School District of South Orange-Maplewood

Robotics Curriculum Grades 10-12

The School District of
SOUTH ORANGE
& MAPLEWOOD
525 Academy Street • Maplewood, NJ 07040

SOMSD
January 2013

THE SCHOOL DISTRICT OF SOUTH ORANGE-MAPLEWOOD

WRITTEN BY:
NOAH BRAUNER, TEACHER

TERRY WOOLARD
SUPERVISOR OF EDUCATIONAL MEDIA AND TECHNOLOGY; K-12 ONLINE LEARNING

TABLE OF CONTENT

I. Rationale

The South Orange Maplewood School District believes students should be engaged in the use of technology to excel in various areas of their lives including academics, civic duties, the work place, and within an ever-changing global society. As technology becomes increasingly important in today's world, it is invaluable to not only learn how to use technology, but also to understand how to create it. Technology is the future, and today's kids are tomorrow's technologists. Robotics is a multi-disciplinary tool that is being increasingly used by over 5,000 schools worldwide to motivate, excite and inspire children about math and science.

Robotics inspires students to make connections across several disciplines rather than learning topics in isolation as it combines mechanical, electronic, electrical and programming skills. Students are motivated to learn by creating their own robotic devices, while at the same time gain a deeper understanding of interdisciplinary fields of study. In addition, robotics appeals to a broad range of students and allows multiple points of access to science and technology for a variety of learners.

Robotics is already playing a very pivotal and cutting edge role in diverse sectors such as manufacturing, avionics, medicine, defense, automobile, and entertainment to name a few.

At the high school level the focus can be either on introductory or a deeper understanding of a specific skill set; i.e. programming or mechanical design. Robotic programs include the development of 21st century skills; teamwork, problem solving, ideation, project management, communications. It is our goal to provide our students with the opportunity to explore the field of robotics, providing an education that not only meets, but exceeds world standards.

II. Purpose

Technology is increasingly becoming more important in the lives of our children. They are what society has deemed Digital Natives. A Digital Native as defined by popular culture is any child born after 1982; this would include all of our students. The Digital Native has grown up with technology at their fingertips. They are equally as comfortable with a keyboard and a touch screen as past generations are with pen and paper. The students of this generation have access to multimedia technology in the form of cell phones, I-pods, laptops, television, and the internet. They can retrieve and create information on YouTube, blog information through any number of sites, and send out podcasts of themselves doing a myriad of activities. However, research has suggested that these same students who are so comfortable with technology have little conceptual understanding of technology, how it works, why it works, and the ramifications of its use. This sets our premise for providing students with instruction on the use of such powerful tools.

Furthermore, The NJDOE's Technological Literacy Standards 6A:8-1.1 states that the purpose of this curriculum should be:

To prepare students for success in life, future education, and work in an economy driven by information, knowledge, and innovation requires a public education system where teaching and learning are aligned with 21st century learning outcomes. These outcomes move beyond a focus on basic competency in core subjects and foster a deeper understanding of academic content at much higher levels by promoting critical thinking, problem solving, and creativity.

Through this curriculum, South Orange Maplewood School District will provide students with an increased knowledge of how to utilize technology to:

- *Enhance problem solving skills*
- *Compile data to formulate solutions to real world problems*
- *Build/engineer a tool to assist with everyday activities*
- *Discuss social and ethical responsibilities in the use of technology*
- *Develop products/models that address societal issues*
- *Examine the relationship that exist between software functions and daily activity*
- *Build logical thinking*
- *Develop innovation and creativity*
- *Increase teamwork skills*
- *Provides a visual grasp of math and science*
- *Analyze how technology can be used to improve the design and functionality of the environment*

III. Description

This curriculum has been developed to assist students in becoming technology literate. Robotics technology is a pillar of 21st century American innovation. It highlights the growing importance in a wide variety of application and emphasizes its ability to inspire technology education. Robotics is positioned to fuel a broad array of next-generation products and applications in fields as diverse as manufacturing, health-care, national defense and security, agriculture and transportation. Robotics enable participants of all ages to learn important Science, Technology, Engineering and Math (STEM) concepts and at inspiring them to pursue careers in STEM-related fields.

Robotics is an interdisciplinary field requiring knowledge of Engineering and Art. To build a robot one needs to have technical know-how of Electronics, Mechanics, Computer Science, Art and believe it or not, even Biology.

Robotics is a tool to learn the real world applications of the theory and concepts covered in the class. We are surrounded by gadgets, electronics and mechanical systems that are so deeply integrated into our lives that we hardly ever notice how important these systems are and how difficult it is to build them. The curriculum is aligned with the New Jersey Core Curriculum Content Standards for Technology Literacy and is designed to be engaging and rigorous. The curriculum is based on a Project-Based Learning (PBL) model. Students work cooperatively to complete their assignments and each unit culminates with a project, and presentation to assess student learning.

The Goals set forth to achieve this vision are:

GOAL 1: All students will be prepared to excel in the community, work place and in our global society using 21st century skills.

GOAL 2: All educators, including administrators, will attain the 21st century skills and knowledge necessary to effectively integrate educational technology in order to enable students to achieve the goals of the core curriculum content standards and experience success in a global society.

GOAL 3: Educational technology will be accessible by students, teachers and administrators and utilized for instructional and administrative purposes in all learning environments, including classrooms, library media centers, and other educational settings such as community centers and libraries.

GOAL 4: New Jersey school districts will establish and maintain the technology infrastructure necessary for all students, administrators and staff to safely access digital information on demand and to communicate virtually.

COURSE TITLE: ROBOTICS

GRADE LEVEL: 10-12

LENGTH OF COURSE: 1 SEMESTER

PREREQUISITE: NONE

Overview

The course of study combines a lab component based on the LEGO MINDSTORM NXT robot system which consists of a series of hands on building and programming problems and a research/lecture component exploring current and possible future applications of robotics. The two components will augment each other; in the lab students will learn by applying the fundamental principles of robotics; task planning, control systems, sensor control, orientation and programming. In the lecture/research portion of the course students will analyze current robotic systems in the context of these fundamental principles . Seeing how sophisticated robots are solving the problems that students are encountering in their own work will deepen their appreciation and understanding of the technical complexities involved in these systems. The class will also be discussing the impact of robotic technologies on society and inventing and envisioning new applications of robotics.

Lecture component.

1) What is a robot?
   a) Working definition
      i) Automated vs. robotic
      ii) Remote control
      iii) autonomus
   b) History of robots
      i) Automatons
      ii) Automation
   c) Popular perception of robots
      i) Science fiction
      ii) Androids
   d) Impact of robotics on society
      i) Displacement of workers
      ii) Benefits of efficiencies
      iii) Costs and benefits

2) Applications of robots. These topics will be assigned as research projects for students. They will create presentations to the class. Fundamental to the presentations will be an understanding of the specific problems that must be solved for the particular application.
   a) Industrial/ manufacturing
      i) Farming
      ii) Nano manufacture
      iii) Assembly
      iv) Task specific: welding, painting
   b) Medical
      i) Surgical
      ii) Rehabilitative
      iii) Hospital logistics

c) Hazardous environments
   i) Fire fighting
   ii) Bomb detection detonation
d) Transportation
   i) Driverless cars
   ii) Aviation: autonomous drones
   iii) Air traffic control
   Exploration

   iv) Undersea
   v) Outer space
e) Military
   i) Unmanned aircraft
   ii) Unmanned vehicles
   iii) Smart weapons
f) Entertainment
   i) Animatronics/ special effects
   ii) toys
g) Intelligent home
   i) Cleaning
   ii) Serving /cooking
h) Retail,
   i) order fulfillment
i) Any other application that fits the class defined definition of a robot that a student suggests

3) Invention component. Students will be asked to think of a smart product and develop it
   a) The future of computing is in making products that utilize computing power to make them function in new and unique ways
   b) Students will be asked to create sketches and if they have CAD skill create a model of device

Lab component

The curriculum for the Lab component of the class will be based on the ROBOTC Curriculum for TETRIX from the Carnegie Melon Robotics Academy. (2009, Tetrix)

Students will work on a series of increasingly complicated tasks with instructions coming from the video files, as well as printed materials. The course of study is a semester in duration and quite detailed. It is designed for both the LEGO MINDSTORM and TETRIX building systems. The LEGO system is a less complicated building system and the one this introductory class will use. The TETRIX system can be applied to more advanced class offerings. As the class evolves this curriculum will be modified and refined to meet the needs of CHS students.

Below is a summary of the sequence of the topics of study

1) Into to Robotic Lab overview, definitions of engineering, programming, systems and project management
2) Class Procedures, engineering notebook,
3) Intro to NXT hardware
4) Intro to ROBOTC Software
5) Intro to Programming
6) Movement
7) Sensors
   a) Touch Sensors
   b) Ultra sonic Sensors
   c) Encoders
   d) Light Sensors
   e) Line tracking
   f) Sound Sensors
   g) Automatic Threshold Calculations
   h) Variables and Functions
   i) Debugging
8) Remote Control

Core Curricula Standards

A detailed description of how the robotic curriculum aligns with national science, technology, engineering and mathematics standards can be found on pgs 75 – 85 of the document Robotic TETERIX Curriculum. PDF.

Robotics: Introduction

Learning Goal NJCCCS & CPI	Enduring Understandings	Essential Questions
9.4.12.O.(1).8 9.4.12.B.(1).4 9.4.12.B.(1).10 6.2.12.C.3.b 6.2.12.D.3.b	• Robotics Technology is a hundred billion dollar emerging industry that is an integral part of industry and manufacturing. • By the year 2014 95% of the overall program code developed will be for embedded computing systems. • Robots can be used to replace human workers.	• Why teach robotics? • What is a robot? • What is engineering? • What is programming? • What is the history of robots? • What impact do robots have on society?

Skills (proficiencies)	Key Content
• Define the key terms: **Robot:** A machine capable of carrying out a complex series of actions automatically. **STEM:** Science Technology Engineering Mathematics **Engineering:** The branch of science and technology concerned with the design, building, and use of engines, machines, and structures. **CADD:** Computer Aided Draft Design	• History of Robotics • Concepts about the impact of machines on society • Connection to CADD • Basic understanding of engineering

Assessment:	Rubric:	Key Criteria for Differentiation:
A variety of assessment techniques may be used, including written quizzes,	Similar rubric will be used to assess the following: correct definition of terms.	Written and visual tools will be used for

projects, presentations, and other assignments	Understanding of Robotics place in society.	different type of learners.
Resources: http://www.education.rec.ri.cmu.edu/robots/tetrixteacher/index.htm	Instructional Strategies / Best Practices:	Enrichment: Essay on the impact of robotics on the world economy.

Robotics: Application

Learning Goal NJCCCS & CPI	Enduring Understandings	Essential Questions
9.4.12.A.(4).5 9.4.12.A.(4).6 9.4.12.A.(4).8 9.4.12.A.(4).10 9.4.12.H.(5).1 9.4.12.H.(5).4 CCSS.ELA-Literacy.RST.11-12.9	• Robots can be used to mass-produce products and services. • The use of robots can minimize the danger inherent in the medical field. • Robotics must be monitored. • There are safety issues inherent in the construction and application of robotics. • Robotics accounts for a substantial reduction in the industrial work force.	• How are robots utilized in manufacturing? • What safety measures must be in place to utilize robotics? • How have robotics influenced the agricultural field? • What are the ethical implications of using robots instead of human work force? • Has robotics had an impact on the medical industry? • Where are robotics used in transportation?

Skills (proficiencies)	Key Content
• Define the key terms: **Cyber:** Of the culture of computers, information technology, and virtual reality. **Agriculture:** The science or practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals	• Robotics Technology is utilized in various fields to improve upon production, accuracy, transportation, and safety. • Maintain a journal on the utilization of robotics and the various applications

Assessment:	Rubric:	Key Criteria for Differentiation:
A variety of assessment techniques may	Similar rubric will be used to assess the	Written and visual tools will be used for

be used, including written quizzes, projects, presentations, and other assignments	following: correct definition of terms. Presentation of ideas. Work place competencies.	different type of learners.
Resources: http://www.education.rec.ri.cmu.edu/robots/tetrixteacher/index.htm	Instructional Strategies / Best Practices:	Enrichment: Design of robotics to improve upon one of the industries discussed within the unit.

Robotics: Software

Learning Goal NJCCCS & CPI	Enduring Understandings	Essential Questions
CCSS.ELA-Literacy.RST.11-12.2 9.4.12.K.(4).1 9.4.12.K.(4).2 9.4.12.K.(4).4 9.4.12.K.(4).5 9.4.12.K.(4).6 9.4.12.K.(4).7 CCSS.Math.Content.HSS-MD.B.5	• **Software is utilized to teach a robot how to maneuver and perform various skills.** • **Mathematics and measurement are used to write programming language.** • **The software is driven by the consumer/societal needs for the robot.**	• **Can a robot be programmed to understand simple commands?** • **What types of robotic behaviors and or movements can be controlled through programming software?** • **How do we Asses the needs of a client/community to produce the necessary movements via the software for a robot?** • **How does programming language relate to written/technical language?**

Skills (proficiencies)	Key Content
• **Define the key terms:** **Software:** The programs and other operating information used by a computer. **Firmware:** Permanent software programmed into a read-only memory. **Programming:** The action or process of writing computer programs, for predetermined behavior.	• **Programmers utilizing computer languages to write code to enable robots to perform specification actions.** • **A mistake in code means a mistake in actions.** • **Codes must be precise, utilization of mathematics and measurements is necessary.**

Assessment: A variety of assessment techniques may be used, including written quizzes, projects, presentations, and other assignments	Rubric: Similar rubric will be used to assess the following: correct definition of terms. Presentation of ideas. Creation of programmatic code. Robotic Maneuvers.	Key Criteria for Differentiation: Written and visual tools will be used for different type of learners.
Resources: http://www.education.rec.ri.cmu.edu/robots/tetrixteacher/index.htm	Instructional Strategies / Best Practices:	Enrichment: Design of robotics to improve upon one of the industries discussed within the unit.

Robotics: Hardware

Learning Goal NJCCCS & CPI	Enduring Understandings	Essential Questions
CCSS.Math.Content. HSA-REI.A.2 9.4.12.B.(1).2 9.4.12.B.(1).6 9.4.12.B.(1).9 9.4.12.B.(1).11	• Various sensors must be used to assist in maneuvering a robot. • The configuration of the robots hardware dictate the function of the robot. • A remote control can be used in combination with programming to extend the maneuverability of robotic technology.	• How does a robot know when it is approaching an object? • What types of hardware does a robot use to simulate the use of our five senses? • Can a remote control be used to maneuver a robot?

Skills (proficiencies)	Key Content
• Define the key terms: **Sensor:** A device that detects or measures a physical property and records, indicates, or otherwise responds to it. **Variable:** An element, feature, or factor that is liable to vary or change. **Bluetooth:** an open wireless technology standard for exchanging data over short distances (using short wavelength radio transmissions)	• Definition and use of various sensors • Understanding mathematical variables • How a remote control device works • Bluetooth

Assessment:	Rubric:	Key Criteria for Differentiation:
A variety of assessment techniques may	Similar rubric will be used to assess the	Written and visual tools will be used for

be used, including written quizzes, projects, presentations, and other assignments	following: Use of sensors to perform different actions. Robot design.	different type of learners.
Resources: http://www.education.rec.ri.cmu.edu/robots/tetrixteacher/index.htm	Instructional Strategies / Best Practices:	Enrichment: Robot mining challenge.

Pacing Guide

Month	New Jersey Core Curriculum Content Standards	Enduring Understandings/ Essential Questions	Instructional Objectives/ Skills	Suggested Activities	Assessments
1	9.4.12.O.(1).8 9.4.12.B.(1).4 9.4.12.B.(1).10 6.2.12.C.3.b 6.2.12.D.3.b	• Robotics Technology is a hundred billion dollar emerging industry that is an integral part of industry and manufacturing. • By the year 2014 95% of the overall program code developed will be for embedded computing systems. • Robots can be used to replace human workers. • What is a robot? • What is engineering? • What is the impact of robotics on society?	• Define the key terms: • **Robot:** A machine capable of carrying out a complex series of actions automatically. • **STEM:** Science Technology Engineering Mathematics • **Engineering:** The branch of science and technology concerned with the design, building, and use of engines, machines, and structures. • **CADD:** Computer Aided Draft Design • Explain the place of robotics in society • Explore new options for robotics • Make the connection between CADD and robot design	• Familiarize themselves with definitions. • View various videos on robots in use in different industries. • Define a problem that may need a robot as its solution. • Draft/sketch a robot. • Allow students time to view robot pieces and manipulate pieces to create a robot (no power, not final project)	• Vocab. Quiz • Safety Review • Journal writing.

2	9.4.12.A.(4).5 9.4.12.A.(4).6 9.4.12.A.(4).8 9.4.12.A.(4).10 9.4.12.H.(5).1 9.4.12.H.(5).4 CCSS.ELA-Literacy.RST.11-12.9	• Robots can be used to mass-produce products and services. • The use of robots can minimize the danger inherent in the medical field. • Robotics must be monitored. • There are safety issues inherent in the construction and application of robotics. • Robotics accounts for a substantial reduction in the industrial work force.	• Define the key terms: • **Cyber:** Of the culture of computers, information technology, and virtual reality. • **Agriculture:** The science or practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals • **Follow safety procedures** • **Discuss ethical implications behind using robots to replace individuals.**	• Review Safety procedures • Review careers and industries that are instrumental to robotics technology. • Generate a survey as to the needs of the community. • Conduct interviews on the place of robots in society •	• Drafting/sketch • Subject Quiz • Journal writing. • Create robot survey • Community involvement
3&4	CCSS.ELA-Literacy.RST.11-12.2 9.4.12.K.(4).1 9.4.12.K.(4).2 9.4.12.K.(4).4 9.4.12.K.(4).5 9.4.12.K.(4).6 9.4.12.K.(4).7 CCSS.Math.Conte	• Software is utilized to teach a robot how to maneuver and perform various skills. • Mathematics and measurement are used to write programming language. • The software is driven by the consumer/societ	• Define the key terms: • **Software:** The programs and other operating information used by a computer. • **Firmware:** Permanent software programmed into a read-only memory. • **Programming:** The action or process of writing computer programs, for predetermined behavior.	• Basic programming • Use of mathematics to maneuver robot. • Redesign/draft and sketch robot based on schematics •	• Basic algebra quiz • Journal writing • Program code

	nt.HSS-MD.B.5	al needs for the robot. •			
5	CCSS.Math.Conte nt.HSA-REI.A.2 9.4.12.B.(1).2 9.4.12.B.(1).6 9.4.12.B.(1).9 9.4.12.B.(1).11	• **Various sensors must be used to assist in maneuvering a robot.** • **The configuration of the robots hardware dictates the function of the robot.** • **A remote control can be used in combination with programming to extend the maneuverability of robotic technology.**	• **Define the key terms:** • **Software:** The programs and other operating information used by a computer. • **Firmware:** Permanent software programmed into a read-only memory. • **Programming:** The action or process of writing computer programs, for predetermined behavior. • **Understand the concepts that make a remote control work.** • **Recognize and use each sensor properly.**	• **Creation of final project to move to specific coordinates** • **Build a robot based on the needs defined and the draft created earlier in the school year**	• **Final Project** • **Presentation of robot** • **Powerpoint Presentation**

APPENDIX A

RUBRICS

Rubrics for Robotics Explorations Assessment

	(4) Advanced - A	(3) Proficient - B	(2) Basic - C	(1) Below Basic - D or E
Build/ Program Test Robot	• Robot is built accurately with no mistakes • Robot is programmed accurately with no errors	• Robot is built with few mistakes • Robot is programmed with few errors	• Robot is built with some mistakes • Robot is programmed with some errors	• Robot is built with some mistakes • Robot is programmed with some errors • Robot is built with many mistakes • Robot is programmed with many errors
Data Analysis/ Scientific Method	• Make reasonable predictions based on prior knowledge • Correctly gather and record all data • Accurately construct a bar graph illustrating results	• Make predictions based on prior knowledge • Correctly gather and record most data • Construct a bar graph illustrating results with few errors	• Predictions are irrational and not based on prior knowledge • Correctly gather and record some data • Construct a bar graph illustrating results with some errors	• No predictions made • Data is not gathered or recorded correctly • Bar graph is inaccurate
Writing an Analytical Paragraph	Paragraph includes: • A topic statement accurately presenting information on probability. • A detailed explanation of how the results of the trial compare with probability calculations. • A concluding statement thoroughly summarizing results of the experiment.	Paragraph includes: • A topic statement accurately presenting information on probability. • An explanation of how the results of the trial compare with probability calculations. • A concluding statement summarizing results of the experiment.	Paragraph includes: • A topic statement presenting some information on probability. • Some explanation of how the results of the trial compare with probability calculations. • A concluding statement summarizing some results of the experiment.	Paragraph includes: • A topic statement that does not present information on probability. • Little explanation of how the results of the trial compare with probability calculations. • A concluding statement that does not summarize results of the experiment.

