and problems. • Evaluate and select appropriate components to be used to meet the design specifications. • Test design solutions and compile a report to communicate the results of the collected data.	**Inquiry Questions:** • What role does research play in the design process? • How can we assess/measure the quality of design solutions? **Relevance and Application:** • Technology drives invention and innovation as a dynamic process. **Nature of Discipline:** • Project-based design and implementation

Content Area: Technology – Middle Level Robotics

Standard: 4. Critical Thinking, Problem Solving, and Decision Making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate tools and resources.

Prepared Graduates:

Identify and define authentic problems and significant questions for investigation. Plan and manage activities to develop a solution or complete a project. Collect and analyze data to identify solutions and/or make informed decisions. Use multiple processes and diverse perspectives to explore alternative solutions.

GRADE LEVEL EXPECTATION

Concepts and skills students master:

- Identify and define authentic problems and significant questions for investigation.
- Plan and manage activities to develop a solution or complete a project.
- Collect and analyze data to identify solutions and/or make informed decisions.
- Use multiple processes and diverse perspectives to explore alternative solutions.

Evidence Outcomes	21st Century Skills and Readiness Competencies
Students can: • Identify and define project goals and intentions by describing the problem or challenge. • Define the strategies they will use to meet project goals while addressing constraints. • Explore and refine design solutions by starting with sketches or drawings created with differing forms of media. • Assess strengths and weaknesses of alternate design solutions. • Demonstrate evidence of creativity in the design process and final product.	**Inquiry Questions:** • How and why do we use the design process? • What are the steps or stages of a typical design process? **Relevance and Application:** • Technological design is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems. **Nature of Discipline:** • Design and engineering.

Content Area: Technology – Middle Level Robotics

Standard: 5. Digital Citizenship: Students understand human, cultural, and societal issues related to robotics technology and practice legal, ethical behavior.

Prepared Graduates:

Advocate and practice safe, legal, and responsible use of information and technology. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity. Demonstrate personal responsibility for lifelong learning.

GRADE LEVEL EXPECTATION

Concepts and skills students master:

- Advocate and practice safe, legal, and responsible use of information and technology.
- Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
- Demonstrate personal responsibility for lifelong learning.

Evidence Outcomes	21st Century Skills and Readiness Competencies
Students can: • Demonstrate knowledge of copyright, patent, and fair practices. • Illustrate the impact robotics can have on quality of life. • Describe ethical and human impact issues in robotics through classroom discussion. • Exhibit personal initiative, leadership, and responsibility.	**Inquiry Questions:** • Is the impact of robotics on society positive in all aspects? • What is the relationship between robotics and quality of life? • What are the implications of constantly evolving robotics technology?
	Relevance and Application: • Advances in robotics technology can impact us in both positive and negative ways. • Robotics can be used to improve our quality of life. • There are inherent risks that come with the use of certain technologies.
	Nature of Discipline: • How robotic technology impacts our lives will become more and more prevalent for a 21st century graduate.

Content Area: Technology – Middle Level Robotics

Standard: 6. Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems, and operations.

Prepared Graduates:

Understand and use technological system. Select and use applications effectively and productively.

GRADE LEVEL EXPECTATION

Concepts and skills students master:

- Understand and use technological systems through robotics.
- Select and use mechanical components and applications effectively and productively.

Evidence Outcomes	21st Century Skills and Readiness Competencies
Students can: • Correctly identify, categorize, and use project-relevant resources. • Show evidence of operational skills when using computers and other robotics related technologies. • Demonstrate safe use of all resources.	**Inquiry Questions:** • How do I use our technology responsibly and safely? **Relevance and Application:** • The acquisition of knowledge is needed to use and operate the various technologies used in robotics. **Nature of Discipline:** • Using tools and equipment to design and build projects with real world application potential.

