# Robotics and Automated Processing 120

## Curriculum: Grade Twelve

New Nouveau Brunswick

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# Introduction

**Overview:**
Robotics and Automated Processing introduces students to the skills and knowledge required to pursue further studies in the robotics field. Students can easily transfer skills and knowledge gained in this course to other technology fields such as electronics, automotive mechanics, industrial mechanics, electrical wiring, and computer programming. The Robotics and Automated Processing course is designed for students who are interested in a technical or engineering career. Three main disciplines—computer science, electronics, and engineering—interrelate in robotic technology concepts.

Robots are complex and involve many subsystems such as electronics, mechanical parts, power transmission and software programming. The actual creation of robots, or fabrication of parts built from “scratch” are not included in the course objectives; however, students will be involved with the assembly of components in order to build a robot. Trouble shooting and analysis are developed through the understanding of malfunctions, and students are required to read and produce technical documents, think critically to address technical situations, and assess isolated subsystems to understand the complexities of subsystem interactions.

**Learning Activities:**
Automated or robotic technology will be explored through experimentation, including hands-on and programming of robotic devices. Students will work to create automatic or robot-operated systems that model concepts used in industry. Teachers will use “Project Based Learning” strategies to meet the curriculum outcomes.

**Maximum Class Size**
Students will be using fabrication equipment, test equipment, and prototypical electrical devices which will require close supervision; therefore, to ensure student safety within the robotics class, the maximum recommended class size is 22 students.

Suggested **Learning Resources:**

Student access to computers for programming: one computer/two students.
One Lego® NXT Base Set per class.

One Lego® NXT Robotics Engineering II – Getting Started Package. (#730120 from Spectrum Learning Resources)
Included in the package:

- twelve Lego® Mindstorms Education Base Sets
- one NXT Poster Package
- one NXT Robotics Engineering 1 Software: Introduction to Mobile Robotics Curriculum (Volumes 1 and 2: Carnegie Mellon)
- one Lego® Mindstorms Education Software and Site License
- one Lego® NXT Robotics Engineering 2 Software: Guided Research Curriculum

Parallax BoE-Bot Kit #28832 (twelve kits per class) – available through ABRA Electronics

Parallax Sensor Sampler Kit #28028 (one per school) – available through ABRA

*Introduction to Electronics*. Earl Gates, Recent edition – three copies as a teacher/classroom resource

Multisim (Student Edition) Software

Carnegie Mellon Software

Electronics Package - See Appendix C

**Additional Resources**

Access to NBED online courses: Electronics 110 and Computer Science 110
Spare parts box (teacher to collect over time) – motors, gears, wheels, building materials
Additional Parallax texts – available on-line from http://www.parallax.com in PDF format (*Stamps in Class* section: Process control, Applied Sensors, Smart Sensors, etc.)
Project Based Learning On-line Resource - http://www.pbl-online.org

**Prerequisites:** none

**Duration:** 90 hours

**Course Name:** Robotics and Automated Technology 120

**Data Entry Name:** Robotics & Tech 120

**Course Code:** 1039440

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**General Curriculum Outcomes**

Upon completion of this course, students will meet the following outcomes:*

GCO 1 Students will reflect on and predict the evolution and application of robotics.

GCO 2 Students will design, construct, and appraise automated control systems and subsystems that create a robot.

GCO 3 Students will develop a systematic approach to solving problems.

GCO 4 Students will demonstrate general material processing and assembly skills.

* Student friendly versions are listed in Appendix A.

**GCO 1 Students will reflect on and predict the evolution and application of robotics.**

| **Specific Curriculum Outcomes**<br>Students will be expected to: | **Suggestions for Teaching/Learning:** |
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| • assess the evolution and the future of robotics systems<br><br>• analyze the historical development of robots in society<br><br>• examine the use of robots in society and the potential of robots in the future (personal and industrial)<br><br>• scrutinize the potential risks to the environment and humans in an ecological and social context | Students observe a demonstration of teacher-supplied robots.<br><br>Students participate in whole and/or small group discussions to compare and contrast the media portrayal of robots with real-world robots.<br><br>Students view online videos of robots. Provide appropriate and interesting sites to support student searches.<br><br>Students create a presentation (e.g., PowerPoint) on a particular robot, past or present, and describe potential improvements for future use.<br><br>Arrange a visit an industrial site which uses robotic technologies. Preparation and activities to accompany the field research should include the following:<br>– before – decide purpose, formulate questions, and develop observation techniques;<br>– during – make observations and gather information; and<br>– after – organize, compile, and analyze the observations and information.<br><br>Students, with the whole class, in small groups, or individually, conduct online research to provide an account of the evolution of robotics and the societal effects.<br><br>Students create a time-line of the evolution of robotics. |