Rubrics for Engineering Journal Assessment

The Engineering Journal

The Engineering Journal is a highly recommended organizational method for the instructor to keep track of each group's work throughout the multi-week project. It consists of a folder or binder for each individual in the class, which contains the entirety of that student's work for the project. Consolidating each student's work in a single place allows for easy collection of assignments, and gives students responsibility for keeping his or her own material organized.

This gives the instructor the option of collecting students' journals to grade when assignments are due (and even when they're not).

Each student's Engineering Journal contains:

- Class handouts
- Daily logs and notes
- All completed and returned assignments
- Final (turned-in) version of any individual assignments that are due

All material should be kept in chronological order

Alternatively, you may choose to have only one journal per group, or have every student keep a copy of both individual and group assignments. The Engineering Journal is your tool for efficient assessment – customize the requirements to fit the needs of your classroom.

Assessment

- The Journal itself should be graded based on completeness and organization
    - A complete journal should include:
        - All class handouts, including syllabus and assignment sheets
        - All teacher-assigned work (homework, quizzes, etc.)
        - Daily logs, one per day of independent work
        - All major project deliverables (proposal, etc. – group journal keeper only)
        - Group meeting notes (group journal keeper only)
    - All documents in the journal should be organized by date

- Students should be responsible for lost, damaged, or poorly kept Journals
    - Points should be deducted for journals that are:
        - Lost (no credit for assignments that are lost!)
        - Damaged or sloppy (unprofessional!)

- When requested, students should hand in their journals
    - This is the preferred method for collecting work on days assignments are due
        - Penalties apply for groups or individuals who are not prepared

- Journal contents should be graded and returned in the journal
    - Assignments should be graded according to their own rubrics
        - Quizzes and journal hand-ins can be done together for convenience

- Notes and logs are a student's evidence of work done on a daily basis
    - Self- and peer-reported student records are how work habits are tracked
        - Teamwork
        - Effective use of time
        - Good planning and preparation

Rubrics for External Design Review

	(4) Advanced - A	(3) Proficient - B	(2) Basic - C	(1) Below Basic - D or E
Timeliness (10%)	• Prototype is fully functional at the time of review • Group is present and ready to begin on time	• Prototype is semi-functional (has at least one working component) at the time of review • Group is present and ready to begin on time	• Prototype is together, but not functional at the time of review • Group is present but not ready to present	• Prototype is not built or functional at time of review • Not all group members are present, and group is not ready
Presentation (15%)	• Discussion remains professional in tone and direction • Discussion proceeds efficiently due to understanding and articulation of the groups ideas and design • Group is able to focus on relevant aspects of the robot design	• Discussion remains professional in tone and direction • For the most part discussion proceeds efficiently • Group may not focus on relevant aspects of design, but does articulate important issues	• Discussion does not have a professional tone or manner • Discussion does not stay on topic • Students may articulate some ideas of the project, but do not focus on main aspects of robot design	• Little discussion occurs during the presentation • Students show lack of understanding of group ideas and design of robot • Group does not focus discussion
Project Management (30%)	• Development is in line with timeline submitted with proposal • Group member roles and responsibilities are defined and adhered to • Schedule for future development is practical and workable	• Development is mostly in line with timeline submitted with proposal • Group members have roles and responsibilities which were mostly adhered to • Schedule for future development is present and likely practical and workable	• Group member do not abide by timeline that was submitted with proposal • Group members do not adhere to clearly defined set of roles and responsibilities • Future development is present but may not be in schedule or practical and workable	• Timeline is not submitted, or timeline is disregarded during development process • Group members do not clearly define roles • No schedule for future development is created

Rubrics for External Design Review

(Cont.)	(4) Advanced - A	(3) Proficient - B	(2) Basic - C	(1) Below Basic - D or E
Progress (30%)	• Project shows a clear progression beyond what was available at the time of proposal • Every team member has effectively contributed to development • Decisions show evidence of a thoughtful decision-making process • Group has given appropriate consideration to all aspects of development, including mechanics, programming, and testing	• Project has progressed from what was available at time of proposal • Most team members have effectively contributed to development • Most decisions show evidence of use of a thoughtful decision-making process • Group has spent some time considering all aspects of development	• Project has made only fair progression beyond what was available at the time of proposal • Few team members have effectively contributed to development • Decision were made without using a decision-making process • Group has spend little time considering all aspects of development	• Project has not progressed from time of proposal • Little contribution from any team member • No clear decisions made • Group did not consider all aspects of development
Future Plans (15%)	• Group can describe what aspects of design will be worked on next • Groups has prioritized remaining tasks to ensure project will be completed on time	• Groups can give overall ideas of what future aspects of design will look like • Group has prioritized the ideas they have come up with for future design	• Groups have very little idea about future aspects of design • Group can provide a sketch of a timeline for future ideas	• Group has not thought about future aspects of design • Group has no timeline to get future tasks done

Rubrics for Internal Design Review

	(4) Advanced - A	(3) Proficient - B	(2) Basic - C	(1) Below Basic - D or E
Timeliness (10%)	• Design Candidate Sheets are completed on time for each design • Design Assessment Criteria sheet is completed on time • Group is present and ready to begin on time	• Design Candidate Sheets are complete but not on time • Design Assessment Criteria sheet is completed but not on time • Group is present and read to begin on time	• Most Design Candidate Sheets are complete • Design Assessment Criteria sheet is mostly complete • Group is present	• Design Candidate Sheets are not completed • Design Assessment Criteria sheet is not completed • Group is not present
Discussion (30%)	• Group follows good meeting and teamwork procedures • Discussion remains professional in tone and direction • Discussion proceeds efficiently • Group is able to focus on the relevant aspects of the robot designs	• Group follows decent meeting and teamwork procedures • Discussion remains professional in tone and direction • For the most part discussion proceeds efficiently • For the most part group focuses on relevant aspect of robot designs	• Group follows few meeting and teamwork procedures • Discussion does not have a professional tone or manner • Discussion does not proceed efficiently • Group rarely focuses on relevant aspects of robot design	• Group does not work as a team • Little discussion occurs • Discussion does not stay on topic • Group does not focus on relevant aspects of robot design

Rubrics for Internal Design Review

(Cont.)	(4) Advanced - A	(3) Proficient - B	(2) Basic - C	(1) Below Basic - D or E
Problem Understanding (40%)	• Design Assessment Criteria are appropriate • Discussion indicates that all team members are familiar with the problem • Discussion indicates that all team members understand the needs of the solution • Candidate designs are oriented toward solving the problem • Candidate designs show evidence of thought out design including mechanics, programming, and testing	• Design Assessment Criteria are mostly appropriate • Discussion indicates that most team members are familiar with the problem • Discussion indicates that most team members understand the needs of the solution • Candidate designs are mostly oriented towards solving the problem • Candidate designs mostly show evidence of thought out designs	• Design Assessment Criteria are not very appropriate • Discussion indicates that a few team members are familiar with the problem • Discussion indicates that a few team members understand the needs of the solution • Candidate designs do not really try to solve the problem • Candidate designs do not show a thought out design	• Design Assessment Criteria do not exist • Little discussion takes place • Candidate designs do not exist
Consensus (20%)	• Group members avoid unnecessary "attachment" to their designs that gets in the way of productive discussion • All group member are able to reach consensus	• Group members avoid unnecessary "attachment" to their designs that gets in the way of productive discussion • Most group members are able to reach a consensus • Group is present and ready to begin on time	• Group member must keep pieces of their original design which may temporarily halt productive discussion • Few group members reach consensus	• Group members feel that their design is the only design • Group members never reach consensus

Rubrics for Presentations

	(4) Advanced - A	(3) Proficient - B	(2) Basic - C	(1) Below Basic - D or E
Use of Multimedia Technology	**Excellent use of multimedia technology.** • The presentation was eye appealing. • The pictures were clear. • The sequence of the presentation was well thought out. • Presentation was organized, • Speakers were clear and used proper terminology. • Complete	**Student demonstrated they knew how to use multimedia technology.** • The presentation was eye appealing. • The pictures were clear. • The sequence of the presentation was well thought out. • Complete	**Multimedia technology use needs work.** • The use of multimedia technology was a distraction rather than help. • Incomplete	**Multimedia technology didn't support topic.** • Pictures were not clear and didn't seem to have a purpose. • Incomplete
Content Analysis	**Content was excellent.** • Presentation was organized. • Project was fully described. • I learned something when I listened to the presentation. • Presentation enjoyable to watch.	**Content was good.** • Presentation was organized. • Presentation was organized but needed more practice to be excellent.	**Content of presentation lacked clarity.** • Presentation lacked organization and didn't have a unified theme. • Presenters didn't use proper terminology.	**Content of presentation lacked clarity.** • Presentation lacked organization and didn't have a unified theme. • Presenters didn't use proper terminology.

Rubrics for Project Proposal Assessment

	(4) Advanced - A	(3) Proficient - B	(2) Basic - C	(1) Below Basic - D or E
Timeliness (10%)	• All required elements are produced on time	• Most required elements are produced on time	• Few required elements are produced on time	• Required elements are not turned in
Presentation (20%)	• Proposal is well written with no grammatical or spelling errors • Proposal has been reviewed at least once • All required elements are included • Timelines and charts are written clearly, with no unnecessary marks or cross-outs	• Proposal is well written with few grammatical or spelling errors • Proposal has been reviewed at least once • Most required elements are included • Timelines and charts are written clearly with few unnecessary marks or cross outs	• Proposal is fairly well written with many grammatical or spelling errors • Proposal has never been reviewed • Most required elements are included • Timelines and charts are written clearly with many unnecessary marks and cross-outs	• Proposal is not well written and has many grammatical or spelling errors • Proposal has never been reviewed • Few required elements are included • Timelines and charts are not written clearly with many unnecessary marks and cross-outs
Practicality (30%)	• Proposed solution demonstrates understanding of real-world constraints (i.e. laws of physics, time) • Timeline specifies due dates for required deliverables • Materials list is reasonable, given resources • Proposal clearly links problem to proposed solution	• Proposed solution demonstrates a fair understanding of real-world constraints (i.e. laws of physics, time) • Timeline specifies most due dates for required deliverables • Materials list is mostly reasonable, given resources • The proposal mostly links problem to the proposed solution	• Proposed solution demonstrates a poor understanding of real-world constraints (i.e. laws of physics, time) • Timeline specifies few due dates for required deliverables • Materials list is not reasonable, given resources • Very little connection made between the proposed solution and the problem	• No proposed solution is given • No timeline indicated • Materials list is not reasonable • No connection made between the proposed solution and the problem

Rubrics for Project Proposal Assessment

(Cont.)	(4) Advanced - A	(3) Proficient - B	(2) Basic - C	(1) Below Basic - D or E
Problem Understanding	• Proposal demonstrates clear understanding of problem • Shows consideration for need and potential users of product	• Proposal shows a good deal of understanding of problem • Shows a good deal of consideration for need and potential of users of product	• Proposal shows little understanding of problem • Shows little consideration for need and potential of users of product	• Proposal demonstrates no understanding of problem • Shows no consideration for need and potential users of product
Teamwork (10%)	• Team has defined appropriate roles/ responsibilities for all members	• Most of the team has defined roles/ responsibilities	• Few members of the team have defined roles/ responsibilites	• No roles/ responsibilities were defined for group members

Rubrics for Work Habits Evaluation

Student Name ______________________ Date __________

Course Title ______________________ Grading Period __________

10 Advanced	9 Proficient	8 Basic	7-0 Unacceptable

		Self	Teacher
1	Gives full attention to instructions and follows directions.		
2	Comes prepared and works the entire class period.		
3	Works well with minimal supervision.		
4	Works up to potential, shows maximum effort.		
5	Works cooperatively as a member of a group.		
6	Makes effective use of time and/or materials.		
7	Demonstrates initiative and motivation.		
8	Has a cooperative, positive attitude.		
9	Is on time for class.		
10	Participates daily in the cleanup program.		
	Work Habits Point Total		

Rubrics for Workplace Competencies Evaluation

Student Name ______________________ Date __________

Course Title ______________________ Grading Period __________

Calculate a score based on the following workplace competencies

1	**Consistently demonstrates a positive attitude** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
2	**Cooperates all of the time** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
3	**Communicates well** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
4	**Honest** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
5	**Dependable** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
6	**Recognizes problems and finds acceptable solutions** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
7	**Concentrates** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
8	**Produces quality work** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
9	**Makes smart decisions** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
10	**Always attends** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
12	**Always punctual** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
13	**Follows directions** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
14	**Reads, writes, and calculates well** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
15	**Shows leadership** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
16	**Practice good grooming and dresses appropriately** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
17	**Meets deadlines while producing quality** Always (7) - Usually (5) - Sometimes (3) - Seldom (1) - Never (0)	
	Work Habits Point Total	

Rubrics for Robotics Class Writing

All students in robotics class will be using the writing process when completing assignments for class. Brainstorm your topic, outline what you plan to write about, then write your essay.

For full credit you will need to turn in proof of the following:

1. Brainstorm worksheet: A sheet of paper that includes all ideas generated during the brainstorming process. Include everything that you think of about your topic when brainstorming.
2. An outline of how you you plan to present your topic. Outline the information that you have in your brainstorming sheet. What will you talk about first, second, third, how will you support what you are writing about? Put it on the back of your brainstorming sheet.
3. 1st draft of your paper: Double-space your paper so that it will be easier to edit. You can edit on the same copy that you turn in. Just make sure that it can be read.

You will be evaluated on the following:

- One point for your brainstorm worksheet.
- One point for your outline.
- One point for the accuracy of the information being presented.
- One point for how well your paper reads. Is it choppy? Does the information you wrote clearly support what you are trying to say? Did you proofread your paper for errors?
- One point for spelling.

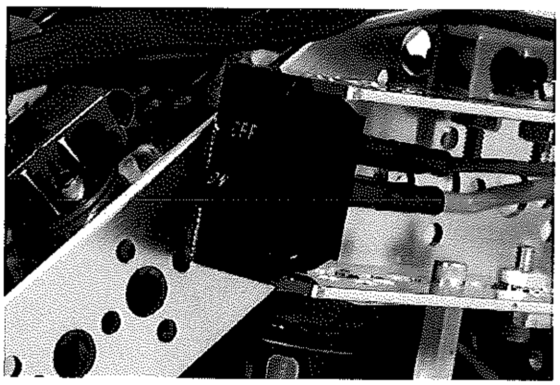
5pts A 4pts B 3pts C 2pts D

APPENDIX B

SAFETY GUIDELINES

Safety

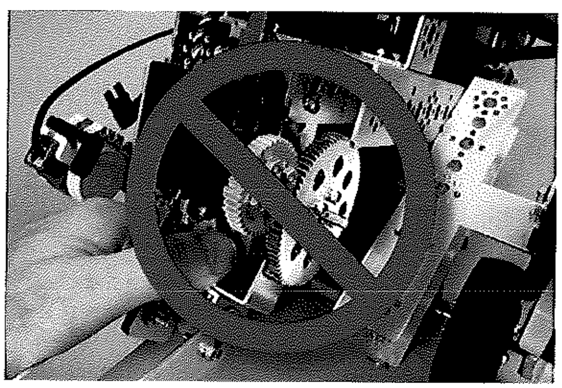
INDEX



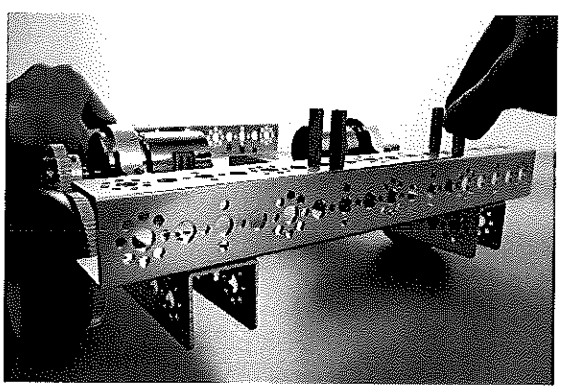
1. Personal Safety

The TETRIX DC motors have a very powerful torque rating of 300 oz/inches. Proper care must be taken to protect you as well as your assembly.

The robot should ***always*** be powered down before operating or working with any section of it.



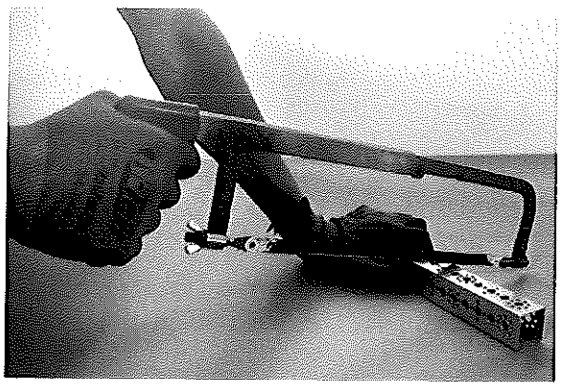
Keep hair, clothing, and all parts of your body away from the moving components on the robot while it is turned on. This includes (but is not limited to) any motors, wheels and gears that could start spinning.