Word	Definition
ABSO Data	Absolute Data (ABSO Data) is a correction factor for data that establishes an indicated value of zero when the robot is at the predetermined Home (calibration position).
Accuracy	Accuracy is the measurement of the deviation between the command characteristic and the attained characteristic ,or the precision with which a computed or calculated robot position can be attained. Accuracy is normally worse than the arm's repeatability. Accuracy is not constant over the workspace, due to the effect of link kinematics.
Active Compliant Robot	An active compliant robot is one in which motion modification during the performance of a task is initiated by the control system. The induced motion modification is slight, but sufficient to facilitate the completion of a desired task.
Actual Position	The position or location of the tool control point. Note that this will not be exactly the same as the demand position due to a multitude of un-sensed errors (such as link deflection, transmission irregularity, tolerances in link lengths, etc.)
Actuator	A power mechanism used to affect motion, or maintain position of the robot (for example, a motor which converts electrical energy to effect motion of the robot). The actuator responds to a signal received from the control system.
Axis	A direction used to specify the robot motion in a linear or rotary mode.
Arm	An interconnected set of links and powered joints comprising a robot manipulator that supports and/or moves a wrist and hand or end-effector through space. The arm itself does not include the end-effector. See Manipulator, End-effector and Wrist.
Articulated Manipulator	A manipulator with an arm that is broken into sections (links) by one or more joints. Each of the joints represents a degree of freedom in the manipulator system and allows translation and rotary motion.
Articulation	Describes a jointed device, such as a jointed manipulator. The joints provide rotation about a vertical axis, and elevation out of the horizontal plane. This allows a robot to be capable of reaching into confined spaces.
Assembly Robot	A robot designed specifically for mating, fitting, or otherwise assembling various parts or components into completed products. Primarily used for grasping parts and mating or fitting them together, such as in assembly line production.
Base	The stable platform to which a robot arm is attached.
Base Link	The stationary base structure of a robot arm that supports the first joint
Burn-In	Burn-In is a robot testing procedure where all components of the robot are operated continuously for an extended period of time. This is done to test movement, and movement programming of the robot at early stages to avoid malfunctions after deployment.
CAD	Computer Aided Design. Computer graphic applications designed to allow engineering of objects (or parts), which are to be manufactured. A computer is used as a tool to design schematics and produce blueprints, which enable the accurate production of the object. The CAD system enables the three-dimensional drawings of basic figures, exact sizing and placement of components, making lines of specified length, width, or angle, as well as satisfying varying geometric shapes. This system also allows the designer to test a

	simulated part under different stresses, loads, etc.
Carousel	A rotating platform that delivers objects to a robot, and serves as an object queuing system. This carousel delivers the objects, or work-pieces to the loading/unloading station of the robot.
Cartesian Topology	A topology, which uses prismatic joints throughout, normally arranged to be perpendicular to each other.
Cartesian Manipulator	A Cartesian Manipulator is a robot arm with prismatic joints, which allows movement along one or more of the three- axes in the x, y, z coordinate system.
Cartesian-Coordinate Robot	A Cartesian-Coordinate robot is a robot whose manipulator-arm degrees of freedom are defined by Cartesian coordinates. This describes motions that are east-west, north-south and up-down, as well as rotary motions to change orientation.
Centrifugal Force	When a body rotates about an axis other than one at its center of mass, it exerts an outward radial force called centrifugal force upon the axis, which restrains it from moving in a straight tangential line. To offset this force, the robot must exert an opposing torque at the joint of rotation.
Circular Motion Type	A calculated path that the robot executes, and is circular in shape.
Clamp	An end-effector which serves as a pneumatic hand that controls the grasping and releasing of an object. Tactile, and feed-back force sensors are used to manage the applied force to the object by the clamp. See End-Effector.
Closed-Loop	Control achieved by a robot manipulator by means of feed-back information. As a manipulator is in action, it's sensors continually feed-back information to the robot's controller which are used to further guide the manipulator within the given task. Many sensors are used to feed-back information about the manipulator's placement, speed, torque, applied forces, as well as the placement of a targeted moving object, etc. See feedback.
Control Command	An instruction fed to the robot by means of the human-to-machine input device. See Pendant (Teaching). This command is received by the robot's controller system and is interpreted. Then, the proper instruction is fed to the robot's actuators, which enable it to react to the initial command. Many times the command must be interpreted with the use of logic units and specific algorithms. See Input Device and Instruction Cycle.
Command Interpreter	A module or set of modules that determines what the received command means. The command is broken down into parts (parsed) and processed.
Command Position	The endpoint position of a robot motion that the controller is trying to achieve
Compliance	Displacement of a manipulator in response to a force or torque. A high compliance means the manipulator moves a good bit when it is stressed. This is called spongy or springy. Low compliance would be a stiff system when stressed.
Compliant Robot	A robot that performs tasks, with respect to external forces, by modifying its motions in a manner that minimizes those forces. The indicated or allowed motion is accomplished through lateral (horizontal), axial (vertical) or rotational compliance.
Configuration	The arrangement of links created by a particular set of joint positions on the robot. Note that there may be several configurations resulting in the same endpoint position.
Contact Sensor	A device that detects the presence of an object or measures the amount of applied force or torque applied on the object through physical contact with it. Contact sensing can be used to determine location, identity, and orientation of work-pieces.