| **Suggestions for Learning &Assessment:** | **Resources:** |
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| *Note: Teachers must provide a rubric for assessing student produced material. Examples are provided in the Appendix B.*<br><br>Students work in small groups to critically evaluate the positive and negative effects of technological development in robotics.<br><br>Students research a robotic installation or prototypical robot and demonstrate their learning through a project which may include a written report, posters, a PowerPoint, sales advertisement, or a kiosk.<br><br>Students design a potential robot to replicate a human task. Students analyze the design (i.e., decide the use and purpose, and scrutinize the possible social and ecological effects). Students present their design and analysis to the class. | http://blog.modernmechanix.com/category/robots/<br><br>http://www.thefutureschannel.com/dockets/hands-on_math/reliable_robots/<br><br>www.roboticstrends.com<br><br>http://www.societyofrobots.com/<br><br>http://www.howstuffworks.com/robot.htm/printable<br><br>http://www.roboticfx.com/<br><br>http://www.faculty.ucr.edu/~currie/roboadam.htm<br><br>http://www.oricomtech.com/projects/gallery1.htm<br><br>Internet search topic: "Isaac Asimov's three laws of robotics".<br><br>History site, with information and pictures: http://www.oricomtech.com/indexa.htm<br><br>Purchase books, parts and tools at: http://www.robotshop.ca/home/products/robot-books/books/<br><br>The following site features a timeline and examples of robots (highlight: the Steam Man): http://davidbuckley.net/DB/HistoryMakers.htm<br><br>The following is a source for an ethics debate: http://www.thirteen.org/curious/episodes/the-future-of-robot-ethics/ |

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| **GCO 2 Students will design, construct, and appraise automated control systems and subsystems that create a robot.** |
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| **GCO 2.1** Students will exercise control of robots using electrical circuits and electronics. |

| **Specific Curriculum Outcomes:**<br>Students will be expected to: | **Suggestions for Teaching/Learning:** |
|---|---|
| **2.1 Electricity/Electronics**<br><br>• deduce the appropriate power source, based on voltage and current, for safe operation with a robot<br><br>• identify, compare and contrast:<br>– basic AC versus DC power sources; and<br>– DC Circuits, simple, series, parallel<br><br>• create and interpret schematic diagrams of DC electrical circuits<br><br>• safely configure and connect components in a simple series, parallel, and DC motor control circuits<br><br>• safely employ interfaces between electronic components<br><br>• design and construct logic circuits (i.e., AND, OR and NOT) as they relate to series and parallel circuits | Students investigate, through an Internet Research Project, the safety issues of AC and DC power.<br><br>Students observe a demonstration of DC Power Supply function.<br><br>Students observe a demonstration of DC circuits and connection practices.<br><br>Students view online demonstrations of AC and DC circuits.<br><br>Students select, from various adapters (i.e., with different voltages and amperages), the appropriate power source, for the safe operation of a robot.<br><br>Lead a safety workshop about the “killer current”—the small amperage, at low voltage, that travels through the arms and can upset the heart rhythm.<br><br>Students participate in laboratory work focused on building simple, series, and parallel circuits.<br><br>Use Multisim to simulate the onscreen creation of various circuits; this software is very effective for demonstrating logic circuits. |

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| | Students control electric motors with the following<br>– simple circuit with on/off switch to power a motor<br>– a variable resistor to control speed<br>– a reversing circuit (switches, polarity reversal, relays).<br><br>Students gain practical experience, in the design of various applications of logic, through the programming of the microcontroller or through the use of hardwired circuits. Practical applications in school or at home that demonstrate a series or parallel circuit include the following:<br>• OR* - the roof light of car, fire pulls in school; safety switch “off” of power in shop; home alarm system; and three way light switches at home;<br>• AND* - the safety switch “on” of a power tool.<br>• NOT* - a refrigerator light, seatbelt indicator;<br><br>Students work in teams to illustrate the characteristics of and differences between DC and AC electricity.<br><br>Use breadboards to build understanding of electronic components. Breadboard demonstrations may include: simple series, parallel, and motor control circuits. Typical prototyping involves building temporary circuits on breadboards.<br><br>* Boolean logic terms used in digital decisions (logic gates):<br>OR = only one input needs to be “on” for the value to go to next section.<br>AND = all the inputs must be “on” for the value to continue.<br>NOT = input passed along the “opposite” value (i.e., an “on” becomes an “off”). |

| **Suggestions for Learning/Assessment:** | **Resources:** |
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| A series of practical labs provides students with the opportunity to acquire fundamental electronic concepts. Provide a variety of open-ended projects from which students chose and complete one to demonstrate their independent learning.<br><br>Upon the independent completion of a series of pre-developed labs (Carnegie Mellon software) the teacher provides evaluation of the lab with feedback comments.<br><br>Practical Testing (manipulative performance testing): Students complete a lab in which they must read a schematic drawing and connect the electronic components.<br><br>Formal lab documentation: Students complete a technical drawing of the electrical/electronic circuit; build the circuit; and test the circuit. The concept is then documented and submitted for evaluation.<br><br>Provide an open-ended electrical configuration problem in which conditions reflect but are altered from previous class presentations/labs. Students are required to evaluate new conditions and apply skills and knowledge to solve the problem outlined in the project. | Online research sites such as;<br><br>http://physics.mtsu.edu/~phys2020/Lectures/L12-\c_vs__ac/dc_vs__ac.html<br>http://www.play-hookey.com/dc_theory/<br>http:\\www.howstuffworks.com/electricity5.htm<br>http\\:physics.mtsu.edu\<br>www.allaboutcircuits<br>http://www.allaboutcircuits.com/vol_4/chpt_6/1.html<br>http://www.plcs.net/chapters/example10.htm<br><br>Internet Resources:<br>http://www.edumedia-sciences.com/a182_l2-dc-motor.html<br>http://www.allaboutcircuits.com/vol_1/chpt_3/2.html<br>Logic Gates<br>http://www.kpsec.freeuk.com/gates.htm<br>Logic Gate Simulator<br>http://richardbowles.tripod.com/dig_elec/tools/sim/sim.htm<br><br>Basic electronic equipment including LED, power supplies, batteries, conductors, prototyping boards, etc.<br><br>Lab Manuals (online or paper based).<br><br>A practical work area.<br><br>Tools, including: wire strippers, screwdrivers, solder guns, glue guns, multi-meters, pliers, etc. |