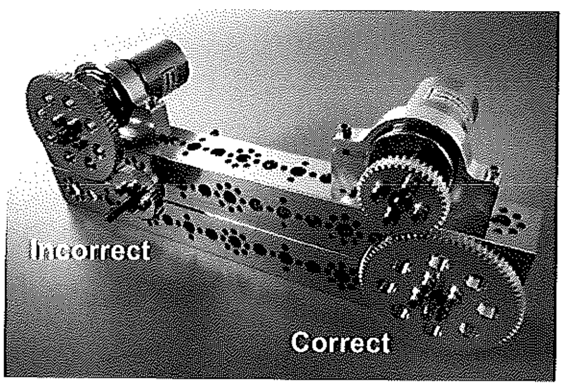
Only work in clean environments free of both clutter and moisture.

TETRIX™ Hardware

When working on metal robots, wear safety gloves and goggles to protect the skin and eyes.

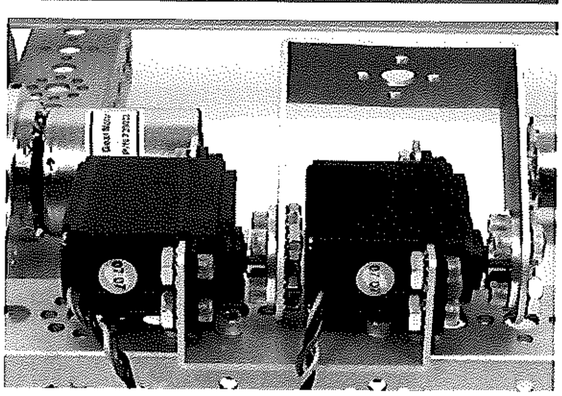


Use extra caution when cutting metal. Only do so under direct supervision and always cut away from your body (not toward). After cutting, be sure to file, sand down or tape off any rough or jagged edges.

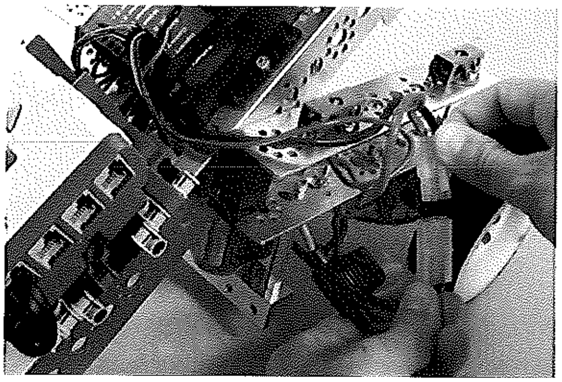


2. Mechanical Safety

Never drive a smaller gear with a larger gear. Doing so risks exceeding the the DC motor's torque rating and damaging the inner gearbox (burning out the motor).

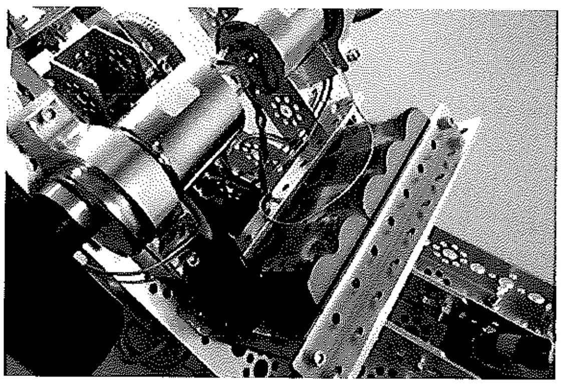


When using two or more servo motors together, the centers must be identified and aligned so the motors will run on a common axis. If this is not done, the servo's motion may be hindered and moving parts damaged by contact with mis-aligned components.

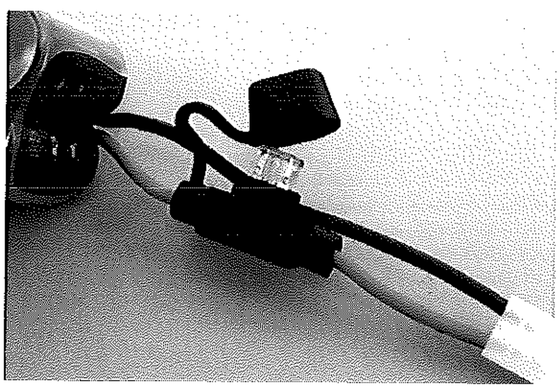


3. Electrical Safety

Make sure the power supply is disconnected when wiring the DC Motor or Servo Controllers.

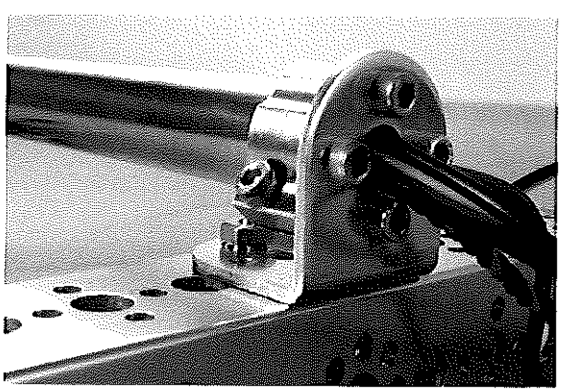


The battery should be positioned so it will not rub against sharp edges. A damaged, leaking battery is a safety hazard.



Never bypass the battery's inline fuse. Doing so will damage your robot's electrical components.

To extend the life of the battery, don't allow it to stay connected to the charger for extended periods of time.



Avoid running wires along 'pinch points'. Sharp metal pieces and gears can damage the wires and their insulation, causing them to break or be exposed.

When possible, run wires through metal tubing and wire-tie them to structural components.

ROBOTC©

Curriculum for TETRIX™ and LEGO© MINDSTORMS©

Product Overview

Robomatter

Carnegie Mellon Robotics Academy

Why Robotics/STEM Education

We can't predict what the hot new technology will be in five years, but we can confidently predict that it will include computer programming, electronic embedded systems, engineering design, and mathematics. If you believe these things, then you need to know that robotics has the ability to teach these concepts. At the same time, robotics teaches 21st century skill sets like time management, resource allocation, teamwork, problem solving, and communications.

Think about this...

- Approximately 98% of all the 32-bit microprocessors currently in use worldwide are used in embedded systems; in other words they are being used in robotic smart technologies.
- By the year 2010, it is forecasted that 90% of the overall program code developed will be for embedded computing systems; to innovate and compete globally we will need more people that know how to program.
- Robotics Technology is a hundred billion dollar emerging industry that has moved from being an industry that could potentially employ thousands of people to an *integral part of all industries.* Robotics will impact the economy the same way that mass production impacted the industrial revolution and the computer impacted the information age.
- Science and Engineering (S&E) occupations are projected to grow by 26% from 2010 to 2020, twice as fast as the overall job market during that period (S&EI 2008) yet we have fewer students pursuing S&E careers.

The Teaching ROBOTC for TETRIX Curriculum

If you are reading this, then you are probably considering teaching using a combination of the NXT, TETRIX, and ROBOTC. I understand the dilemma that you are facing, I taught in the Pittsburgh Public School System for 27 years before coming to Carnegie Mellon. You have a limited budget, you have a thousand things to do every day that don't involve teaching, and then you also teach five or six sections of students. (Sometimes with multiple preps!) This curriculum is designed for a teacher with no programming background that is interested in teaching programming and engineering. This curriculum also supports a teacher that knows how to program, but has students of various skill levels and wants to allow them to move at their own pace. The teaching materials that we've developed use a high level of multimedia and have been tested with hundreds of students; they work. ROBOTC is the best programming software available for use with TETRIX and the NXT if you consider the percentage of teams that use ROBOTC software and made it to the finals of the FTC competition. You have one of the hardest jobs in the world; you teach. This training tool will make it easier.

Math is the language of science, engineering and technology

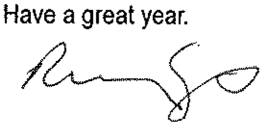
Many teachers see robotics as a way to teach STEM education. We've seen that robotics *does* provide unique opportunities for teachers to place engineering design, scientific process, technological literacy and mathematics in contexts that students find engaging and understand. Across the nation, many schools and community-based organizations are using robotics to address STEM competencies. Yet, our research is finding that many teachers miss key STEM "teaching moments" that robotics enables. Often, robotics teachers will allow students to be haphazard in their design process and avoid mathematics when possible (e.g., using guess-and-check strategies). This methodology leads to weak solutions and reduces student learning.

At the Robotics Academy we believe that:

- Math is the language of STEM and if you can't do math, then you won't be able to compete for a STEM job.
- Mathematics needs to be carefully thought out by the teacher and foregrounded for the student. The focus of the math instruction must be centered on addressing specific mathematics concepts (not general) and the mathematics in the lesson must be made explicit not implicit.
- For students' STEM understanding to move beyond parroting the teacher's words, ideas, and solutions, and to develop deep understanding, students need the opportunity to struggle with the problem, be able to defend their decisions, and explain their answer in their own words.

The moral of the story is "require your students to do the math." To learn more about teaching with robotics visit our web site. Carnegie Mellon is committed to helping teachers teach robotics. If there is something that we can help you with, then please contact us. If you see opportunities to make our teaching products stronger, then please contact us.

Have a great year.



Robin Shoop,
Director, Carnegie Mellon Robotics Academy

ROBOTC Curriculum for TETRIX and LEGO MINDSTORMS

Teaching is a craft and every teacher does it differently. This curriculum is designed to teach "engineering process" and "programming". The Robotics Academy has developed this curriculum to help teachers to teach and students to learn those competencies. The Robotics Academy is committed to helping teachers use robotics to teach science, technology, engineering, and mathematics. Teachers can find additional TETRIX resources to teach robotics and engineering at our TETRIX site, which is continually upgraded by the Robotics Academy, go to www.tetrixteacher.com.

The scope and sequence below is designed to help you to quickly find resources to teach your class. The number of days at the right will depend on the number of challenges and labs that your students complete.

Welcome to Robotics Class..**1-2 days**

- What are the goals of this class?
- What is the definition of a robot? - SPA handout - page 37
- What is the definition of engineering? - Videos and handouts - page 10 & 11
- What is the definition of programming? - Videos and handouts - page 15
- What is the definition of a system?
- What does it mean to manage a project? - Videos and handouts - page 10

Class organization rules..**1-2 days**

- Grading/Rubrics for Evaluation – page 13
- Lab Procedures – pages 13 & 14
- Keeping an Engineering Journal – page 10

Safety..**2-3 days and then ongoing**

- General Safety handout – page 8
- Safety Checklist handout – page 9
- Safety Quiz – page 9

Introduction to the NXT Hardware..**2-3 days then ongoing**

- The NXT Controller – page 18
- NXT Sensors – page 17
- NXT Parts Identification – page 17
- Building your first robot – page 21

Introduction to ROBOTC Software..**1 days then ongoing**

- Download Firmware video – page 21
- Download Your First Program lesson video – page 21
- Introduction to ROBOTC 2.0 Software lesson video – page 15
- Programming Quizzes and handouts – page 22

Introduction to Programming..**1-2 days**

- Thinking About Programming lesson video – page 15
- ROBOTC Programming Syntax lesson video – page 16
- Behaviors/psuedocode handout – page 15
- Whitespace/Comments/ reserved words handouts – page 16

Movement – NXT Forward/Backward/Turning..**8-10 days**

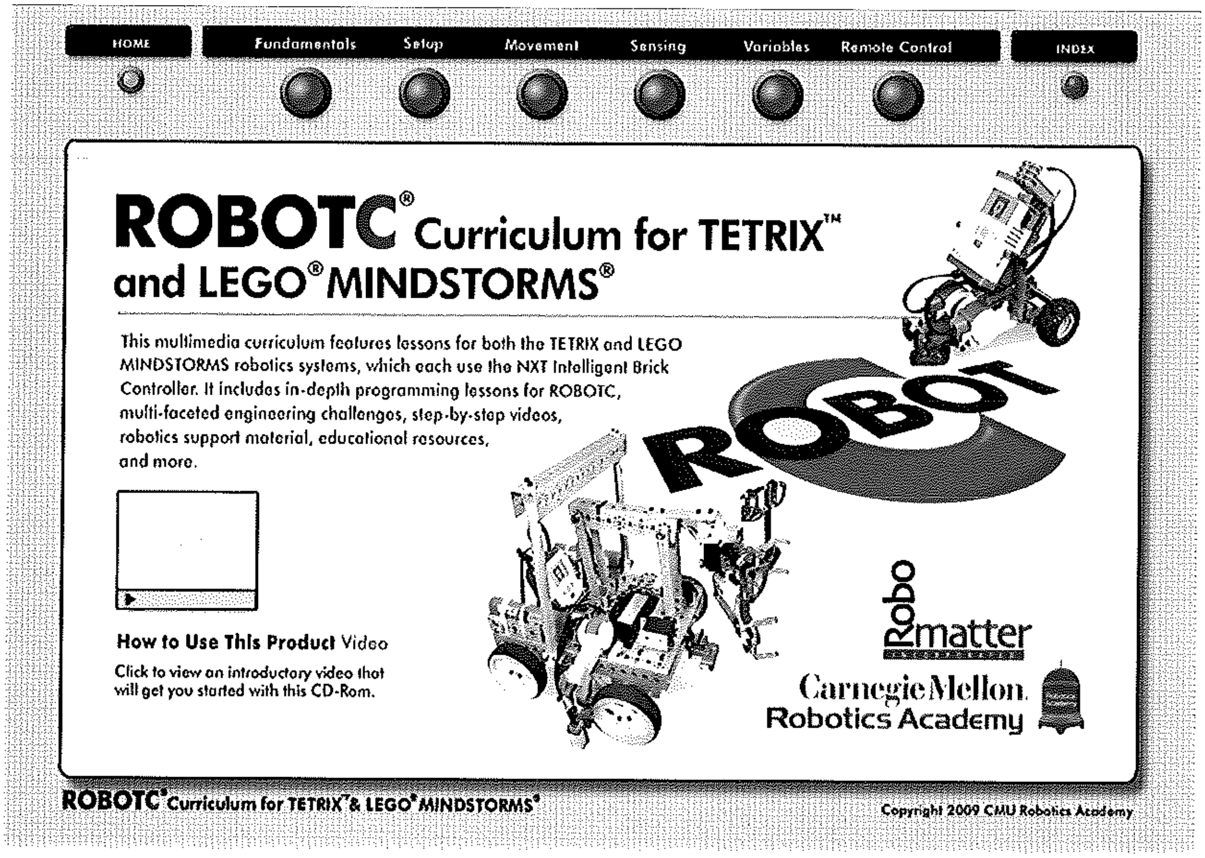
- Labyrinth Challenge – page 27
- Moving Forward lesson videos and handouts – pages 28 & 29
- Motor Power Engineering Lab – page 30
- Speed and Direction lesson videos and handouts – pages 29 & 30
- Turning Engineering Lab – page 30
- PID videos and handout – page 31
- Synchronized Motors lesson video and handout – page 32
- Synchronized Motors Engineering Lab – page 32
- Introduction to Encoders lesson video and handouts – page 32

ROBOTC Curriculum for TETRIX and LEGO MINDSTORMS

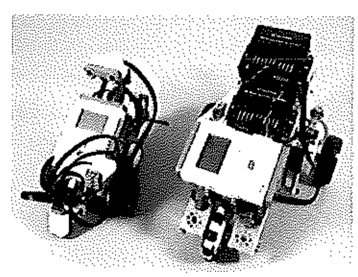
ROBOTC Curriculum for TETRIX and LEGO MINDSTORMS

Getting Started

The ROBOTC Curriculum for TETRIX and LEGO MINDSTORMS is a comprehensive guide that teaches how to program the NXT Mindstorms and TETRIX hardware systems as it helps student develop engineering competencies.

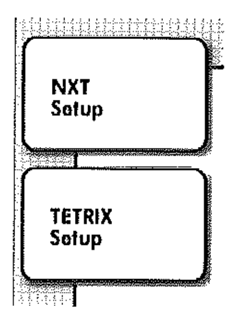


Scaffolded Approach to Learning



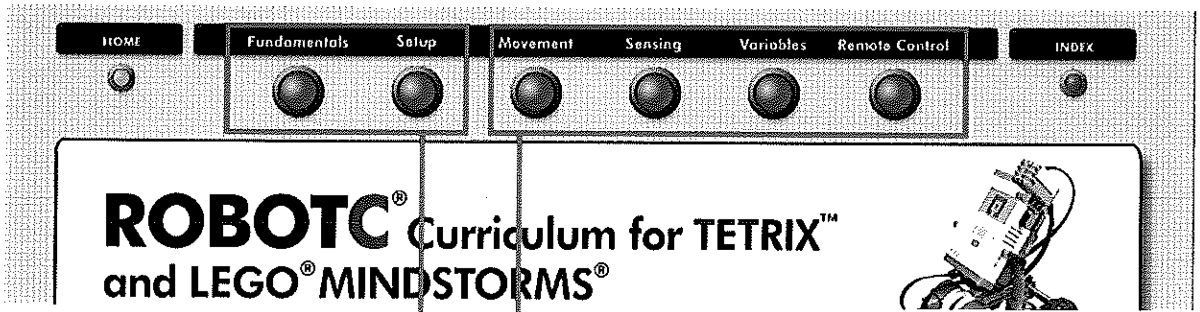
This curriculum uses a scaffolded approach to teach students how to program the NXT-based TETRIX system. Students begin by learning to use, troubleshoot, and program the less complicated LEGO MINDSTORMS NXT robot system before they begin to work with the more complex TETRIX robot system. Once students understand how to program and troubleshoot the NXT system, programming and troubleshooting the TETRIX system is easier.

All lessons are color coded. The NXT lessons are gray and the TETRIX lessons are blue. Students should complete all of the NXT lessons before they begin the TETRIX lessons



Getting Started/Fundamentals

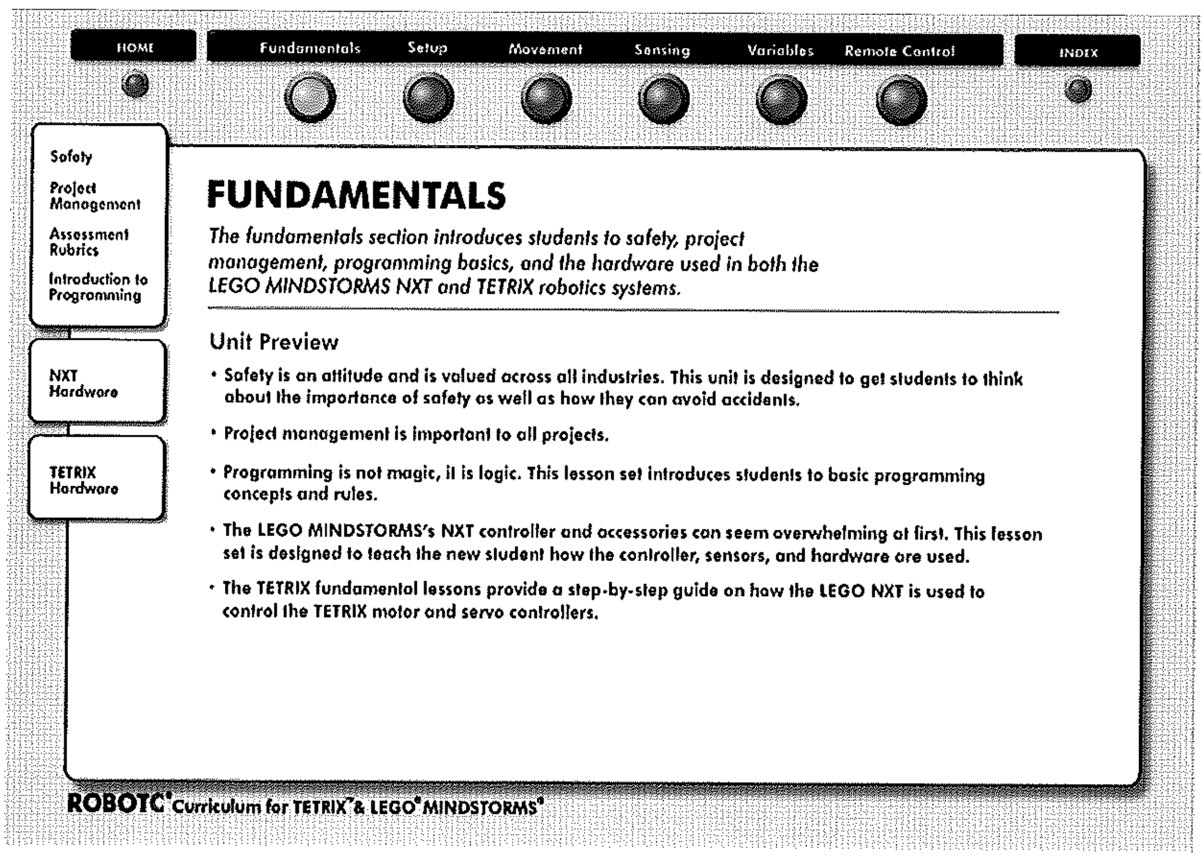
The curriculum is divided into two sections: "Getting Started" and "Programming and Engineering."