Continuous Path	Describes the process where by a robot is controlled over the entire path traversed, as opposed to a point-to-point method of traversal. This is used when the trajectory of the end-effector is most important to provide a smooth movement, such as in spray painting etc. See Point-to-Point.
Control Algorithm	A monitor used to detect trajectory deviations in which sensors detect such deviations and torque applications are computed for the actuators.
Control Device	Any piece of control hardware providing a means for human intervention in the control of a robot or robot system, such as an emergency-stop button, a start button, or a selector switch.
Control Mode	The means by which instructions are communicated to the robot.
Controllability	The property of a system by which an input signal can take the system from an initial state to a desired state along a predictable path within a predetermined period of time.
Controller	An information processing device whose inputs are both the desired and measured position, velocity and other pertinent variables in a process and whose outputs are drive signals to a controlling motor or actuator.
Controller System	The robot control mechanism is usually a computer of some type, which is used to store data (both robot and work environment), and store and execute programs, which operate the robot. The controller system contains the programs, data, algorithms; logic analysis, and various other processing activities, which enable it to perform. See Robot.
CPU (Central Processing Unit)	The main circuit board and processor of the Controller System.
Cycle	A single execution of a complete set of moves and functions contained within a robot program.
Cyclic Coordinate System	A coordinate system that defines the position of any point in terms of an angular dimension, a radial dimension, and a height from a reference plane. These three dimensions specify a point on a cylinder.
Cylindrical Topology	A topology where the arm follows a radius of a horizontal circle, with a prismatic joint to raise or lower the circle. Not popular in industry.
Cyclo Drive	A brand name for a speed reduction device that converts high speed low torque to low speed high torque, usually used on the major axis (larger).
Dead Man Switch	See Enabling Device.
Degrees Of Freedom	The number of independent directions or joints of the robot, which would allow the robot to move its end effector through the required sequence of motions. For arbitrary positioning, 6 degrees of freedom are needed: 3 for position (left-right, forward-backward, and up-down) and 3 for orientation (yaw, pitch and roll).
Direct-Drive	Joint actuation including no transmission elements i.e. the link is bolted onto the output of the motor.
Downtime	A period of time in which a robot, or production line is shut down due to malfunction or failure. See Uptime.
Drive	A speed (gear) reducer to convert high speed low torque to low speed high torque (see Harmonic Drive, Cyclo Drive, Rotary Vector Drive).
Drop Delivery	A method of introducing an object to the workplace by gravity. Usually, a chute or container is so placed that, when work on the part is finished, it will fall or drop into a chute or onto a conveyor with little or no transport by the robot.