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| **GCO 2.2** - Students will utilize mechanical components such as gears, levers, pulleys, and screws (incline plane) to demonstrate an understanding of mechanical principles. |

| **Specific Curriculum Outcomes:**<br>Students will be expected to: | **Suggestions for Teaching/Learning:** |
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| • demonstrate an understanding of the three classes of levers<br><br>• select and employ the appropriate lever for a given task<br><br>• calculate gear and pulley ratios and determine the appropriate components for a specified task<br><br>• utilize screws (nut and bolt, screw feeds, etc.) as linear motion translators in robotic devices<br><br>• recognize forces such as torque, friction and mechanical advantage acting on or within the robot | http://www.mos.org/sln/leonardo/InventorsToolbox.html<br><br>Research the following topics using online or reference software resources;<br>- gear ratio<br>- pulley ratio<br>- classes of levers<br>- mechanical advantage calculation for gears, pulleys, and levers<br>- the relationship between speed and mechanical advantage in a simple machine<br><br>Create one or more design plans detailing the use of mechanical components in the robotic structure.<br><br>Research the use of bearings, bushings, and lubricants to reduce frictional forces in a robot.<br><br>Examine the material selection for mechanical components. Create a graphic representation (e.g., Venn diagram) of the advantages and disadvantages associated with the use of wood, plastic, and metal in robotic design and construction. |

| Suggestions for Learning/Assessment: | Resources: |
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| Students design a Lego® structure that must lift a small predetermined mass a defined distance from a pedestal. The structure must not touch a surface between the mass and a pedestal. The objective is to have the mass lifted using counterbalancing levers. Students can imagine a crane lifting materials for use in a bridge over a deep canyon.<br><br>Students create a project that uses an automatic screw jack to lift the robot off of the ground, or level a robot on uneven surfaces.<br><br>Students examine drilling techniques used in Mars exploration, and prepare a report or presentation to the class. | |

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| **GCO 2.3 - Input -** Students will select appropriate sensors and utilize inputs in robot control. |

| **Specific Curriculum Outcomes:** Students will be expected to: | **Suggestions for Teaching/Learning:** |
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| • identify appropriate sensors available in the resource manipulative materials | Students perform various lab exercises to learn the basic functioning of sensors available in the resource materials (e.g., the Carnegie Mellon software package). |
| • determine if the signal provided by the sensor is digital or analog | Demonstrate the advanced use of sensors (e.g., using the NXT light sensor to determine colour). |
| • configure and connect sensors in a circuit to produce input signals (i.e., use components such as touch tensor, ultrasonic, light sensor, sound, and switches) | Provide examples of digital and analog signals. Have students suggest and analyze common devices as being analog or digital.<br>A digital signal is ON/OFF and an analog signal is a range.<br>– digital – number display clock, light bulb (on or off)<br>– analog – clock with hands, volume control, thermostat, speedometer |
| | Students use input sensors to enable a robot to complete a specified task. For example, a light sensor incorporated into a robot causes the robot to seek darker areas of the room. |

| Suggestions for Learning/Assessment: | Resources: |
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| A variety of sensors are featured in Lego® Robotics Engineering. The students demonstrate the ability to calibrate the sensors and troubleshoot un-calibrated devices.<br><br>Provide a robot with an un-calibrated sensor, and the student(s) independently calibrate the sensor.<br><br>Students demonstrate the independent ability to identify proper components to build a robot by interpreting the data specification sheets on particular sensors (e.g., IR sensor in the Lego® NXT/Robotics Engineering package) and writing an explanatory report to identify the complete range the sensor will work in.<br><br>Students design a robot with available sensors and describe (e.g., written, oral, visual) the sensor functions required to operate it. Following this, students chose a media robot (e.g., Wall-E) and assess their current ability (compared to the robot they designed) to replicate the functions of the media robot. Students are able to reflect upon and identify why or why not they are able to do this.<br><br>Students work in groups to design a robot that uses sensors to complete a task. | Lego® NXT/Robotics Engineering package |

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| **GCO 2.4 Processing -** Students will be able to create a functional logic program. |

| **Specific Curriculum Outcomes:** Students will be expected to: | **Suggestions for Teaching/Learning:** |
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| • control a robot through programming a microprocessor | Students learn to use software to write and debug programs.<br><br>Students use the Carnegie Mellon software tutorials to learn the NXT software. The tutorials feature a simulated or hands-on lab experience for each application.<br><br>Students use a programming language to program a microcontroller. The microcontroller will react to a sensor as a digital signal and in turn cause the microcontroller to do something. For example, when the microprocessor detects a sensor signal from a touch sensor, it interprets the signal as a touch, and causes the robot to start moving.<br><br>Illustrate the use of a programming language through lectures and demonstrations. |

| Suggestions for Learning/Assessment: | Resources: |
|---|---|
| Upon the independent completion of a series of pre-developed labs (Carnegie Mellon software) the teacher provides evaluation of the lab with feedback comments.<br><br>Provide an open-ended programming problem in which conditions reflect but are altered from previous class presentations/labs. Students are required to evaluate new conditions and apply skills and knowledge to solve the problem outlined in the project.<br><br>Students create a functional logic program to complete a series of tasks from across curricular areas.<br><br>**Enrichment:**<br>Challenge students with tasks that require the use of advanced algorithms to analyze multiple sensor inputs. | Lego NXT Programming/Robotics Engineering Package<br><br>http://www.societyofrobots.com/programming_robot.shtml<br><br>http://www.play-hookey.com/computers/programming.html |