The *Getting Started Lessons* are found in the "Fundamentals" and "Setup" sections.

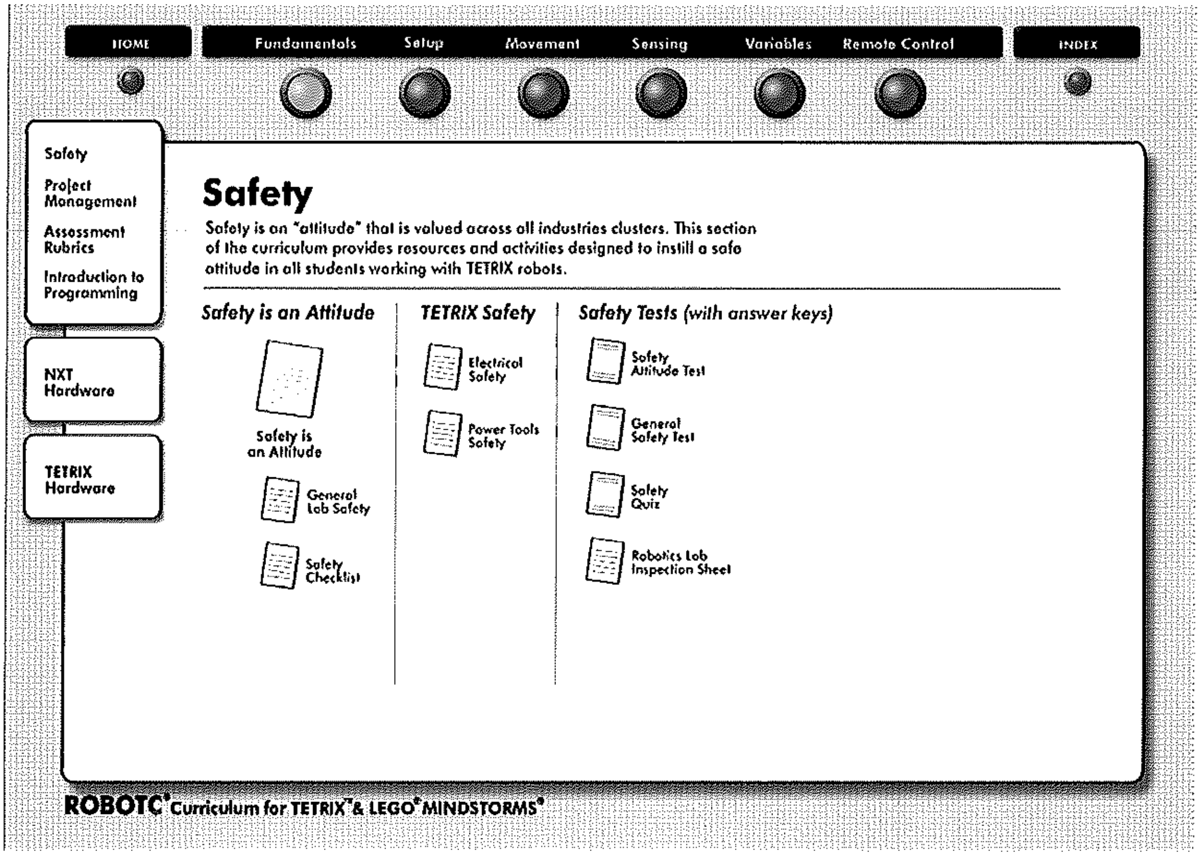
The *Programming and Engineering Lessons* are found in the Movement, Sensing, Variables, and Remote Control" sections.

The Fundamentals Unit



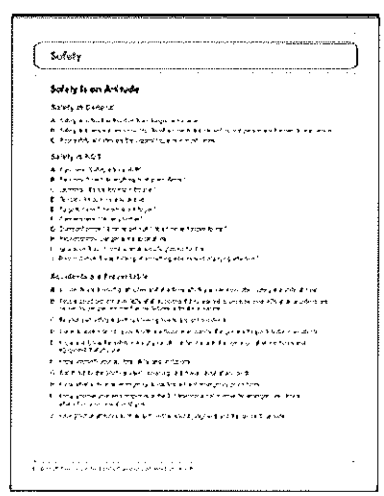
The Fundamentals Unit is divided into six Lesson Sets: ***Safety, Project Management, Assessment Rubrics, Introduction to Programming, NXT hardware***, and ***TETRIX Hardware.***

Getting Started/Fundamentals/Safety



Safety

Any course that involves moving parts, handling and processing materials and students requires safety training. Safety begins with the development of a safe attitude. Most accidents can be avoided if a student develops a safe and conscientious attitude. The safety lesson begins by challenging a student's general beliefs about safety and concludes with a safety inspection of the robotics lab.



Safety is an Attitude - A one page handout that defines what safety is and what safety is not, and concludes with statements that support the fact that most accidents are preventable with the development of a safe attitude.

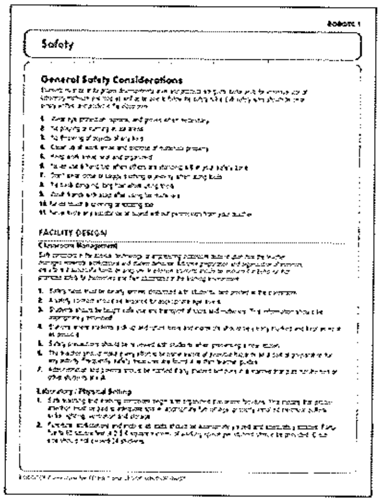
General Lab Safety - A four page handout that spells out general safety rules, describes features of a safe classroom, safe storage, material handling, disposal of materials, tools and equipment, and ends with a list of definitions of terms that students may not know.

Safety Checklist - A three page handout that contains a safety checklist, rules to consider when you are moving things around the lab, and a one page safety poster.

Electrical Safety - A two page handout that describes safety rules when working with electricity and common causes of electrical accidents, including defective equipment, unsafe practices, and lack of electrical knowledge.

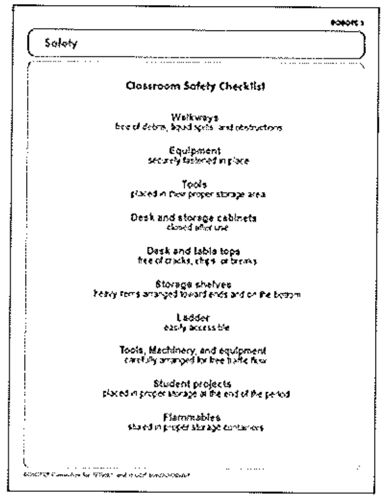
Power Tool Safety - A one page handout that sets rules and expectations for when students use power tools in the robotics lab.

Getting Started/Fundamentals/Safety continued


Safety

General Safety Considerations

FACILITY DESIGN


Safety

Classroom Safety Checklist

Walkways
free of debris, liquid spills, and obstructions

Equipment
securely fastened in place

Tools
placed in their proper storage area

Desk and storage cabinets
closed after use

Desk and table tops
free of cracks, chips, or breaks

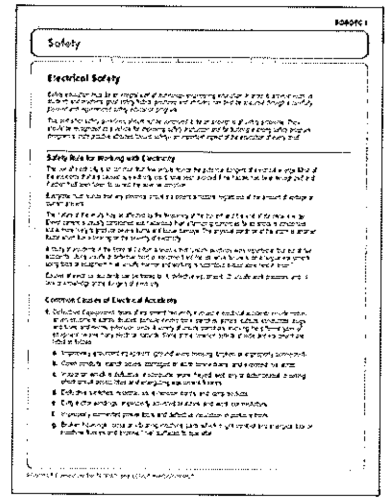
Storage shelves
heavy items arranged toward ends and on the bottom

Ladder
easily accessible

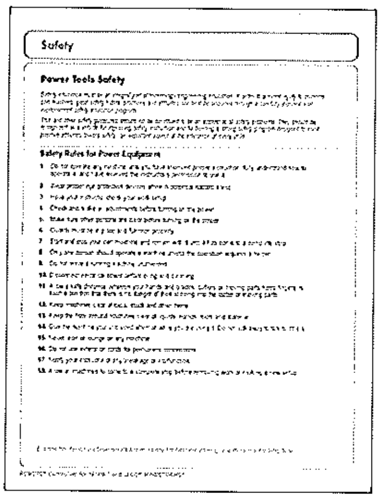
Tools, Machinery, and equipment
carefully arranged for free traffic flow

Student projects
placed in proper storage at the end of the period

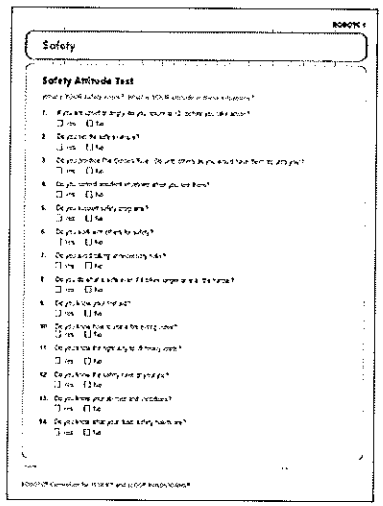
Flammables
stored in proper storage containers


Safety

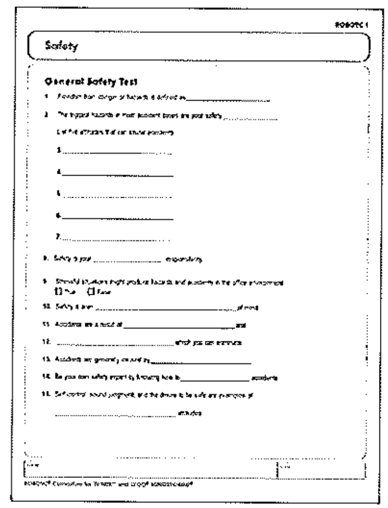
Electrical Safety


Safety

Power Tools Safety


Safety

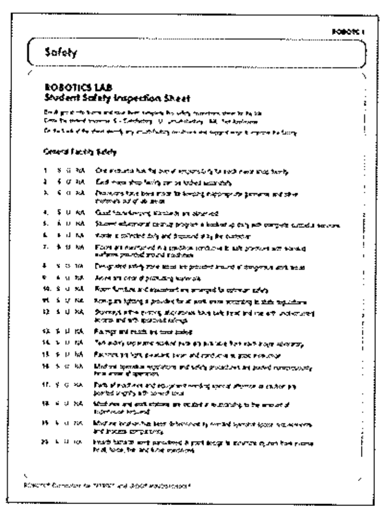
Safety Attitude Test


Safety

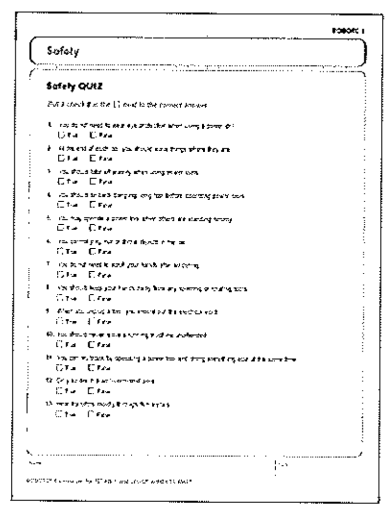
General Safety Test

Safety Tests and Answers - Three different safety quizzes designed to check students' understanding of the importance of safety.

Robotics Lab Safety Inspection Sheet - Helps students to understand that they need to monitor the robotics classroom for safety.

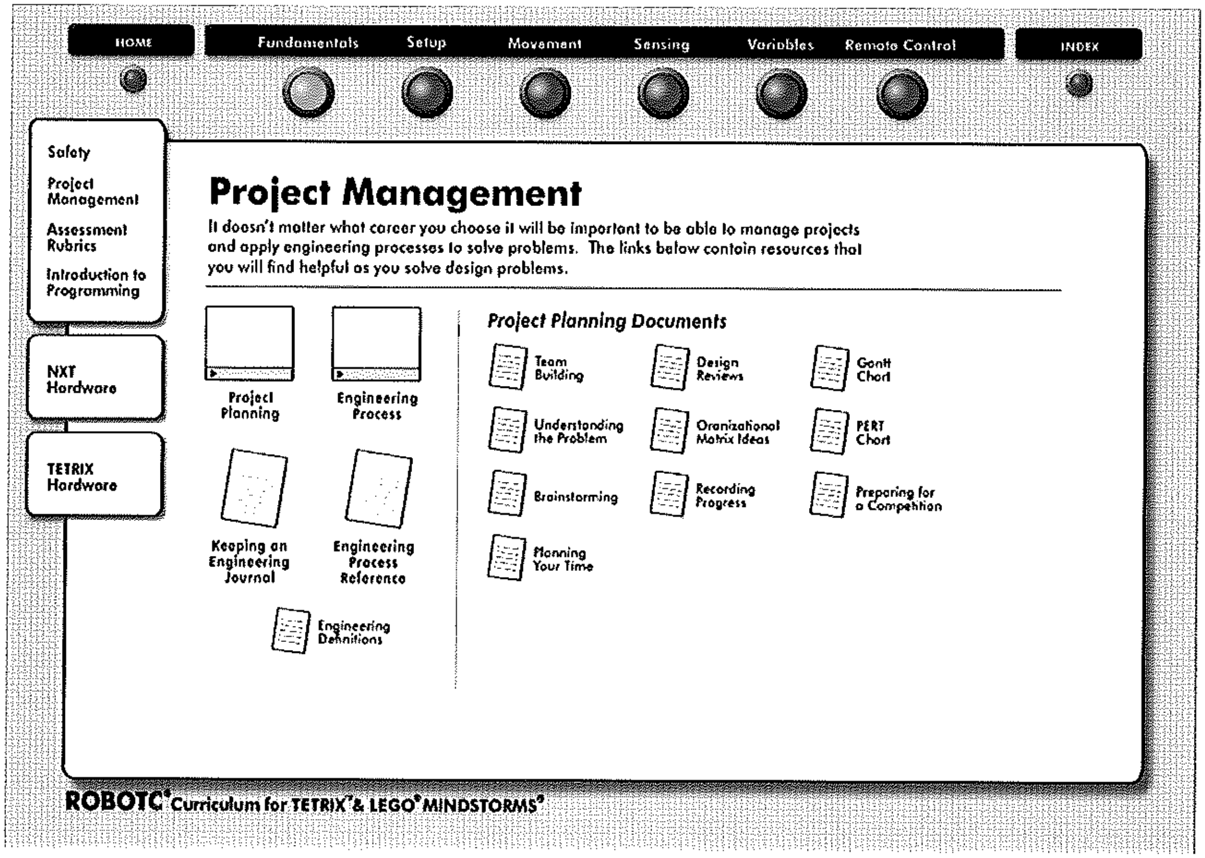

Safety

ROBOTICS LAB
Student Safety Inspection Sheet


Safety

Safety QUIZ

Getting Started/Fundamentals/Project Management



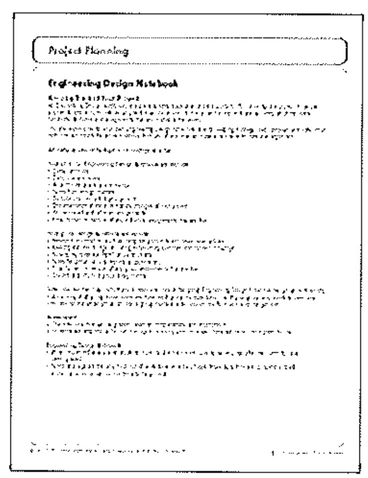
Project Management

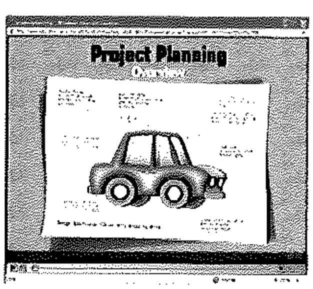
Many schools compete in robotic competitions; other schools are using MINDSTORMS and TETRIX to teach engineering. The links on this page provide students with resources that teach how to manage projects and solve engineering design problems.

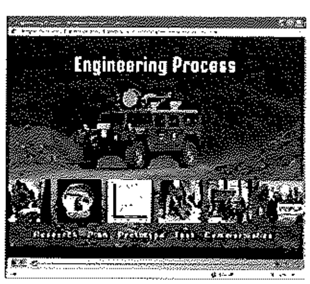
Project Planning Video - The five minute Project Planning Video uses a combination of humor and examples to describe what a well planned project looks like.

Engineering Process Video - The five minute Engineering Process Video highlights the importance of research, planning, developing prototypes, and iterative testing when solving engineering design problems.

Engineering Design Notebook - Each student is required to keep an engineering design notebook. This two page handout describes the what is kept in the notebook and what a daily log is.







Getting Started/Fundamentals/Project Management continued

Project Planning Documents

Engineering Process Reference - This three page set of handouts describes steps that engineers use to solve problems, provides a set of definitions for the word "engineering", and describes the iterative nature of design.

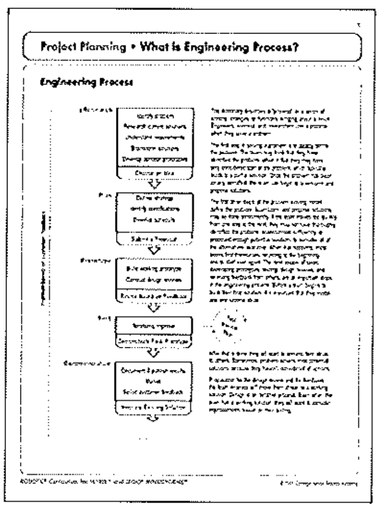
Team Building PDF- The Team Building Lesson Set consists of four documents that describe guidelines that teams should use for the first team meeting, general ground rules for any team meeting, things to consider when building teams, and a description of roles on a robotics team: Project Management, Programming, Engineering, Documentation and Communications.