Dynamics	The study of motion, the forces that cause the motion, and the forces due to motion. The dynamics of a robot arm are very complicated as they result from the kinematical behavior of all masses within the arm's structure. The robot arm kinematics are complicated in themselves.
Emergency Stop	The operation of a circuit using hardware-based components that overrides all other robot controls, removes drive power from the robot actuators, and causes all moving parts to stop.
Enabling Device	A manually operated device which when continuously activated, permits motion. Releasing the device shall stop robot motion and motion of associated equipment that may present a hazard.
Encoder	A feedback device in the robot manipulator arm that provides current position (and orientation of the arm) data to the controller. A beam of light passes through a rotating code disk that contains a precise pattern of opaque and transparent segments on its surface. Light that is transmitted through the disk strikes photo-detectors, which convert the light pattern to electrical signals. See Feedback, Closed-Loop Control , and Feedback Sensor.
End-Effector	An accessory device or tool specifically designed for attachment to the robot wrist or tool mounting plate to enable the robot to perform its intended task. (Examples may include gripper, spot weld gun, arc weld gun, spray point gun, or any other application tool.)
Endpoint	The nominal commanded position that a manipulator will attempt to achieve at the end of a path of motion. The end of the distal link.
Error	The difference between the actual response of a robot and a command issued.
Expandability	Being able to add resources to the system, such as memory, larger hard drive, new I/O card, etc.
Feedback	The return of information from a manipulator, or sensor to the processor of the robot to provide self-correcting control of the manipulator. See Feedback Control, and Feedback Sensor.
Feedback Control	A type of system control obtained when information from a manipulator, or sensor is returned to the robot controller in order to obtain a desired robot effect. See Feedback, Closed-Loop Control and Feedback Sensor.
Feedback Sensor	A mechanism through which information from sensing devices is fed back to the robot's control unit. The information is utilized in the subsequent direction of the robot's motion. See Closed-Loop Control and Feedback Control.
Flexibility	The ability of a robot to perform a variety of different tasks.
Force Feedback	A sensing, technique using electrical signals to control a robot end-effector during the task of the end-effector. Information is fed from the force sensors of the end-effector to the robot control unit during the particular task to enable enhanced operation of the end-effector. See Feedback, Feedback Sensor and Force Sensor.
Force Sensor	A sensor capable of measuring the forces and torque exerted by a robot and it's wrist. Such sensors usually contain strain gauges. The sensor provides information needed for force feedback. See Force Feedback, Strain, Stress, and Strain Gauge.
Forward Kinematic Solution	The calculation required to find the endpoint position given the joint positions. For most robot topologies this is easier than finding the inverse kinematic solution.
Forward Kinematics	Procedures which determine where the end effector of a robot is located in space. The procedures use mathematical algorithms along with joint sensors to determine its location.
Frame	A coordinate system used to determine a position and orientation of an object in space, as well as the robot's position within its model.

Gantry	An adjustable hoisting machine that slides along a fixed platform or track, either raised or at ground level along the x, y, z axes.
Gantry Robot	A robot which has three degrees of freedom along the X, Y, and Z coordinate system. Usually consists of a spooling system (used as a crane) which when reeled or unreeled provides the up and down motion along the Z axis. The spool can slide from left to right along a shaft which provides movement along the Z axis. The spool and shaft can move forward and back along tracks which provide movement along the Y axis. Usually used to position its end-effector over a desired object and pick it up.
Gravity Loading	The force exerted downward, due to the weight of the robot arm and/or the load at the end of the arm. The force creates an error with respect to position accuracy of the end-effector. A compensating force can be computed and applied bringing the arm back to the desired position.
Gripper	An end effector that is designed for seizing and holding (ISO 8373), and "grips" or grabs an object. It is attached to the last link of the arm. It may hold an object using several different methods, such as: applying pressure between its "fingers", or may use magnetization or vacuum to hold the object, etc. See End-Effector.
Hand	A clamp or gripper used as an end-effector to grasp objects. See End Effector, Gripper.
Harness	Usually several wires, bundled together to deliver power and/or signal communications to/from devices. For example the robot motors are connected to the controller through a wire harness.
Harmonic Drive	Compact lightweight speed reducer that converts high speed low torque to low speed high torque. Usually found on the minor axis (smaller).
Hazardous Motion	Unintended/unexpected robot motion that may cause injury.
Hold	A stopping of all movements of a robot during its sequence, in which some power is maintained on the robot. For example, program execution stops, however power to the servomotors remain on if restarting is desired.
Home Position	A known and fixed location on the basic coordinate axis of the manipulator where it comes to rest, or to an indicated zero position for each axis. This position is unique for each model of manipulator.
Inductive Sensors	The class of proximity sensors, which has half of a ferrite core, whose coil is part of an oscillator circuit. When a metallic object enters this field, at some point the object will absorb enough energy from the field to cause the oscillator to stop oscillating. This signifies that an object is present in a given proximity. See Proximity Sensor.
Interpolation	The method by which endpoint paths are created. In general to specify a motion a few knot points are defined and then all the intermediate positions between them are calculated by mathematical interpolation. The interpolation algorithm used therefore has a dramatic effect of the quality of motion.
Industrial Robot	A re-programmable multifunctional manipulator designed to move material, parts, tools, or specialized devices, through variable programmed motions for the performance of a variety of tasks. The principle components are: one or more arms that can move in several directions; a manipulator; a computer controller that gives detailed movement instructions.
Input Devices	A variety of devices, which allow a human to machine interface. This allows the human to program, control, and simulate the robot. Such devices include programming pendant, computer keyboards, a mouse, joy-sticks, push buttons, operator panel, operator pedestal etc.
Instruction	A line of programming code that causes action from the System Controller. See Command.
Instruction Cycle	The time it takes for a robot controller system's cycle to decode a command or instruction before it is executed. The Instruction Cycle