**GCO 2.5 Output -** Students will demonstrate an understanding of the use, selection, and connection of various actuators.

| **Specific Curriculum Outcomes:** Students will be expected to: | **Suggestions for Teaching/Learning:** |
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| • identify, select, and control an appropriately rated motor, servo, and solenoid (e.g., amperage, rpm, voltage) for specific uses<br><br>• incorporate buzzers, solenoids, relays, and LEDs as additional output devices into a circuit | Students participate in a practical lab to explore a circuit and answer questions.<br><br>Familiarize students with various motors, servos, and solenoids through real-world examples (e.g., illustrations, multimedia) in large industrial and hobby settings.<br><br>Students use the stamped information on the motor to select, from a variety, an appropriately rated motor to perform a specified robotic function.<br><br>Students follow instructions to build a rudimentary, paperclip motor.<br><br>Conduct internet research to learn about design, application and control of electric motors.<br><br>Arrange a visit to an industrial site which uses robotic technologies. Preparation and activities to accompany the field research should include the following:<br>– before – decide purpose, formulate questions, and develop observation techniques;<br>– during – make observations and gather information; and<br>– after – organize, compile, and analyze the observations and information. |

| Suggestions for Learning/Assessment: | Resources: |
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| Students use bar magnets and coil wire to build a simplified DC motor. Instructions are provided.<br><br>Upon the independent completion of a series of pre-developed labs (Carnegie Mellon software) the teacher provides evaluation of the lab with feedback comments.<br><br>Students combine knowledge of DC motors to control movement of a robotic device.<br><br>**Enrichment**<br>Students investigate the design and control of stepper motors. | *How Stuff Works* shows animated gifs of how a motor operates<br>http://electronics.howstuffworks.com/motor1.htm |

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| **GCO 2.6 Feedback -** Students will construct and evaluate open and closed loop systems. |

| **Specific Curriculum Outcomes:**<br>Students will be expected to: | **Suggestions for Teaching/Learning:** |
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| • differentiate between open and closed loop systems<br><br>• appraise the advantages and disadvantages of open and closed loop systems | Students complete a lab contrasting an open loop system and closed loop system. In an open loop, there is no sensor to detect if the actuator has completed its task. In a closed loop, the sensor will detect that the actuator has completed its task.<br><br>Demonstrate how to read and program codes required to construct open and closed loop systems. Following this, students build open and closed loop systems into their robots. The Lego® NXT kits may be programmed to turn the servo on, and run continuously. They can also be programmed to read the number of degrees/rotations. |

| Suggestions for Learning/Assessment: | Resources: |
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| Provide an example where automated technology may provide a solution to a repetitious situation in the school. Students provide additional examples of closed and open loop solutions, identifying and explaining the use of each.<br><br>Students create a project involving open and closed loop systems. Students evaluate when a closed or open loop system would be a better choice, and apply their skills and knowledge to build open and closed loop systems into their robots. | |

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| **GCO 3** Students will develop a systematic approach to solving problems. |

| **Specific Curriculum Outcomes:**<br>Students will be expected to: | **Suggestions for Teaching/Learning:** |
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| • breakdown a larger task into smaller manageable sub-tasks<br><br>• troubleshoot a large project<br><br>• read schematic drawings<br><br>• generate technical drawings of designs for robots or subsystems<br><br>• follow an accepted design process<br><br>• operate appropriate electronics testing tools (e.g., DMM, logic probes)<br><br>• verify computer coding of microcontroller<br><br>• access component data sheet (IC chips, transistors, etc) and test components for viability | A program for a robot needs to be considered as a series of smaller tasks, each with its own objectives. For example, a robot that needs to pick up an object far away will need to navigate, identify the object, grip the object, and lift the object.<br><br>Demonstrate how to isolate and test individual and interconnected subsystems. Students experiment with a malfunction to determine which subsystem or task is at fault.<br><br>Discuss logical approaches to problem solving (e.g., identify problem, devise a plan for a solution, carry out the plan, assess the results). Please note: problem-solving processes should be developed with students so they understand that real-world problems rarely follow a simple linear model.<br><br>Develop a logical format to prepare a design of a robot. For example, a) brainstorm ideas; b) prepare technical sketches; c) create mock-up; d) prepare dimensioned drawing; e) communicate ideas with technical writing ; f) efficient use of materials.<br><br>Students create a 3D digital representation of their robot using Google SketchUp. |

| Suggestions for Learning/Assessment: | Resources: |
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| Provide an automated device with multiple points where a problem could exist. Student teams isolate and fix a randomly caused problem within a time limitation.<br>Optional: make this a game in which teams solve multiple problems.<br><br>Students apply skills and knowledge to correct a faulty schematic.<br><br>Students use DMM and logic probes to isolate a faulty circuit on a prototyping board.<br><br>Students illustrate the logical steps for troubleshooting a particular problem. Students must articulate each step and the reasoning behind it in the order they performed the task.<br><br>Students use a concept map to identify smaller tasks that need to be completed in a large project. They assign subsystem tasks to specific teams.<br><br>Assign pairs of students a component of a major project to create a Lego® robot which performs multiple tasks. For example, a robot that moves and picks up balls autonomously. Example components are: locomotion; the ball sensor; ball retrieval. | Problem-solving models featured at the following site:<br>http://www.bced.gov.bc.ca/irp/it810/itinstru.htm |