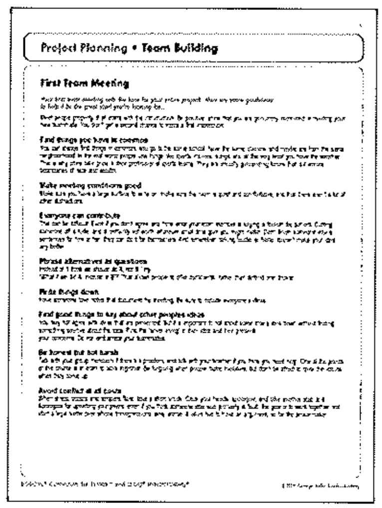
Understanding the Problem PDF - One of the keys to solving any problem is "Understanding the Problem". This three page set of handouts consists of: Defining the Problem, Technical Research, and Creating a Design Specification.

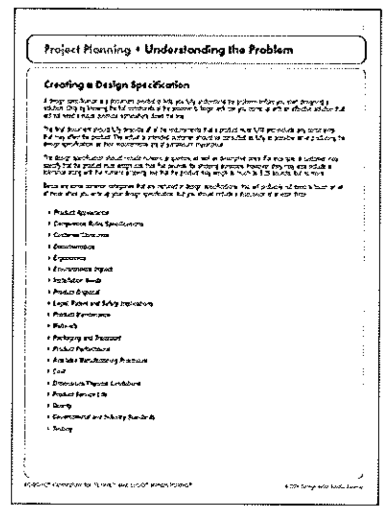
Brainstorming PDF - Another key problem-solving step involves meetings where people brainstorm together to develop potential solutions. This three page set of handouts is broken into: a Brainstorming Primer, Things to Think About, and Brainstorming Tips. Each handout can be used individually or as part of a set.

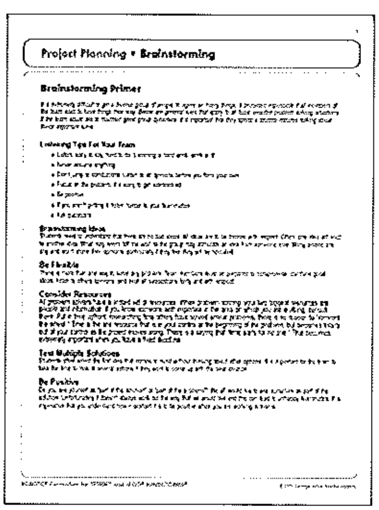
Planning Your Time PDF - Time management is a crucial skill to develop. This four page handout uses a simple activity, planning a birthday party, to describe a critical skill set that everyone should learn: how to manage time.

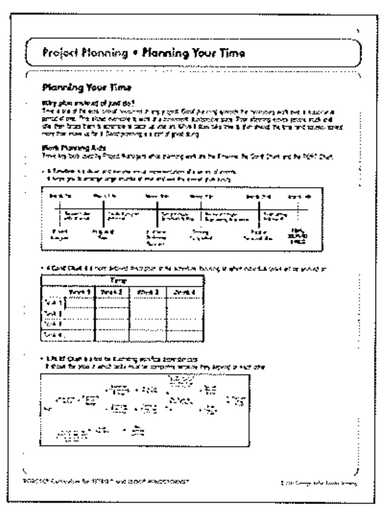
Design Reviews PDF - Engineers conduct design reviews on a regular basis. This two page handout describes how to conduct weekly team design reviews, as well as preliminary and detail design reviews.

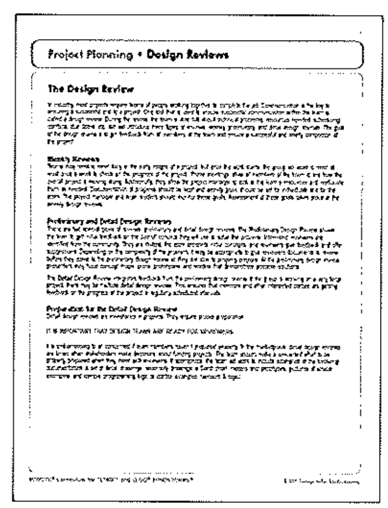












Getting Started/Fundamentals/Project Management continued

Project Planning Documents

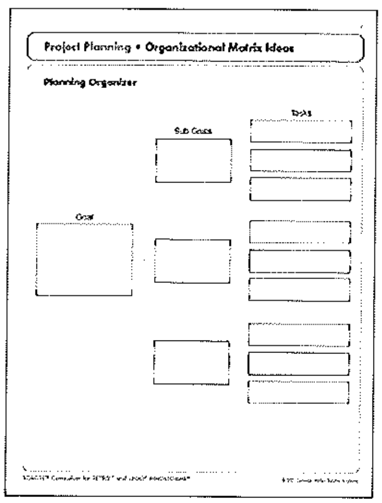
Organizational Matrix Ideas PDF - This three page handout graphically shows three methods of organizing projects.

Recording Progress PDF - The recording progress tools offer the project manager three solutions that can be used to help team members to document the team's progress toward the project goals.

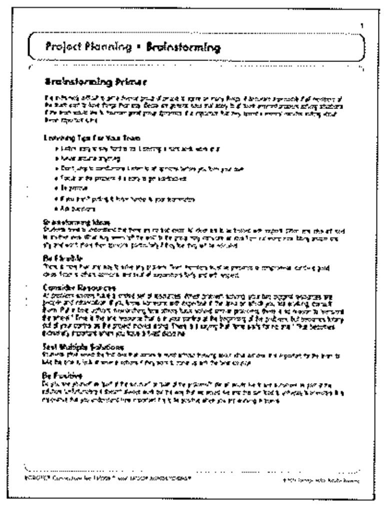
Gantt Chart PDF - A Gantt chart provides a graphical illustration of a schedule to help plan, coordinate, and track specific tasks in a project. This one page handout is designed to teach students how Gantt charts work.

PERT Chart PDF - A PERT chart is a tool that graphically illustrates when parts of the project become due. The advantage of the PERT chart is that it shows which things must be completed in sequence and which things need to be completed simultaneously. This one page handout is designed to teach students how PERT charts work.

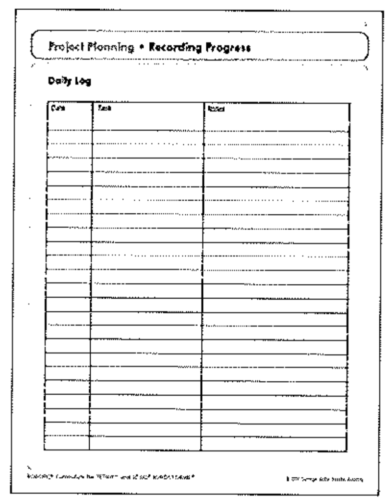
Preparing for a Competition PDF- Robotic competitions offer unique opportunities to teach students about time management, resource allocation, teamwork, and problem solving, all within a context that they find challenging but fun. The Preparing for a Competition handout is designed to support robotics teams as they plan for the competition.


Project Planning • Organizational Matrix Ideas

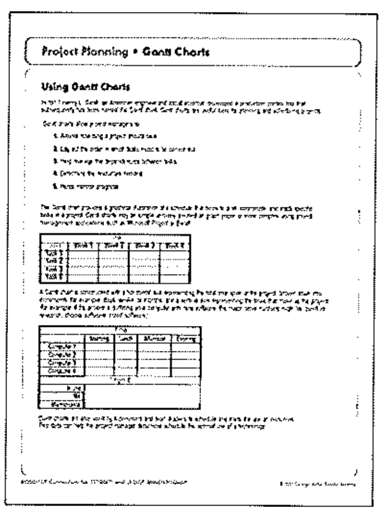
Planning Organizer


Project Planning • Brainstorming

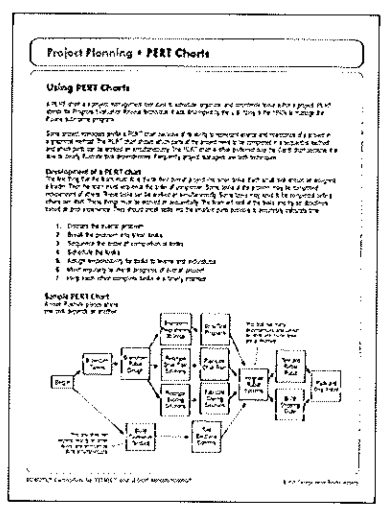
Brainstorming Primer


Project Planning • Recording Progress

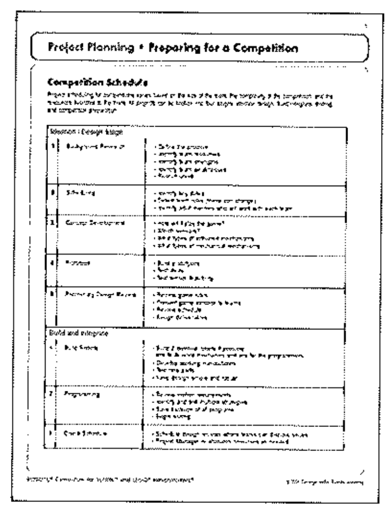
Daily Log


Project Planning • Gantt Charts

Using Gantt Charts

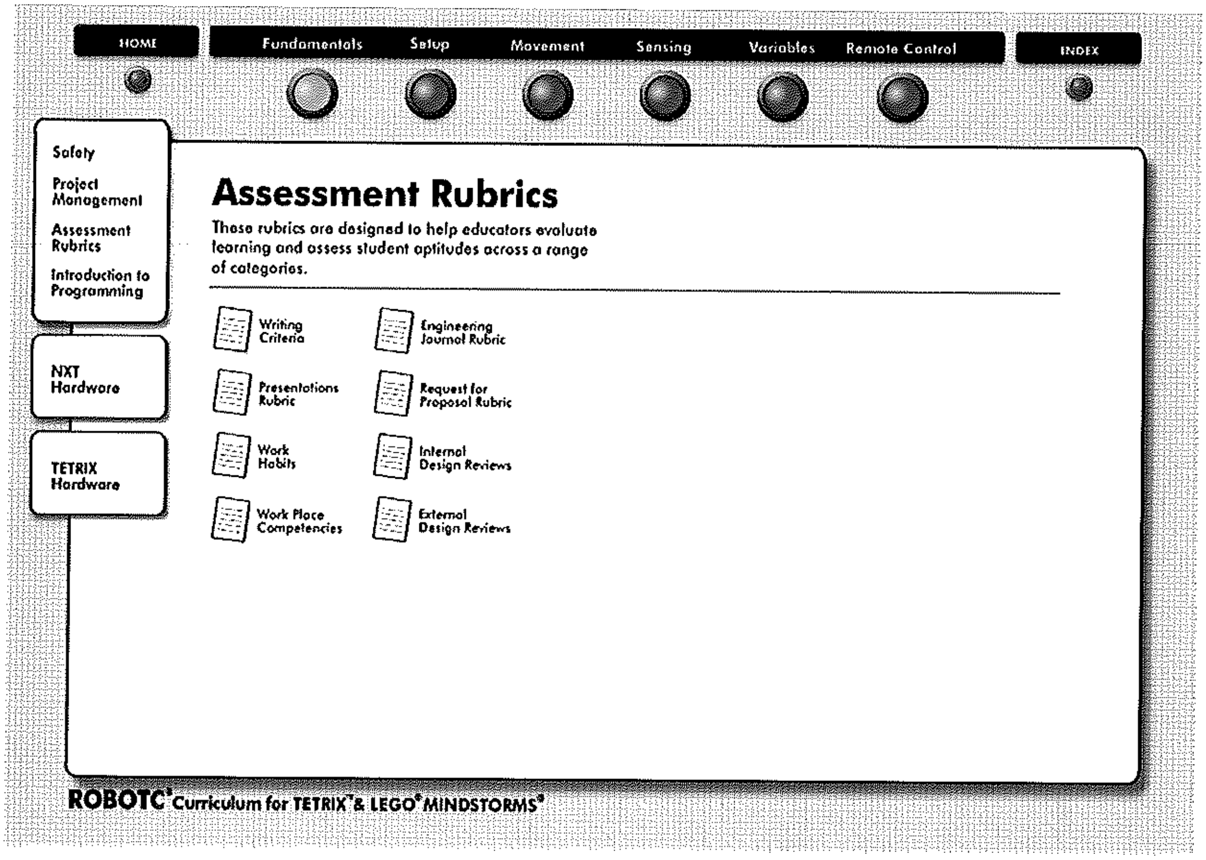

Project Planning • PERT Charts

Using PERT Charts


Project Planning • Preparing for a Competition

Competition Schedule

Getting Started/Fundamentals/Assessment Rubrics



Assessment Rubrics

Timely assessment is paramount in today's educational environment. A clear expectation of what is being assessed is a key to training students. Traditional assessments are provided in the curriculum; ie quizzes. The assessments found in this section are assessment rubrics for project-based learning. There are many other tools that a teacher may use, but this section provides some examples. Rubrics allow all stakeholders to see what is being measured.

Writing Criteria Rubric - Writing is a process and good writing requires several steps: brainstorming, outlining, prewriting, and editing. This is a simple rubric that check for those steps.

Engineering Journal Rubric - Explains to students what is expected in their engineering journals.

Presentation Rubric - Helps students determine what a good presentation should include.

Request for Proposal Rubric - Helps students to determine what is being evaluated in their RPF submission.

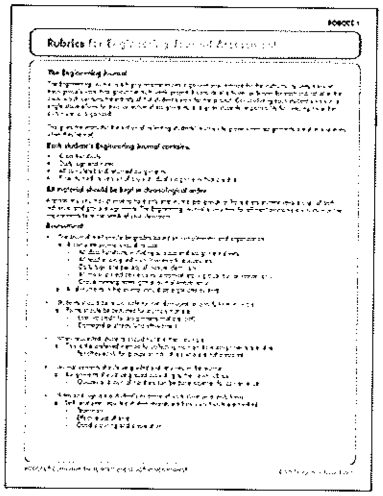
Work Habit Evaluation - This is a great tool for students to use to develop strong work habits.

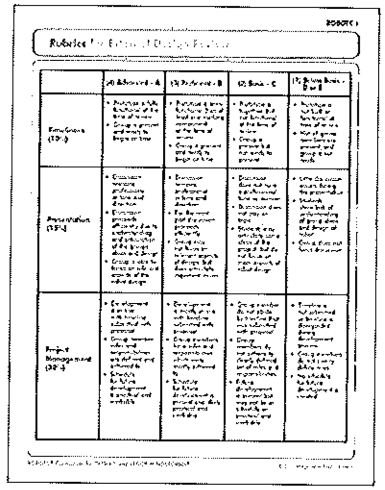
Workplace Competencies Rubric - This rubric helps students to develop the skills that are valued by industry.

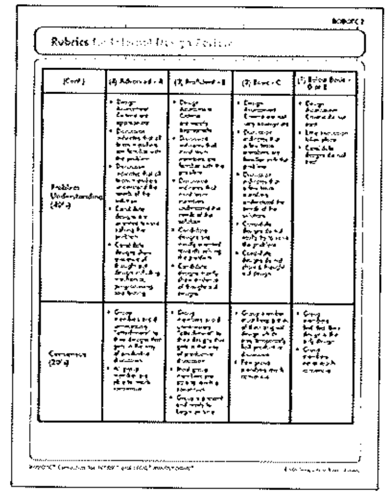
Internal Design Rubric - This evaluation tool helps students understand the expectations and preparation needed for an internal design review.

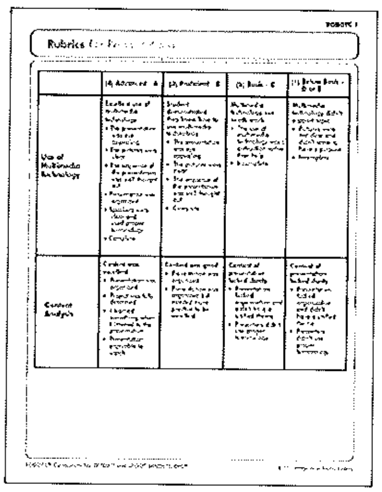
External Design Review - This evaluation tool helps students understand the expectations and preparation needed for an external design review.