	must be analyzed very closely by robotic programmers to enable speedy and proper reaction to varying commands.
Integrate	To fit together different subsystems, such as robots and other automation devices, or at least different versions of subsystems in the same control shell.
Intelligent Robot	A robot that can be programmed to make performance choices contingent on sensory inputs with little or no help from human intervention. See Robot.
Jacobian Matrix	The Jacobian matrix relates the rates of change of joint values with the rates of change of endpoint co-ordinates. Essentially it is a set of algorithm calculations that are processed to control the positioning of a robot.
Joint	A part of the manipulator system, which allows a rotation and/or translational degree of freedom of a link of end-effector.
Joints	The parts of the robot arm which actually bend or move.
Joint Motion Type	Also known as Point to Point motion, is a method of path interpolation that commands the movement of the robot by moving each joint directly to the commanded position so that all axis arrive to the position at the same time. The path is predictable, however the path will not be linear.
Joint-Interpolated Motion	A method of coordinating the movement of the joints, such that all joints arrive at the desired location simultaneously. This method of servo control produces a predictable path regardless of speed and results in the fastest pick and place cycle time for a particular move. See Pick and Place Cycle, Servo-system.
Joint Space	The set of joint positions.
Kinematics	The relationship between the motion of the endpoint of a robot and the motion of the joints. For a Cartesian robot this is a set of simple linear functions (linear tracks that may be arranged in X, Y, Z directions), for a revolute topology (joints that rotate) however, the kinematics are much more complicated involving complicated combinations of trigonometry functions. The kinematics of an arm is normally split into forward and inverse solutions.
Ladle Gripper	An end-effector, which acts as a scoop. It is commonly used to scoop up liquids, transfer it to a mold and pour the liquid into the mold. Common for handling molten metal under hazardous conditions. See End-Effector.
Laser	Acronym for Light Amplification by Stimulated Emission of Radiation. A device that produces a coherent monochromatic beam of light which is extremely narrow and focused but still within the visible light spectrum. This is commonly used as a non-contact sensor for robots. Robotic applications include: distance finding, identifying accurate locations, surface mapping, bar code scanning, cutting, welding etc.
Linear Motion Type	Is a method of path interpolation that commands the movement of the robot by moving each joint in a coordinated motion so that all axis arrive to the position at the same time. The path of the tool control point (TCP) is predictable and will be linear.
Link	A rigid part of a manipulator, which connects adjacent joints.
Links	The static material, which connects the joints of an arm together thereby forming a kinematical chain. In a human body, the links are the bones.
Load Cycle Time	A manufacturing or assembly line process term, which describes the complete time to unload the last work-piece and load the next one.
Magnetic Detectors	Robot sensors that can sense the presence of ferromagnetic material. Solid-state detectors with appropriate amplification and processing can locate a metal object to a high degree of precision. See Sensor.