**GCO 4 Students will demonstrate general material processing and assembly skills.**

| Specific Curriculum Outcomes: | Suggestions for Teaching/Learning: |
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| Students will be expected to:<br><br>• inspect safe assembly techniques<br><br>• choose correct selection of tools for a given application<br><br>• demonstrate correct use of tools<br><br>• maintain and care for provided workspace<br><br>• interpret technical drawings | Explain, model, and demonstrate practices and standards for accident prevention and safe workplace conduct. Workshops should include:<br><br>– WHMIS and MSDS standards<br>– operating a soldering iron<br>– proper use of tools (e.g., a screwdriver should not be used as a pry bar)<br>– prudent use of materials (e.g., wire should not be wasted)<br>– proper material storage<br>– maintenance of workstations (e.g., kept clean, and uncluttered)<br><br>Using Lego® Digital Designer, students design and build a robot. Extend the activity by exchanging designs to build another robot.<br><br>Model how to write a design brief. Prior to robot fabrication and material processing, students prepare design briefs for approval.<br><br>Students practice assembly techniques. For example, threading a nut onto a bolt, aligning connecting holes prior to attaching screws, use of clamps, and jigs to assist in assembly. |

| Suggestions for Learning/Assessment: | Resources: |
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| Students complete a written quiz on safety skills.<br><br>Students demonstrate of safe use of tools.<br><br>Observation of neat and tidy workspace over time.<br><br>Students demonstrate a commitment to quality in their finished products.<br><br>Create an exact copy of a Lego® robot design based on 3D drawings, as found in Robotics Engineering Package. | Lego® Digital Designer – Free download from http://www.lego.com<br><br>Safety resources from PTI (Power Tools Institute) http://www.powertoolinstitute.com/<br><br>Carnegie Mellon Robotics Engineering package contains instructions to build two different robots. |

## Appendix A
## Student-Friendly Versions of General Curriculum Outcomes

GCO 1 Students will reflect on and predict the evolution and application of robotics.

Knowledge and Understanding
- identify early robots and their use to society
- explain basic development of robots from early $20^{th}$ century to today
- explain current trends in robotic development including industrial, space exploration, medical, and personal robots

Reasoning
- analyze the purpose of current robots and their affect on society
- assess the value of a robot in certain situations, like automotive assembly lines
- evaluate situations that a robot may be helpful.
- compare situations where implementing a robot might not be effective.

Products
- create a timeline of significant events in the area of robotics.

GCO 2 Students will design, construct, and appraise automated control systems and subsystems that create a robot.

Knowledge and Understanding
- identify AC and DC power signals
- describe how DC power can be generated
- identify DC power sources, such as batteries, photovoltaic cells, generators and transformers.
- identify simple, series, parallel DC circuits from schematic diagrams
- identify DC circuits when an electronic device is placed in front of me
- create a simple, series, or parallel circuit on a prototyping board, or with components and wires
- identify logic circuits which include AND, OR, and NOT decisions.
- identify input sensors, such as sound, light, and touch components.
- draw simple logic diagrams including AND, OR, and NOT decisions.
- use a computer to input directions for a robot to follow
- identify a servo, DC motor and solenoid
- read required data information from datasheets on servo, motors and solenoids
- identify different parts of the robot that allows it to sense the world around it
- can explain how the electronic parts of the robot need to be connected

- describe what voltage and current can provide for the electronic parts of the robot, and avoid unsafe voltage level so as to avoid damaging equipment or people
- read a data sheet of an electronic component to use the correct voltage level and current to make sure it works properly
- look at a design plan, and identify the parts of the robot, and how the parts connect
- look at an electronic schematic and determine the electrical pathways
- measure distances that a small robot might need to navigate.
- describe how an auger can move grain up an elevator.
- describe how a car jack can raise a car.
- describe where the major forces act on a crane.
- recognize the output speed of a combination of gears will be more or less than the original
- identify the easiest pulley to pull from a set of three or four different pulleys

Reasoning

- choose a sensor that would be helpful for the task at hand
- come up with a plan to make a robot from the sensors, microcontrollers, and materials available to me.
- read a schematic which I have not seen before, and determine what the function of each component is.
- read a schematic and determine what the diagram represents on the actual robot.
- read a schematic and deduce what it is designed to do.
- read the specifications of a component like a motor, and choose the correct voltage and amperage to operate that component safely.
- compare and contrast the use of sensors that would be useful for robotic navigation.
- analyze a situation to determine whether a lever or a pulley would be a better choice to move a heavy object.
- evaluate a problem where a gear ratio would be advantageous to use for a robot design.
- evaluate a basic design that is not strong enough to move or support an object, such as using a toothpick as a lever to move a textbook.
- create a microcontroller program to see if a sensor is being triggered.
- program the microcontroller to cause motors to turn or other components to function when input conditions are met.