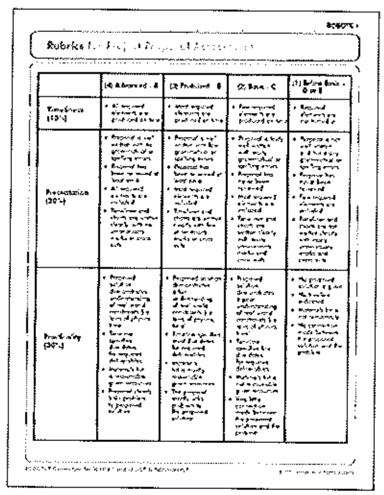
Getting Started/Fundamentals/Assessment Rubrics continued

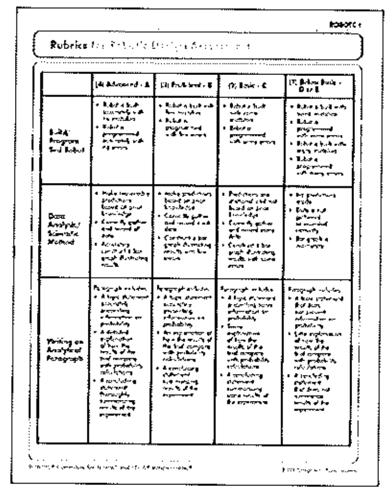


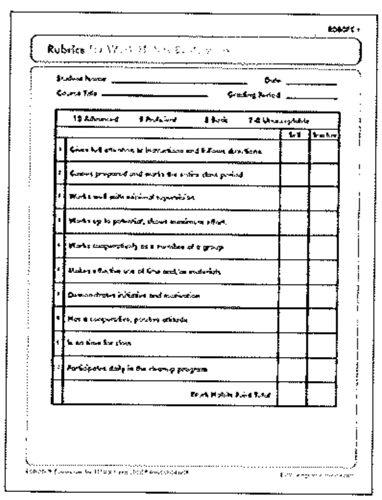


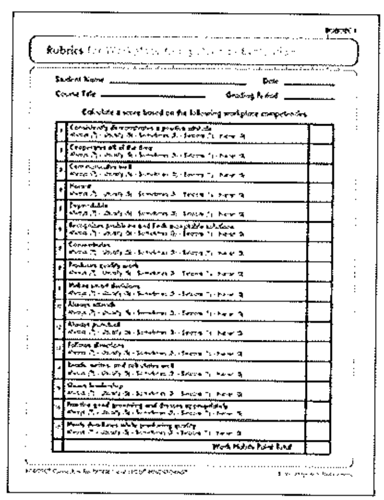


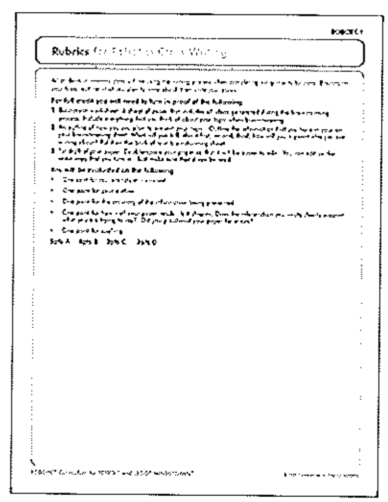




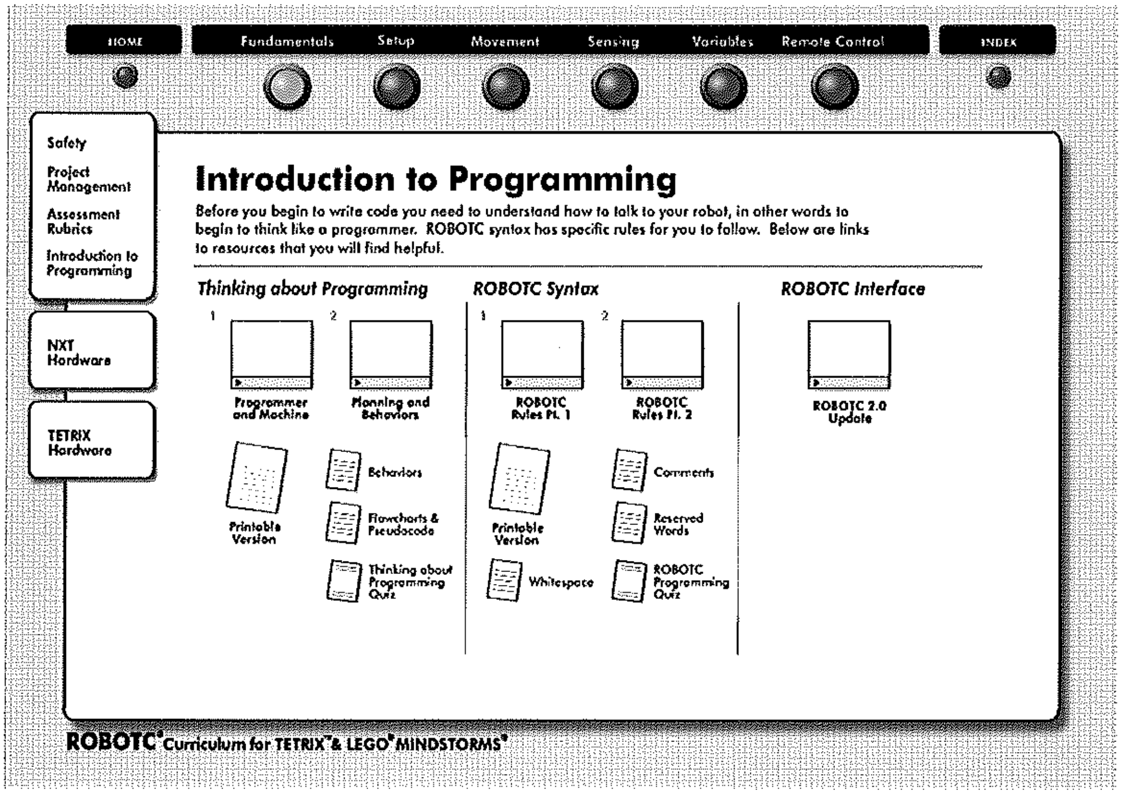






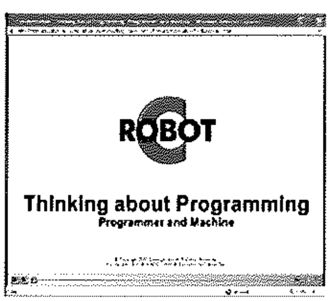


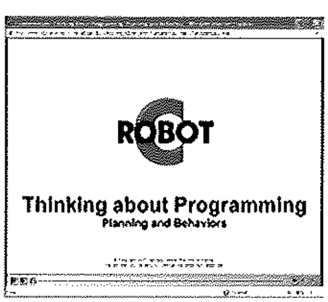
Getting Started/Fundamentals/Introduction to Programming



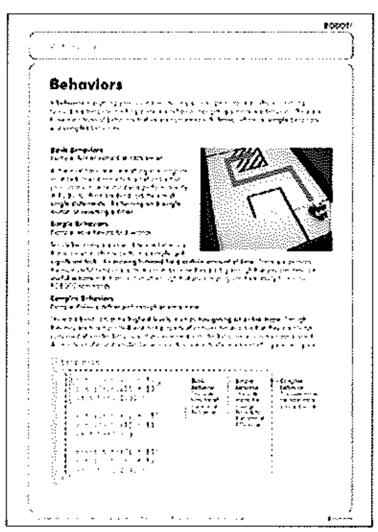
Introduction to Programming

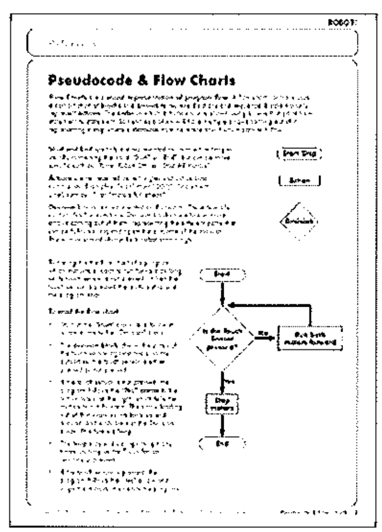
Thinking About Programming Video Set - The "Programmer and Machine" and "Planning and Behaviors" videos explain to students the role of the programmer and the machine, and how the programmer must learn to think like a machine in order to program robots. The videos are designed to explain programming concepts to beginners.



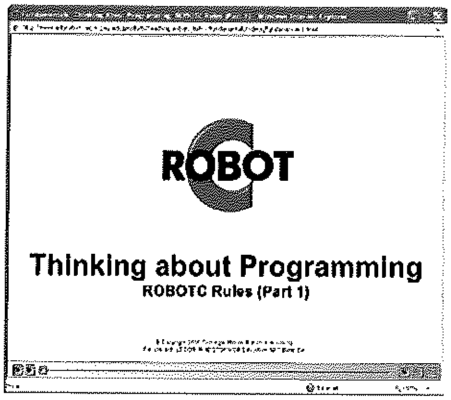


Behaviors and Flowcharts & Pseudocode Helper Pages - These are reference PDFs that students can use as study guides. The helper pages are designed to be guides to the topics.





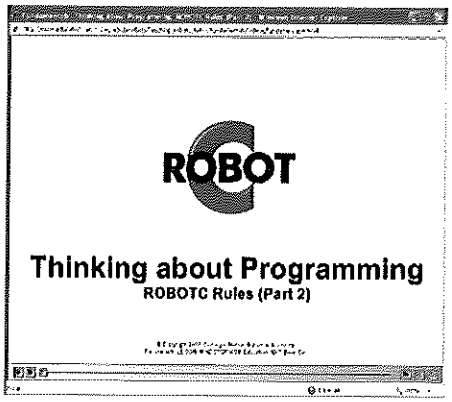
Getting Started/Fundamentals/Introduction to Programming

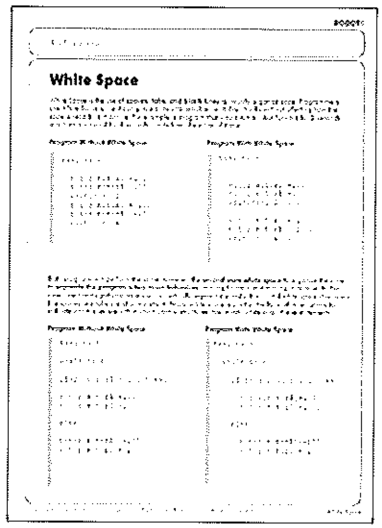


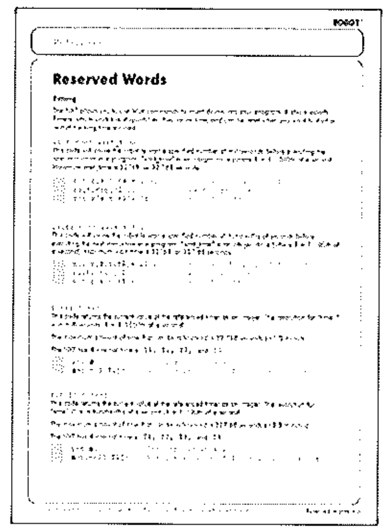
Thinking about Programming ROBOTC Rules Parts 1 & 2 - This video set builds the foundational knowledge that student must develop to begin to program using any syntax-based programming language. This video set introduces syntax concepts in a sequential and logical manner.

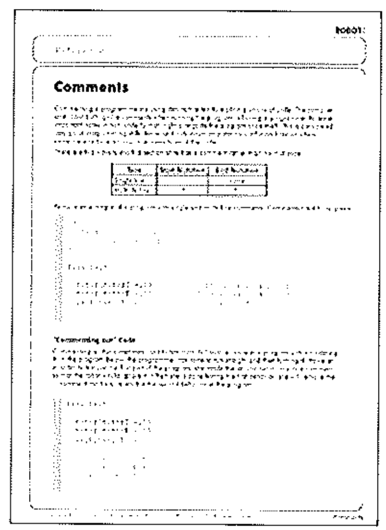
Whitespace, Comments, and Reserved Words Helper Pages - These are reference PDFs that students can use for reference or as study guides.

Thinking About Programming and ROBOTC Programming Quiz - One page quiz designed to check students understanding of introductory programming topics.

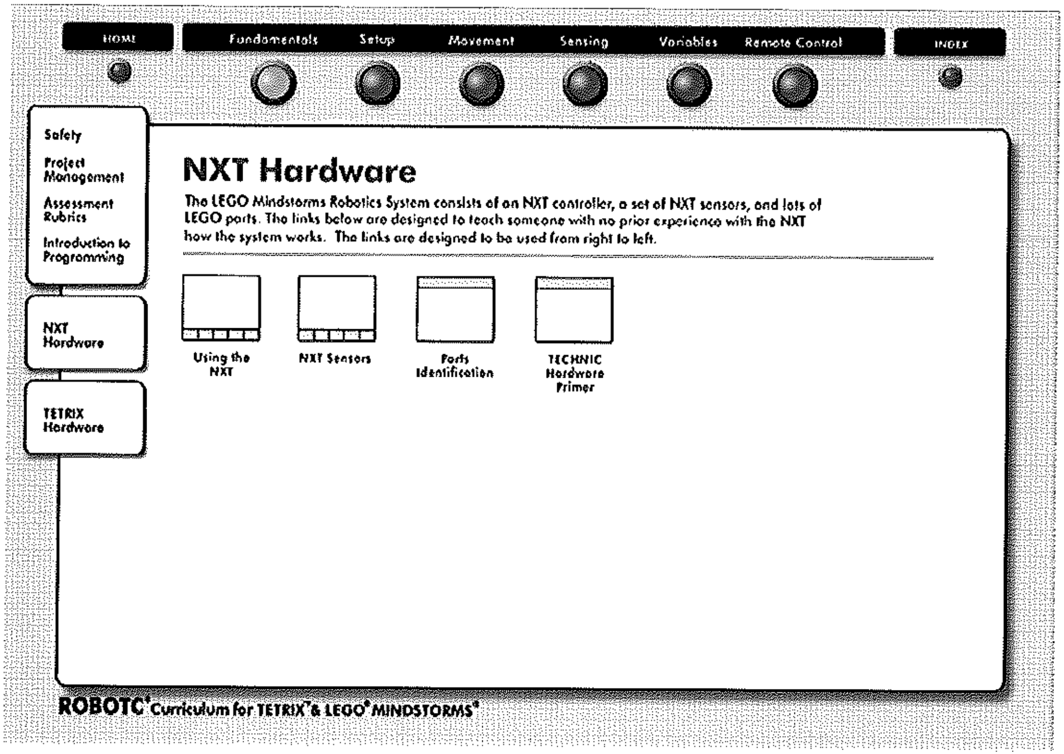








Getting Started/Fundamentals/NXT Hardware

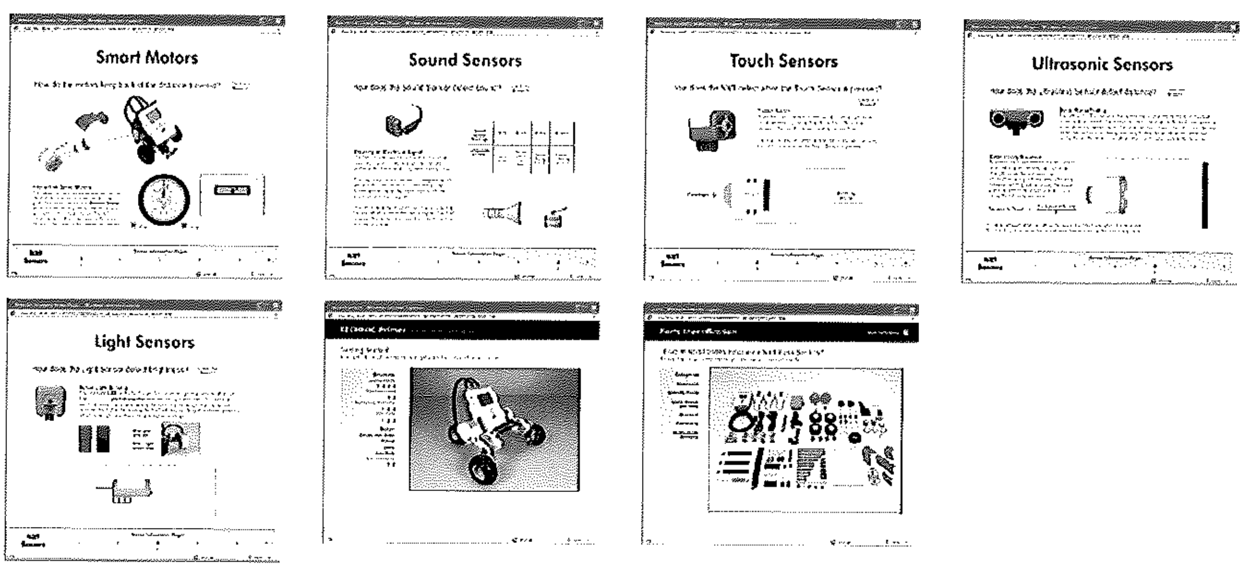


NXT Hardware

NXT Sensors Slide Show - The Sensors Slide Shows introduce new learners to the MINDSTORM sensors that are part of the base set: the smart motors, touch, light, ultrasonic and sound sensors. Students will learn how they work and what type of feedback they record.

NXT Parts Identification - Graphically introduces students to the parts and how they work.

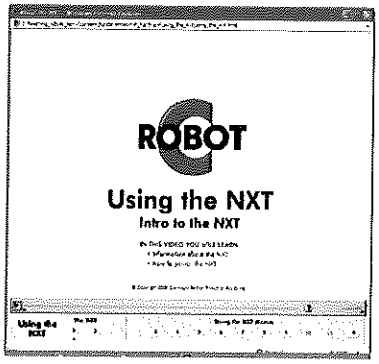
TECHNIC Hardware Primer- The TECHNIC hardware primer is designed to show students how LEGO TECHNIC parts can be used to build subassemblies that they can use in their robot designs.

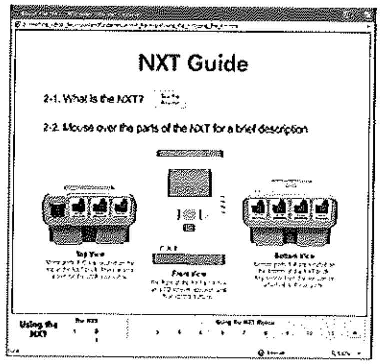


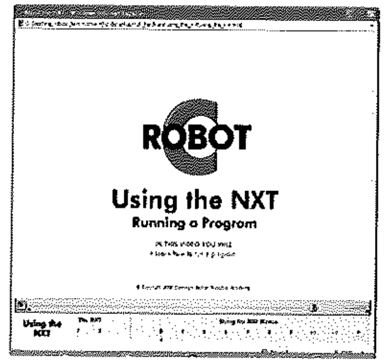
Getting Started/Fundamentals/NXT Hardware

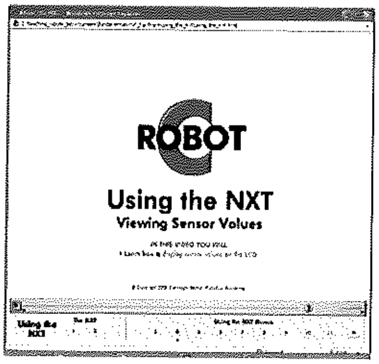
NXT Hardware

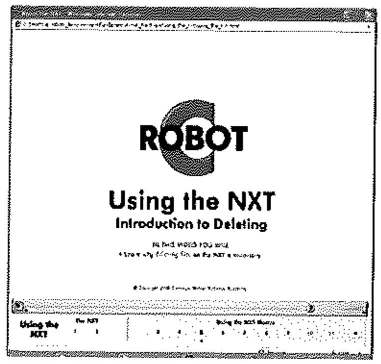
Using the NXT Slide Show - Assumes that the user has never used an NXT. There are 11 sections of the slide show that include: Introduction to the NXT, NXT Guide, Running a Program, Viewing Sensor Values, Introduction to Deleting, Deleting Programs 1, 2 & 3, Returning to the Main Menu, Changing the Volume, and Turning Off the NXT. This resource is a very valuable teaching tool for students just beginning to use the NXT.