Manipulator	A machine or robotic mechanism of which usually consists of a series of segments jointed or sliding relative to one another, for the purpose of grasping and/or moving objects (pieces or tools) usually in several degrees of freedom. The control of the manipulator may be by an operator, a programmable electronic controller, or any logic system (for example cam device, wired, etc.) (ISO 8373) See Arm, Wrist, and End-Effector, Master-Slave Manipulator
Material Handling	The process by which a robotic arm transfers materials from one place to another.
Material Processing Robot	A robot designed and programmed so that it can machine, cut, form, or change the shape, function or properties of materials it handles between the time the materials are first grasped and the time they are released in a manufacturing process.
Modularity	The property of flexibility built into a robot and control system by assembling separate units, which can be easily joined to or arranged with other parts or units.
Module	Self-contained component of a package. This component may contain sub-components known as sub-modules.
Motion Axis:	The line defining the axis of motion either linear or rotary segment of a manipulator.
Motor	See Servo Motor.
Off-Line Programming	A programming method where the task program is defined on devices or computers separate from the robot for later input of programming information to the robot.
On-Line Programming	A means of programming a robot while the robot is functioning. This becomes important in manufacturing and assembly line production due to keeping productivity high while the robot is being programmed for other tasks.
Operator	The person designated to start, monitor and stop the intended productive operation of a robot or robot system. An operator may also interface with a robot for productive purposes.
Optical Encoder	A detection sensor, which measures linear or rotary motion by detecting the movement of markings past a fixed beam of light. This can be used to count revolutions, identify parts, etc.
Optical Proximity Sensors	Robot sensors which measures visible or invisible light reflected from an object to determine distance. Lasers are used for greater accuracy.
Orientation	The angle formed by the major axis of an object relative to a reference axis. It must be defined relative to a three-dimensional coordinate system. Angular position of an object with respect to the robot's reference system. See Roll, Pitch, and Yaw.
Path	The continuous locus of positions (or points in three dimensional space) traversed by the tool center point and described in a specified coordinate system.
Payload - Maximum	The maximum mass that the robot can manipulate at a specified speed, acceleration/deceleration, center of gravity location (offset), and repeatability under continuous operation over a specified working space. Maximum payload is specified in kilograms.
Pendant [Teach Pendant]	A hand-held input device linked to the control system with which a robot can be programmed or moved. (ISO 8373) This enables the human operator to stand in the most favorable position to observe, control, and record the desired movements in the robot's memory.
Pendant Teaching	The mapping and recording of the position and orientation of a robot and/or manipulator system as the robot is manually moved in increments from an initial state along a path to a final goal state. The position and orientation of each critical point (joints, robot base, etc.) is recorded and stored in a database for each taught position the robot passes through on its path toward its final goal. The robot may now repeat the path on its own by following the path stored in the database.

Pick And Place Cycle	The amount of time it takes for a manipulator to pick up an object and place it in a desired location, then return to its rest position. This includes time during the acceleration and deceleration phases of a particular task. The robots movement is controlled from one point location in space to another in a point-to-point (PTP) motion system. Each point is programmed into the robot's control memory and then played back during the work cycle.
Pick-And-Place Task	A repetitive part transfer task composed of a picking action followed by a placing action.
Pitch	Rotation of the end-effector in a vertical plane around the end of the robot manipulator arm. See Roll, and Yaw.
Point-To-Point	Manipulator motion in which a limited number of points along a projected path of motion is specified. The manipulator moves from point to point rather than a continuous smooth path.
Pose	Alternative term for robot configuration, and describes the linear and angular position. The linear position includes the azimuth, elevation, and range of the object. The angular position includes the roll, pitch, and yaw of the object. See Roll, Pitch, and Yaw.
Position	The definition of an object's location in 3-D space, usually defined by a 3-D coordinate system using X, Y, and Z coordinates.
Presence-Sensing Safeguarding Device	A device designed, constructed, and installed to create a sensing field to detect an intrusion into such field by people, robots, or objects. See Sensor.
Programmable Logical Controller (PLC)	A solid-state control system, which has a user programmable memory for storage of instructions to implement specific functions such as: I/O control logic, timing, counting arithmetic, and data manipulation. A PLC consists of a central processor, input/output interface, memory, and programming device, which typically uses relay equivalent symbols. The PLC is purposely designed as an industrial control system, which may perform functions equivalent to a relay panel or a wired solid-state logic control system, and may be integrated into the robot control system.
Programmable Robot	A feature that allows a robot to be instructed to perform a sequence of steps and then to perform this sequence in a repetitive manner. It can then be reprogrammed to perform a different sequence of steps if desired.
Proximity Sensor	A non-contact sensing device used to sense when objects are a short distance away, and determine the distance of the object. Several types include: radio frequency, magnetic bridge, ultrasonic, and photoelectric. Commonly used for: high speed counting, sensing metal objects, level control, reading coding marks, and limit switches. See Inductive Sensor.
Quality Assurance (QA)	Describes the methods, policies, and procedures necessary to conduct quality assurance testing during design, manufacturing and deliver phases of creating, reprogramming, or maintaining robots.
Reach	The volume of space (envelope), which a robot's end-effector can reach in at least one orientation.
Real-Time System	A computer system in which the computer is required to perform its tasks within the time restraints of some process simultaneously with the system it is assisting. The computer processes system data (input) from the sensors for the purpose of monitoring and computing system control parameters (outputs) required for the correct operation of a system or process. The computer is required to do its work fast enough to keep pace with an operator interacting with it through a terminal device (such as a screen or keyboard). The operator interacting with the computer has access, retrieval, and storage capability through a database management system. System access allows the operator to intervene and alter the system's operation.
Record-Playback Robot	A manipulator for which the critical points along desired trajectories are stored in sequence by recording the actual values of the joint-position encoders of the robot as it is moved under operational control. To perform the task, these points are played back to the robot's