Skills

- attach wires and components together on a breadboard to make a circuit from an electronic schematic.
- design a circuit that allows a robot to compare things, such as whether a switch has been touched, or light and dark areas.
- program a microprocessor to control a robot to follow a line by itself.

- program a microprocessor to control a robot to avoid a physical obstacle, like a wall, or the edge of a cliff.
- program a microprocessor to control a robot so that it follows a predetermined path, such as move one meter forward, turn to the right 45° and move two meters.
- operate a DMM to measure voltage, amperage, and resistance of various components.
- choose between gears, pulleys and levers for mechanical advantage.

Products

- build a circuit that includes necessary components to make a decision on a robot.
- build a robot that uses DC electricity to move around by itself.
- build a closed loop system that works. An example might be a door that stays open until the person is clear of the door swing.
- build an open loop system that works. An example might be a door that stays open for four seconds then closes.
- program a microprocessor (such as the NXT) to perform functions such as reading a sensor that detects sound, and then power the motor to move the robot a set distance.
- build a robot that stops before going over the edge of a desk.
- build a robot that uses sensors to move to a darker part of the room.
- build a robot that follows a dark line on a white background.
- build a robot that can move a predetermined distance, turn around and return to its starting position.
- build an automatic device that moves a solar array so that it points toward the most amount of light.

GCO 3 Students will develop a systematic approach to solving problems.

Knowledge and Understanding

- read a schematic drawing of a basic automated device that is electrical, or mechanical.
- read computer coding, such as the Lego Software, knowing what the icons and symbols mean.
- read component data sheet such as for a resistor, and know what the maximum amount of current and voltage that it can operate safely.

Reasoning

- identify a single problem on a schematic drawing that is electrical, or mechanical, such as an incomplete circuit, or missing motor
- read a schematic and trace the parts and circuits on a real device.
- evaluate a real device against a schematic to identify problems on the real device.
- support an opinion about why a problem may exist.
- suggest and support ideas to fix a problem with a robot.

- can break down a large project into smaller sections to help identify a problem. For example, I can isolate the motor and identify if it works.

Skills
- operate a DMM to measure voltage, amperage, and resistance of various components.
- operate a computer to analyze a piece of code used by the microprocessor in a robot.
- create a series of steps to take to logically solve an unknown problem.
- disassemble a circuit to test various parts or components of a robot.

Products
- create a written report describing accurately a problem, and outline steps used to fix the problem.

GCO 4 Students will demonstrate general material processing and assembly skills.

Knowledge and Understanding
- identify common tools (wire strippers, pliers, screwdrivers, knives, etc.)
- select the proper tool when my teacher asks for it.
- identify proper components, or materials used in my classroom.
- identify a blueprint, technical drawing or schematic.
- choose materials that are suited to the type of robot I am building (e.g., waterproof materials for aquatic robot, steel for load lifting)

Reasoning
- foresee potential hazards to working on tools and prevent dangerous situations.
- attach or cut things correctly to prevent wasting materials.
- identify a dangerous situation, and take steps to prevent damage to myself, others, or the workplace.
- know when using a tool may be dangerous.
- assess whether a robot could be improved or changed to make the robot better at solving the task.

Skills
- read a blueprint/technical drawing/schematic drawing.
- secure materials for proper connection (like bracing two materials to be glued together).
- attach two pieces of material (metal/plastic/wood) with a provided device or adhesive
- provide basic maintenance to common tools.
- use commonly available tools (drills, rotary tools, saws) to shape, cut, or mould materials.
- use appropriate tools to connect fasteners (screwdrivers, wrenches)
- prevent endangering myself, others, or equipment by using tools correctly.

- clean up my own work area, and put all materials in proper storage
- use appropriate tools to build a robot (e.g., a Phillips screwdriver to drive a Phillips screw, use a multi-meter to check voltage)
- construct a robot from a plan provided (e.g., build a Lego robot from drawn construction plan)
- solder wires together, or to another component.

Products

- construct a functioning robot from a kit or predetermined design.

## Appendix B

Sample Assessments and Rubrics

### Lab Report : Robotics and Automation Technology Reports

Teacher Name:

Student Name:

_______________________________________

| CATEGORY | Unacceptable 0-59 | Low Standard 60-69 | Good Work 70-85 | Excellent 86-100 |
|---|---|---|---|---|
| Appearance/ Organization | Lab report is handwritten and looks sloppy with cross-outs, multiple erasures, and/or tears and creases. | Lab report is neatly written or typed, but formatting does not help visually organize the material. | Lab report is neatly handwritten and uses headings and subheadings to visually organize the material. | Lab report is typed and uses headings and subheadings to visually organize the material. |
| Analysis of Problem | No valid attempt is made by the student to understand the problem or to offer a solution. | The problem is only partially understood and the student has missed major points and/or concepts. | The problem if fairly well understood but the students needs help to reach the proper conclusion. | The problem is very clearly understood and an appropriate solution presented. |
| Drawing | No solution is apparent; completed in ink or otherwise unacceptable. | The drawing is ambiguous; the line quality is not to standard. A solution may or may not be evident, but the drawing is unacceptable. | Completed in pencil, the line weight is acceptable, but it appears rushed; a solution to the problem is evident. | Completed in pencil, it is well proportioned, the line quality is easy to view and it is an excellent solution to the problem. |
| Schematic Diagram | Drawn in ink; not close to a solution or otherwise unacceptable. | Many labels are omitted. Some necessary components may be missing. Components are connected improperly. | Completed in pencil. Same as with a four, but the proportions are not as accurate and some of the labels have been omitted. | Completed in pencil. The line weight is appropriate with evidence of a ruler being used. The solution is correct. All necessary labels are included. The proportion and position of the components is correct. |
| Conclusion | Conclusion is clean and precise. The writing is easy to read, even by a layman. Spelling, grammar and punctuation are accurate. Appropriate font and point size. | Conclusion is reasonably well written, but some sentences/ paragraphs are poorly constructed and/or awkward. May have omitted some necessary technical details. | Several important technical details have been omitted. Sentences and paragraphs are poorly constructed. | Ignores all conventions set out for this portion of the lab report. |