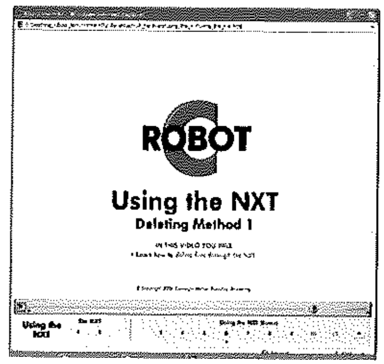


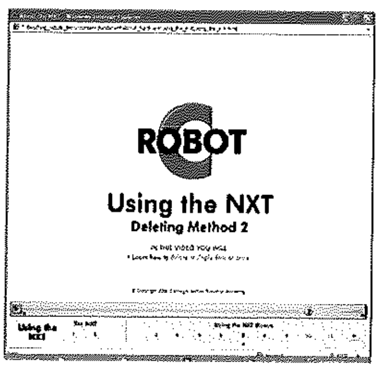


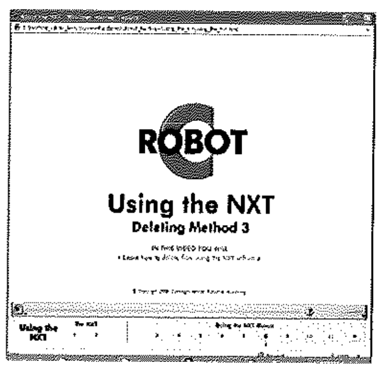


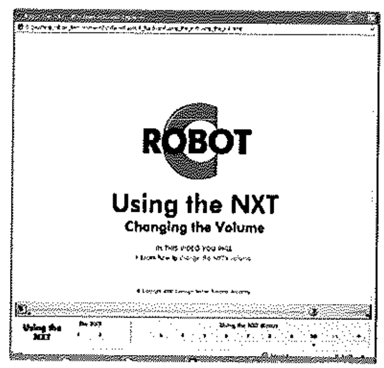


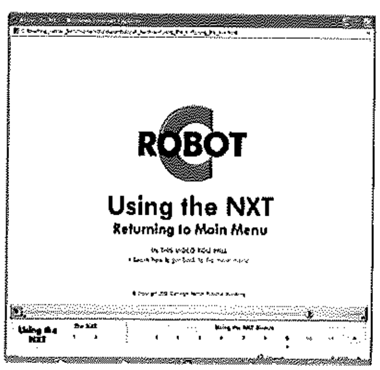


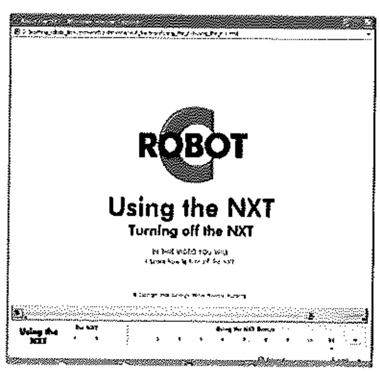




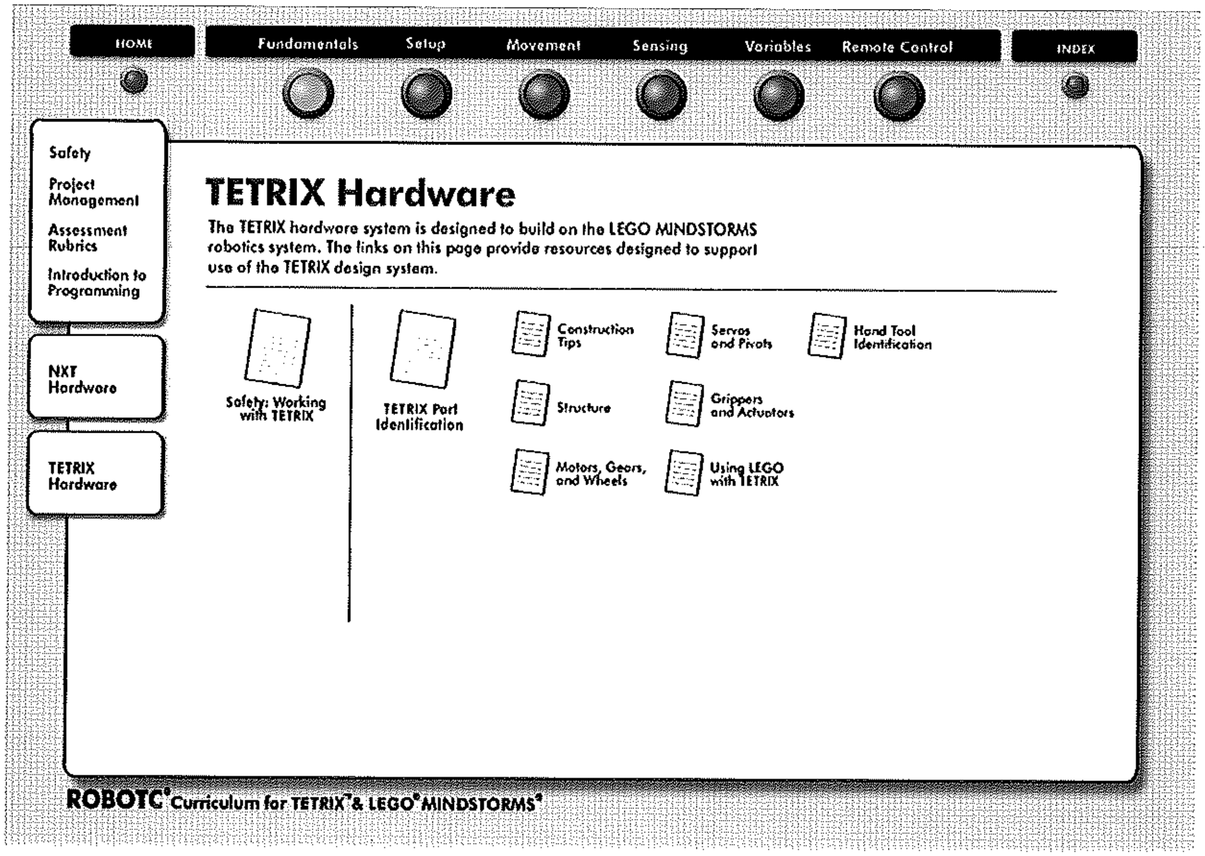








Getting Started/Fundamentals/TETRIX Hardware



TETRIX Hardware PDFs

Safety Working with TETRIX - This three page PDF pictorially shows PITSCO-recommended safe methods of working with TETRIX hardware. This PDF will serve as a great review of safety when beginning to work with the TETRIX system.

TETRIX Part Identification - This five page PDF depicts all of the TETRIX parts along with their names. If students are having trouble identifying part names, this is the place to look.

TETRIX Construction Tips - This six page PDF contains a compilation of best practices for assembly of the TETRIX parts. The high resolution pictures with descriptions are designed to show best practices in TETRIX construction and also to stimulate student creativity.

Building Structures with TETRIX - This six page PDF shows how subassemblies can be made to create larger structures using the TETRIX building systems.

Motors, Gears, and Wheels - This six page PDF covers how to properly mount motors, motor safety, motor direct drive solutions, motor indirect drive solutions, how to assemble driven wheel systems, and the Omni Directional Wheel.

Servos and Pivots - This eight page PDF covers the servo's range of motion, and shows examples of a single servo mount, a single servo mount with a pivot, a double servo mount, a double servo mount with a pivot, as well as examples of pivot structural elements.

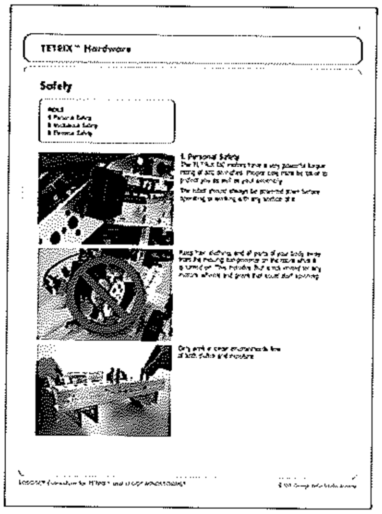
Grippers and Actuators - This seven page PDF illustrates multiple grippers that can be made using the TETRIX system.

Merging TECHNIC and TETRIX - This four page PDF shows how to use the Hard Point connectors, and how to attach Hard Point Connectors, the NXT, HiTechnic Controllers, and NXT Sensors.

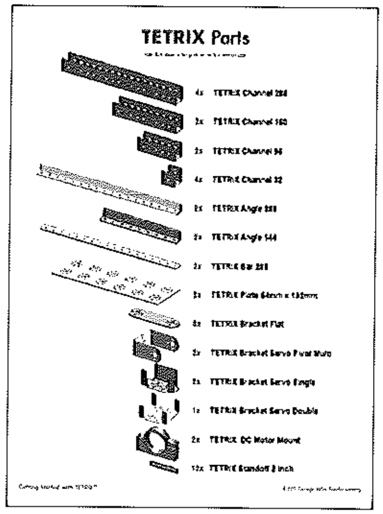
Hand Tool Identification Page - A one page handout that shows pictures of common tools with their names.

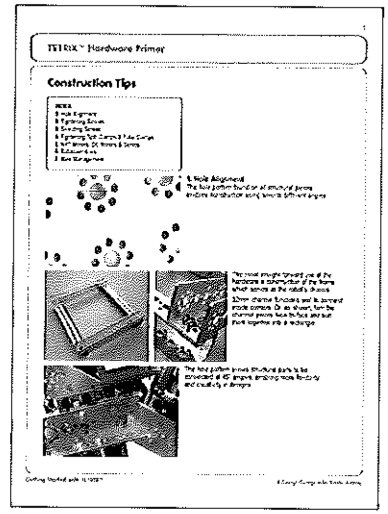
Getting Started/Fundamentals/TETRIX Hardware

TETRIX Hardware PDFs

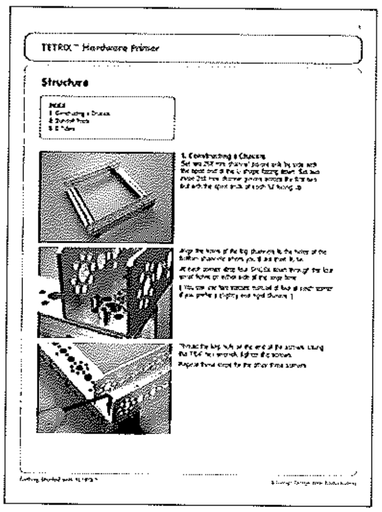

TETRIX™ Hardware

Safety

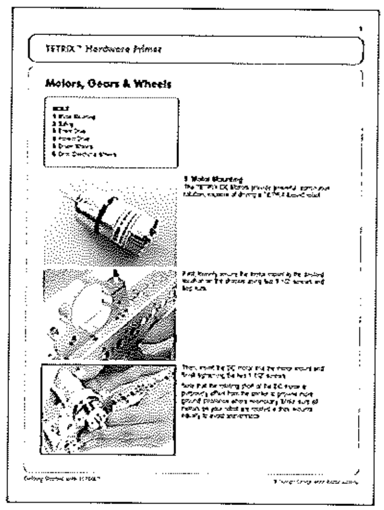

TETRIX Parts


TETRIX™ Hardware Primer

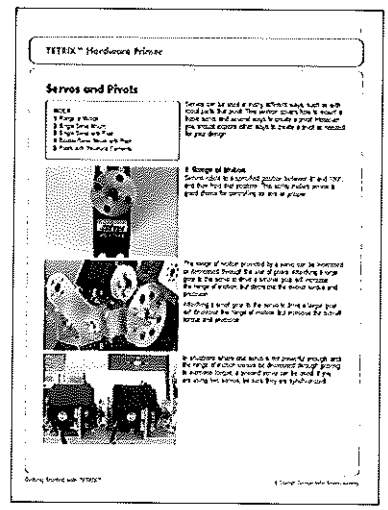
Construction Tips


TETRIX™ Hardware Primer

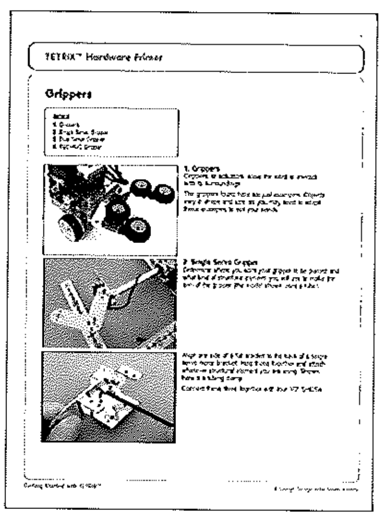
Structure


TETRIX™ Hardware Primer

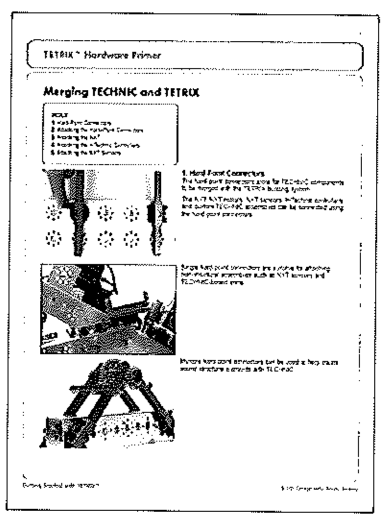
Motors, Gears & Wheels


TETRIX™ Hardware Primer

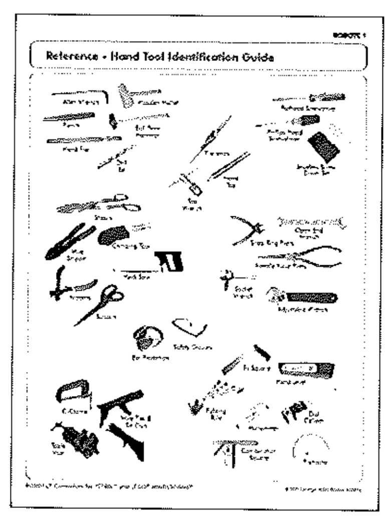
Servos and Pivots


TETRIX™ Hardware Primer

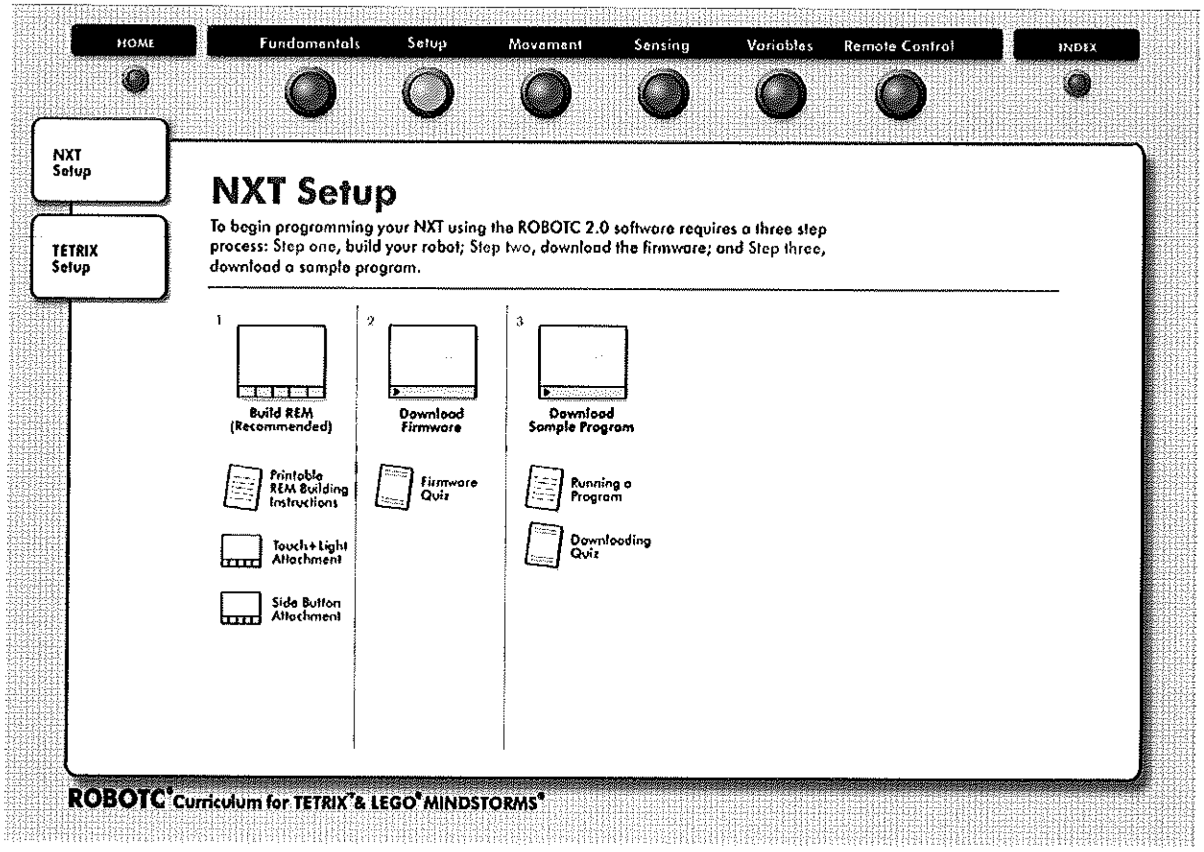
Grippers


TETRIX™ Hardware Primer

Merging TECHNIC and TETRIX


Reference - Hand Tool Identification Guide

Getting Started/Setup/NXT Setup

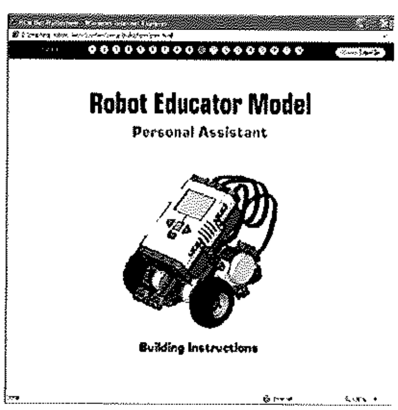


NXT Setup Page

Build the REM Robot - All of the ROBOTC for MINDSTORMS lessons use the "Robot Educator Model" plus attachments. This page provides building instructions in both a printable and digital format.

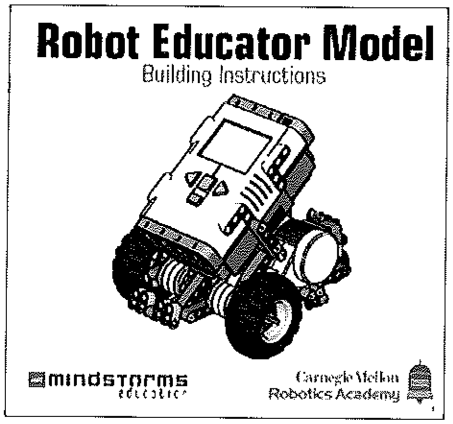
Download Firmware Video and Quiz - Students will learn what firmware is and how to download it to their robots. There is also a quiz designed to check student understanding.

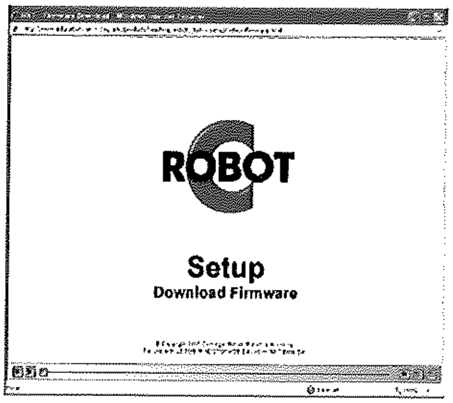
Download Sample Program and Quiz- Students will learn to download their first ROBOTC program and test it on their NXT. The lesson also includes a PDF helper page as well as a quiz designed to check student understanding.