	Servo-system. See Servo-system.
Rectangular-Coordinate Robot	A robot whose manipulator arm moves in linear motions along a set of Cartesian or rectangular axis in X, Y, and Z directions. The shape of the work envelope forms a rectangular figure. See Work Envelope.
Reliability	The probability or percentage of time that a device will function without failure over a specified time period or amount of usage. Also called the robot's uptime or the Mean Time Between Failure (MTBF).
Repeatability	A measure of how close an arm can repeatedly obtain a taught position. For instance: once a manipulator is manually placed in a particular location and this location is resolved by the robot, the repeatability specifies how accurately the manipulator can return to that exact location. The degree of resolution within the robot control system determines the repeatability. In general an arm's repeatability can never be better than its resolution. See Teach, and Accuracy.
Remanufacture	To upgrade or modify robots to the revised specifications of the manufacturer.
Resolution	The amount of robot joint motion required for the position sensing to change by 1 count. Although the resolution of each joint feedback sensor is normally constant, the resolution of the endpoint in world coordinates is not constant for revolute arms, due to the non-linearity of the arm's kinematics.
Revolute Joint	The joints of a robot, which are capable of rotary motion.
Robot	A re-programmable, multifunctional manipulator designed to move material, parts, tools, or specified devices through variable programmed motions for the performance of a variety of tasks. Common elements which make up a robot are: controller, manipulator, and end-effector. See Manipulator, Controller, and End-Effector.
Robot Programming Language	An interface between a human user and a robot, which relates humans commands to the robot.
Robot Simulation	A method for emulating and predicting the behavior and the operation of a robotic system based on the model (e.g. computer graphics) of the physical system.
Roll	Rotation of the robot end-effector in a plane perpendicular to the end of the manipulator arm. See Pitch, and Yaw.
Rotary Joint	A joint which twists, swings or bends about an axis
Rotary Vector Drive (RV	A brand name for a speed reduction device that converts high speed low torque to low speed high torque, usually used on the major axis (larger). See Cyclo Drive, Harmonic Drive.
Safeguard	A barrier guard, device or safety procedure designed for the protection of personnel.
Sensor	Instruments used as input devices for robots, which enable it to determine aspects regarding the robot's environment, as well as the robot's own positioning. Sensors respond to physical stimuli (such as heat, light, sound, pressure, magnetism, motion) and transmit the resulting signal or data for providing a measurement, operating a control, or both.
Sensory Feedback	Variable data measured by sensors and relayed to the controller in a closed-loop system. If the controller receives feedback that lies outside an acceptable range, then an error has occurred. The controller sends an error signal to the robot. The robot makes the necessary adjustments in accordance with the error signal.
Servo Control	The process by which the control system of the robot checks if the attained pose of the robot corresponds to the pose specified by the motion planning with required performance and safety criteria.