## Assemble a Robot from a "Lego" Kit

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Teacher Name:

Student Name:

___

| CATEGORY | 1 Unacceptable<br>0-59 | 2 Minimum Standards<br>60-69 | 3 Good Work<br>70-85 | 4 Excellent Work<br>86-100 |
|---|---|---|---|---|
| **Review Assembly Instructions** | Gives only a quick look at the instructions, if at all, and tries to figure it out as he/she goes. | Starts off in a systematic fashion but quickly regresses to flying by the seat of the pants. | Uses the instruction manual as a reference but relies on intuition. | Takes time to review instructions in a through manner and tries to match the components called for within the instructions. |
| **Modification/ Testing** | Little evidence of troubleshooting, testing or refinement. | Some evidence of troubleshooting, testing and refinements. | Clear evidence of troubleshooting, testing and refinements. | Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles. |
| **Function** | Robot is incomplete, has several flaws and does not function. | Robot will function but is missing features and the construction is poor. | Robot looks good and functions well but has a few flaws in construction and or function. | Robot is exactly as it should be in every detail. |
| **Care and storage of components** | Little respect for the components is demonstrated. Parts are lost or left behind. Parts are not handled with care and treated rough. | Components are treated with respect but there are issues with storage and part loss. | Care for the components is demonstrated in most cases but there are poor choices made on occasion. | Every part is accounted for. Extra parts are stored in the proper places, and the robot itself is stored properly. |
| **Construction Method and Time** | Components are forced. Components are stressed. Too much time is used to assemble. Inattention to detail is obvious. | No damage to components occurs but components are made to "fit" where they are not supposed to. Too much assembly time is required. | Care for components is obvious but more time than usual is required. | A methodical approach is used in construction. Components are handled with care. Attention to detail is obvious. The robot is assembled in a relative short time. |

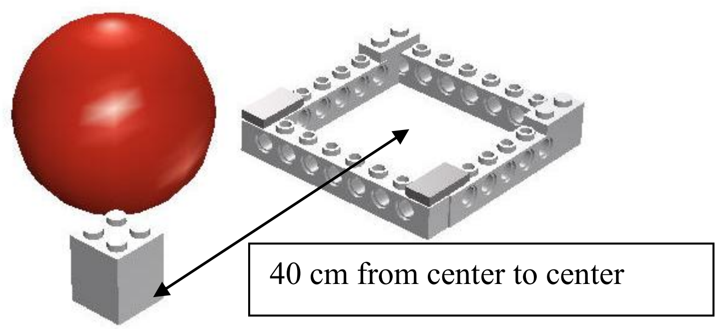
**Robot Arm Challenge**:

Your challenge is to design a Lego product to move a ball from one side of the robot to the other and drop it in a defined space. The arm must start perpendicular/midpoint between the ball and the basket. The materials for arm are constrained by the use of parts from only **one** Lego NXT Mindstorms Education kit.

Dimensions:

The ball is placed on top of two 2x2 Lego bricks located 40 cm from the center of a basket made of (2) 1x8, and (2) 1x6 rails, with corners joined by 1x2 short height connectors. See Diagram 1. The robot is stationary base model. The robot must work autonomously and be located between the ball and the basket.

Diagram 1:



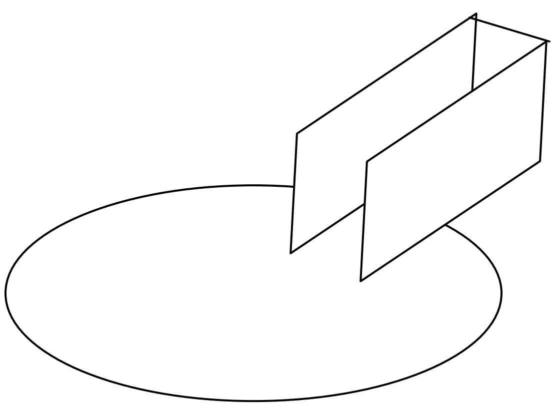
**Building A Structure : Robot Arm** Name: ____________