Servo-Controlled Robot	The control of a robot through the use of a closed loop Servo-system, in which the position of the robot axis is measured by feedback devices and is stored in the controller's memory. See Closed-Loop System, and Servo-system.
Servo Motor	An electrical power mechanism used to affect motion, or maintains position of the robot (for example, a motor which converts electrical energy to effect motion of the robot). The motor responds to a signal received from the control system and often incorporates an encoder to provide feedback to the control loop.
Servo Pack	An alternating current electrical power mechanism that is controlled through logic to convert electrical supply power that is in a sine wave form to a Pulse Width Modulated (PWM) square form, delivered to the motors for motor control: speed; direction; acceleration; deceleration; and braking control.
Servo-System	A system in which the controller issues commands to the motors, the motors drive the arm, and an encoder sensor measures the motor rotary motions and signals the amount of the motion back to the controller. This process is continued many times per second until the arm is repositioned to the point requested. See Servo-controlled Robot
Simulation	A graphical computer program that represents the robot and its environment, which emulates the robot's behavior during a simulated run of the robot. This is used to determine a robot's behavior in certain situations, before actually commanding the robot to perform such tasks. Simulation items to consider are: the 3-D modeling of the environment, kinematics emulation, path-planning emulation, and simulation of sensors. See Sensor, Forward Kinematics, and Robot.
Singularity	A configuration where two joints of the robot arm become co-axial (aligned along a common axis). In a singular configuration, smooth path following is normally impossible and the robot may lose control. The term originates from the behavior of the Jacobian matrix, which becomes singular (i.e. has no inverse) in these configurations.
Spline	A smooth, continuous function used to approximate a set of functions that are uniquely defined on a set of sub-intervals. The approximating function and the set of functions being approximated intersect at a sufficient number of points to insure a high degree of accuracy in the approximation. The purpose for the smooth function is to allow a robot manipulator to complete a task without jerky motion.
Spline Motion Type	A calculated path that the robot executes, and may be parabolic in shape. A Spline motion may also accomplish a free form curve with mixtures of circular and parabolic shapes.
Teach	To program a manipulator arm by manually guiding it through a series of motions and recording the position in the robot controller memory for playback.
Teach Pendant	A handheld control box, which is used by an operator to remotely guide a robot through the motions of its tasks. The motions are recorded by the robot control system for future playback. See Accuracy, Pendant Control, Playback Accuracy, Repeatability, and Teach.
Through-Beam	An object detection system used within a robot's imaging sensor system. A finely focused beam of light is mounted at one end and a detector at the other. When the beam of light is broken, an object is sensed.
Tool	A term used loosely to define a working apparatus mounted to the end of the robot arm, such as a hand, gripper, welding torch, screw driver, etc. See Arm, Gripper, and End-Effector.
Tool Frame	A coordinate system attached to the end-effector of a robot (relative to the base frame).
Touch Sensor	Sensing device, sometimes used with the robot's hand or gripper, which senses physical contact with an object, thus giving the robot an

	artificial sense of touch. The sensors respond to contact forces that arise between themselves and solid objects.
Trajectory Generation (Calculation)	The computation of motion functions that allow the movement of joints in a smooth controlled manner.
Transducer	A device that converts energy from one form to another. Generally, a device that converts an input signal into an output signal of a different form. It can also be thought of as a device which converts static signals detected in the environment (such as pressure) into an electrical signal that is sent to a robot's control system.
Uptime	A period of time in which a robot, or production line is operating or available to operate, as opposed to downtime. See Downtime.
Vacuum Cup Hand	An end-effector for a robot arm which is used to grasp light to moderate weight objects, using suction, for manipulation. Such objects may include glass, plastic; etc. Commonly used because of its virtues of reduced object slide slipping while within the grasp of the vacuum cup. See End-Effector.
Vision Guided	Control system where the trajectory of the robot is altered in response to input from a vision system.
Vision Sensor	A sensor that identifies the shape, location, orientation, or dimensions of an object through visual feedback, such as a television camera.
Work Envelope	The set of all points which a manipulator can reach without intrusion. Sometimes the shape of the work space, and the position of the manipulator itself can restrict the work envelope.
Work-Piece	Any part which is being worked, refined, or manufactured prior to its becoming a finished product.
Workspace	The volume of space within which the robot can perform given tasks.
World Coordinates	A reference coordinate system in which the manipulator arm moves in linear motions along a set of Cartesian or rectangular axis in X, Y, and Z directions. The shape of the work envelope forms a rectangular figure. See Rectangular Coordinates.
World Model	A three dimensional representation of the robot's work environment, including objects and their position and orientation in this environment, which is stored in robot memory. As objects are sensed within the environment the robot's controller system continually updates the world model. Robots use this world model to aid in determining its actions in order to complete given tasks.
Wrist [Secondary Axis]	An interconnected set of links and powered joints between the arm and end effector, which supports, positions and orientates the end effector.
Wrist	A set of rotary joints between the arm and the robot end-effector that allow the end-effector to be oriented to the work-piece. In most cases the wrist can have degrees of freedom which enable it to grasp an object with roll, pitch, and yaw orientation. See Arm, End-effector, Roll, Pitch, Yaw, and work piece.
Yaw	Rotation of the end-effector in a horizontal plane around the end of the manipulator arm. Side to side motion at an axis. See Roll, and Pitch.