| CATEGORY | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Construction - Care Taken** | Great care taken in construction process so that the structure is neat, and attractive. | Construction was careful and accurate for the most part, but 1-2 details could have been refined for a more attractive product. | Construction accurately followed the plans, but 3-4 details could have been refined for a more attractive product. | Construction appears careless or haphazard. Many details need refinement for a strong or attractive product. |
| **Modification and Testing** | Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles. | Clear evidence of troubleshooting, testing and refinements. | Some evidence of troubleshooting, testing and refinements. | Little evidence of troubleshooting, testing or refinement. |
| **Function** | Structure functions extraordinarily well, holding up under atypical stresses.<br>Both basket and ball pedestal are not moved during operation. | Structure functions well, holding up under typical stresses. | Structure functions pretty well, but deteriorates under typical stresses. | Fatal flaws in function with complete failure under typical stresses. |
| **Scientific Knowledge** | Explanations by all group members indicate a clear and accurate understanding of scientific principles underlying the construction and modifications. | Explanations by all group members indicate a relatively accurate understanding of scientific principles underlying the construction and modifications. | Explanations by most group members indicate relatively accurate understanding of scientific principles underlying the construction and modifications. | Explanations by several members of the group do not illustrate much understanding of scientific principles underlying the construction and modifications. |
| **Programming** | Sensors used to detect ball, grip ball and find basket. | Robot programmed to move a pre described sequence. | Limited program that causes robot to move parts of required sequence, but does not complete required sequence. | Program does not complete any of the steps or sequences to completing the task. |

**BoE-Bot Maze Challenge**

Using the BoE-Bot, students will add sensors and program the robot to move to the center of an area, move into a parking area and stop. The area is approximately 1 meter in diameter area (Sumobot competition area works well) black base with a 2.5 cm white ring on the outside, with a parking enclosure (see diagram below). The robot is not expected to leave the ring during the attempt to get to the parking area. The robot must park inside the enclosure within 3 minutes. The robot will start, facing inward, with both wheels on the white outer ring. The robot may be placed anywhere along the white outer ring.

Base area is black. The outer ring is 2.5 cm white with a radius of 1 m. The walls of the enclosure are 20 cm high, 30 cm long, and white. The walls are spaced approximately 20 cm apart. The walls can be constructed from 0.25” foam-core (Foam-core is two pieces of Bristol board with Styrofoam sandwiched in between and can be purchased as a sheet from a stationary store.)



## BoE-Bot Maze Challenge Rubric

| CATEGORY | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Modification/ Testing** | Clear evidence of troubleshooting, testing, and refinements based on data or scientific principles. | Clear evidence of troubleshooting, testing and refinements. | Some evidence of troubleshooting, testing and refinements. | Little evidence of troubleshooting, testing or refinement. |
| **Function** | Robot functions extraordinarily well. The BoE-Bot reaches the top of the ramp and stops. | Robot functions well. Robot does not stop on the finish point. | Robot stays in the white circle, but does not find the ramp opening. | Robot does not stay in the white ring. |
| **Information Gathering** | Accurate information found and used in development of program and sensors used on robot. | Accurate information found on the use of sensors and program, but not applied in an effective manner. | Information taken verbatim from resource. Only partially applicable to completing task. | No information sought to apply to robotic design. |
| **Scientific Knowledge** | Explanations by all group members indicate a clear and accurate understanding of scientific principles underlying the construction and modifications. | Explanations by all group members indicate a relatively accurate understanding of scientific principles underlying the construction and modifications. | Explanations by only one group member indicate relatively accurate understanding of scientific principles underlying the construction and modifications. | Explanations by any members of the group do not illustrate much understanding of scientific principles underlying the construction and modifications. |
| **Microcontroller Program** | Program uses advanced techniques and performs flawlessly. At least one group member can explain concepts used clearly. | Program uses slightly modified techniques straight out of resource. At least one group member can explain the program functions. | Attempt to piece together code from resource and can read sensors. Sensor data does not affect robot properly. Group members cannot explain code techniques. | Program code does not accomplish any part of the task assigned. |
| **Team Collaboration** | Group members have a strategy to finish project, sharing work equitably, and supporting each others efforts. | Group members work together, but one clearly does more than other. Some evidence of mutual support. | Group members work individually, occasionally collaborating when necessary. Little evidence of support. | Group members are rarely focused on task. No evidence of support or collaboration. |

## Appendix C: Electronics Package

Kit may be assembled as a custom package.
Each kit should contain:

| Qty. | Item |
|---|---|
| 1 | Breadboard (Abra-12-J) |
| 1 | Elenco Electronics Kit PK-101 |
| 1 | Mechanical relays (to see internal components) (ABRA K10-110; 12V coil) |
| 1 | Solid state relays (ABRA STE1-110; 5V coil) |
| 1 | Each of red, blue, green, yellow 22 gauge solid strand hook up wire –100ft rolls |
| 2 | Potentiometer (2 watt linear taper 10K Ohm – ABRA P2W10K) |
| 5 | 7408 AND Gate |
| 5 | 7404 Hex NOT Gate |
| 5 | 7432 OR Gate |
| 6 | Red Standard size LED |
| 6 | Green Standard size LED |
| 1 | Each of the following resistor bundles (Solarbotic bundles RB1, RB2, RB3, RB4, RB5, RB6,RB7) |
| 1 | Piezo buzzer (Abra PKB8-4A0) |
| 6 | Push button switches (Abra NO-110) |
| 2 | Wall transformer (Abra DC-1250 12 Volt, 500mA) |
| 12 | 1N4001 Diodes |
| 24 | Transistors 2N2222 |
| 12 | Motors (DC 6V) (Abra 29DM9V 5V-12V) |
| 1 | ABRA Student Tool kit (SKU # CAP385) |
| 1 | ABRA DM-2900 Digital Multi Meter |