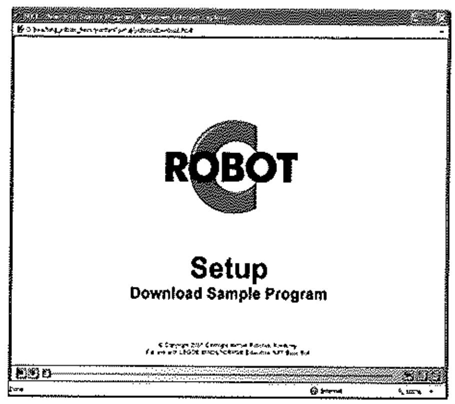


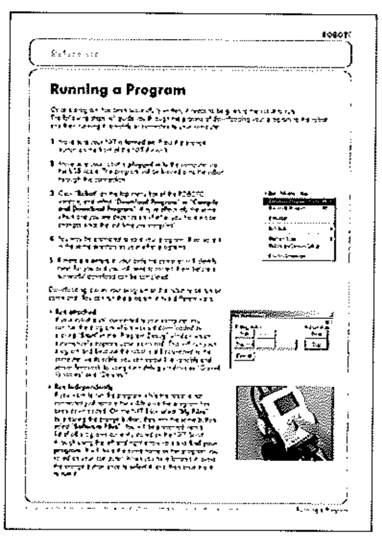
Getting Started/Setup/NXT Setup continued

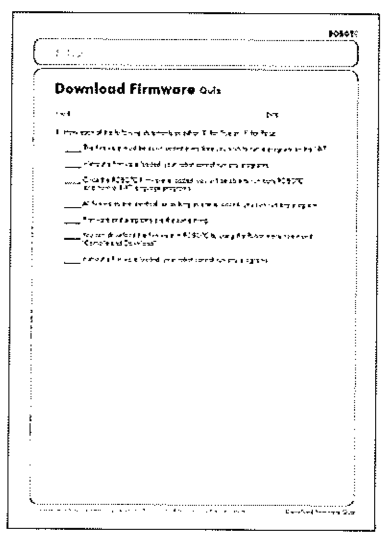
NXT Setup Page Resources Continued

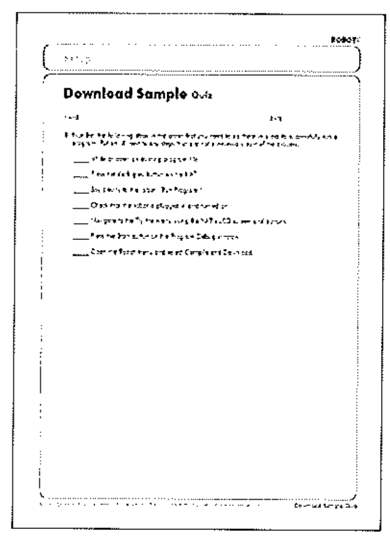




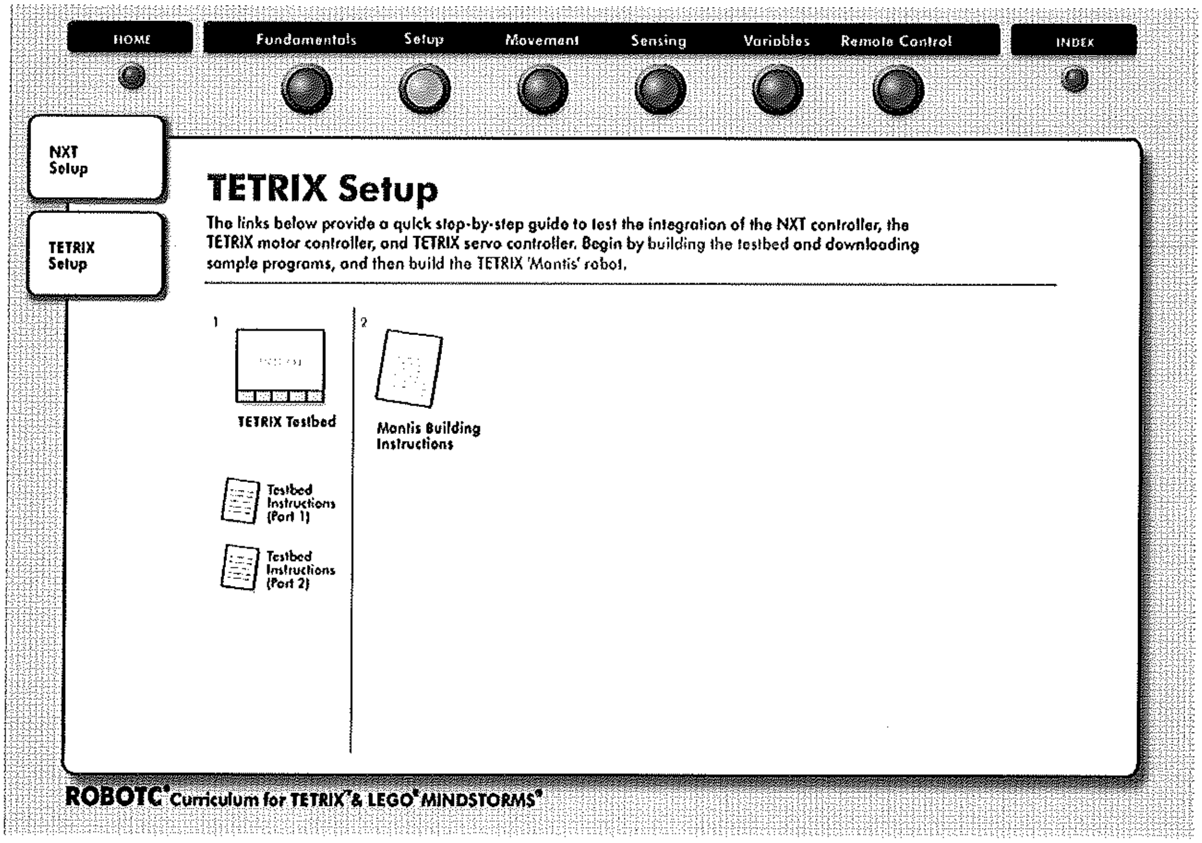



Running a Program


Download Firmware Quiz


Download Sample Quiz

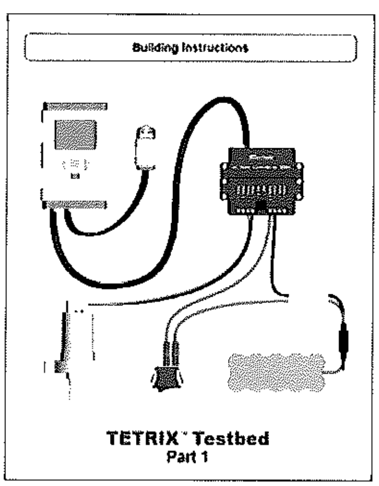
Getting Started/Setup/TETRIX Setup

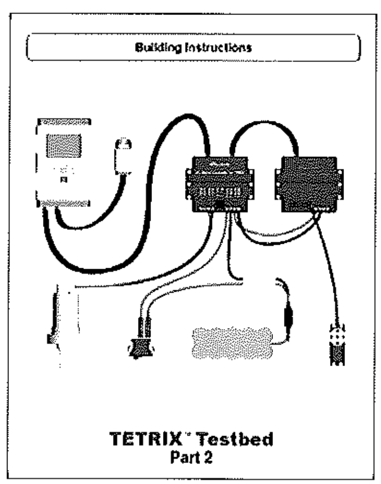


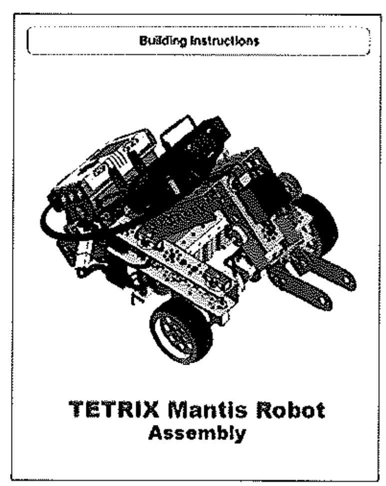
TETRIX Setup Page

TETRIX Testbed Video Instructions - Students are led step-by-step as they build their first working TETRIX system. We recommend that students build and test their TETRIX testbed ***before*** they connect the system to their robot. It will make electronic troubleshooting much easier. The lesson is designed as a two part lesson: first, connect the motor controller and test that system; second, connect the servo controller and test the combined system. The lesson is available as a printable PDF or as a video slide show with voice over and animations.

TETRIX Mantis Robot Building Instructions - The Mantis building instructions allow students to build their first TETRIX robot from a set of plans.



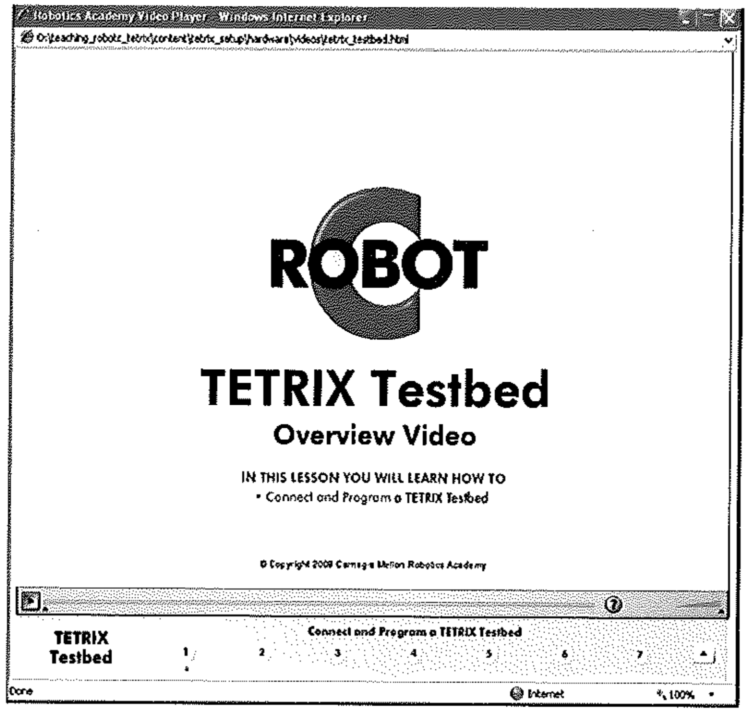




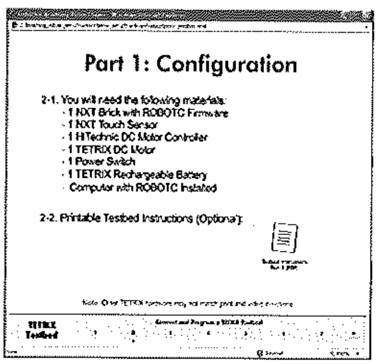
Getting Started/Setup/TETRIX Setup continued

TETRIX Setup Resources

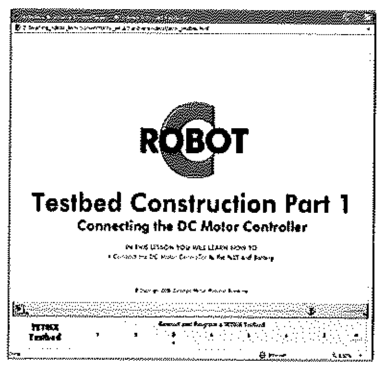
TETRIX Testbed Video Instructions -
The video instruction for the testbed is embedded into this seven step player. The player is designed to give step-by-step student instruction. Students will find a "check your understanding" section included at the end of each video segment.



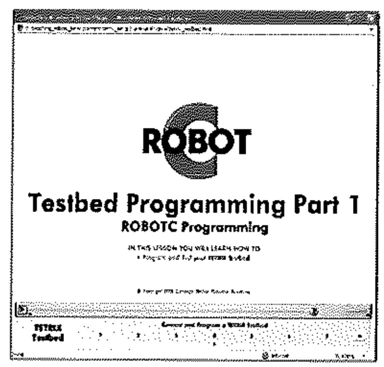
Part One



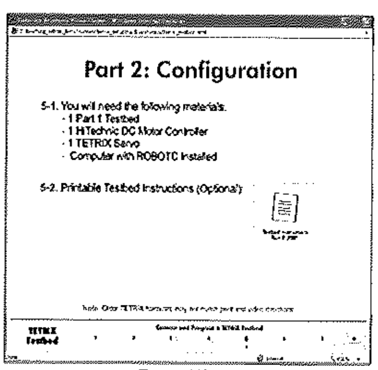
Part Two



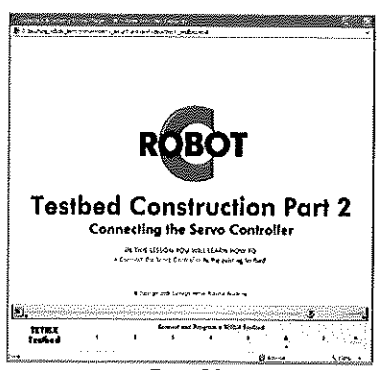
Part Three



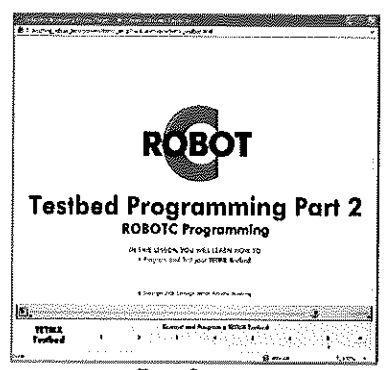
Part Four



Part Five

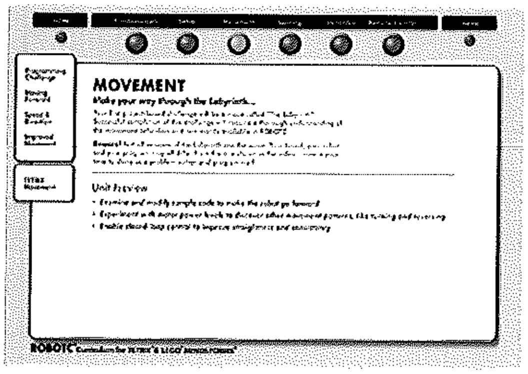


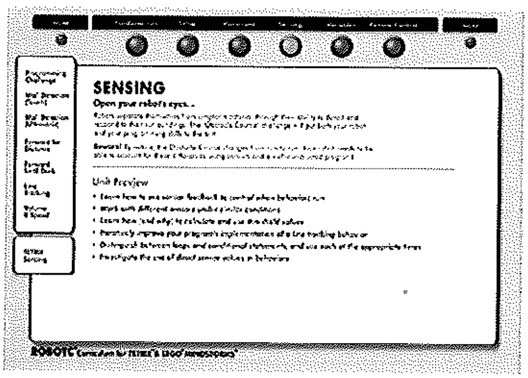
Part Six

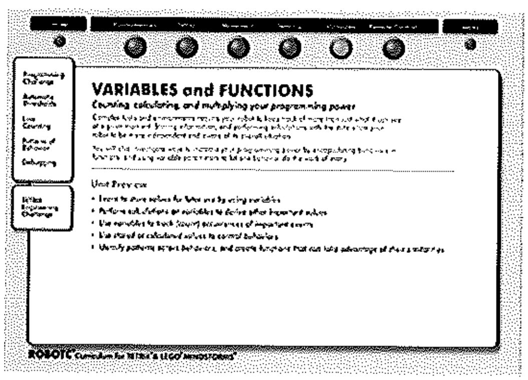


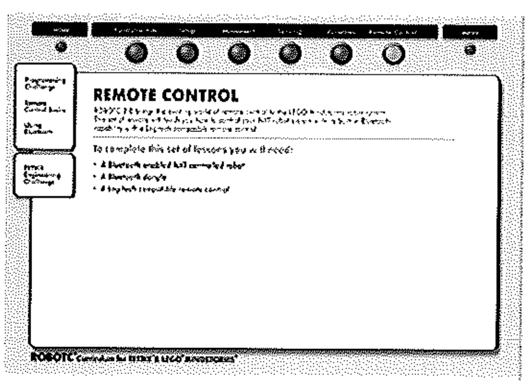
Part Seven

Introduction to Programming... Introduction to Engineering







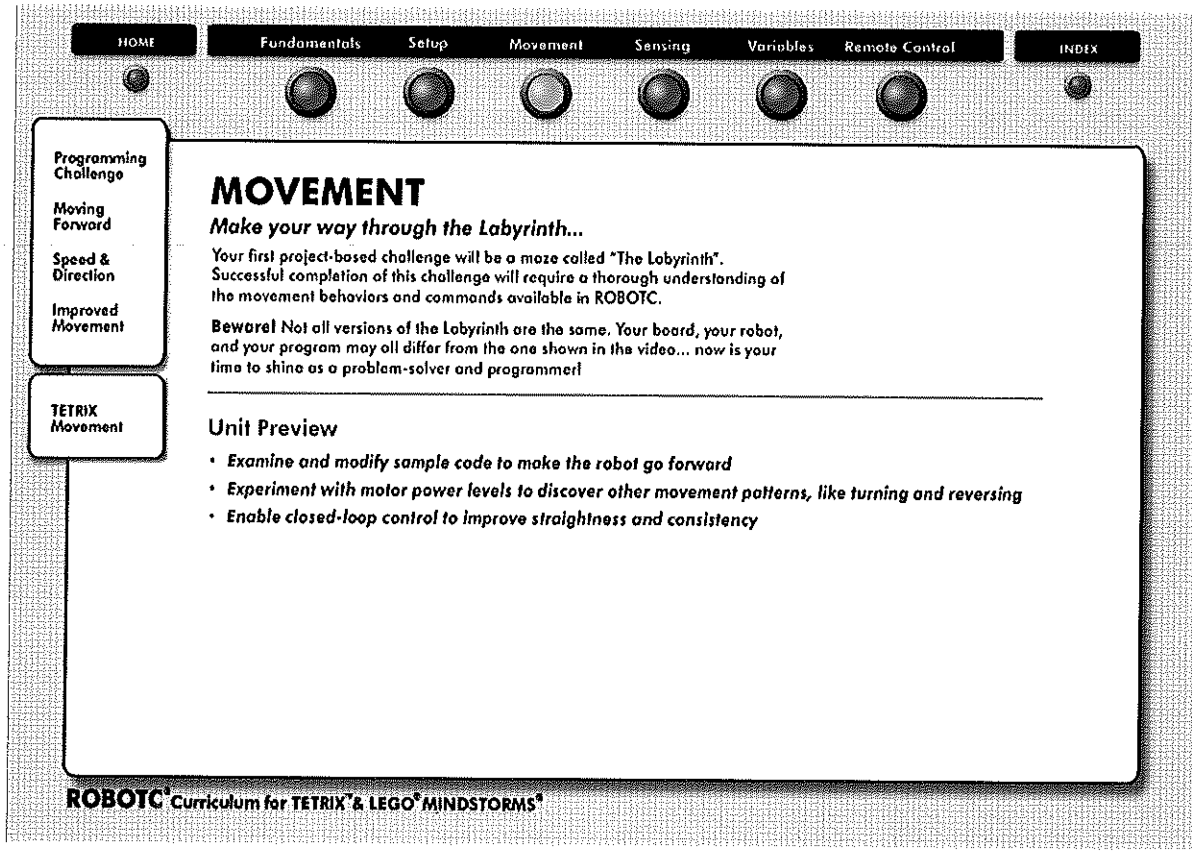


Note: The curriculum is designed so that students complete the NXT lessons before they complete the TETRIX lessons.

The Introduction to Programming Curriculum is divided into four instructional units: Movement, Sensing, Variables and Functions, and Remote Control. Each unit contains a number of Lesson Sets designed to teach a particular concept. Each unit is organized around a "Unit Programming Challenge". The solution for the Unit Programming Challenge is taught as students move through the individual Lesson Sets.

The student will find other exercises designed to reinforce their programming skills or designed to give them a deeper understanding of the NXT or TETRIX hardware. At the end of the Variables Unit there is a TETRIX Engineering Challenge called the TETRIX Robot Mining Challenge. This challenge can be solved using either the TETRIX or the NXT hardware. This challenge is designed to be solved by an engineering team and will require several weeks for students to adequately solve.

Introduction to Programming/Movement/Programming Challenge



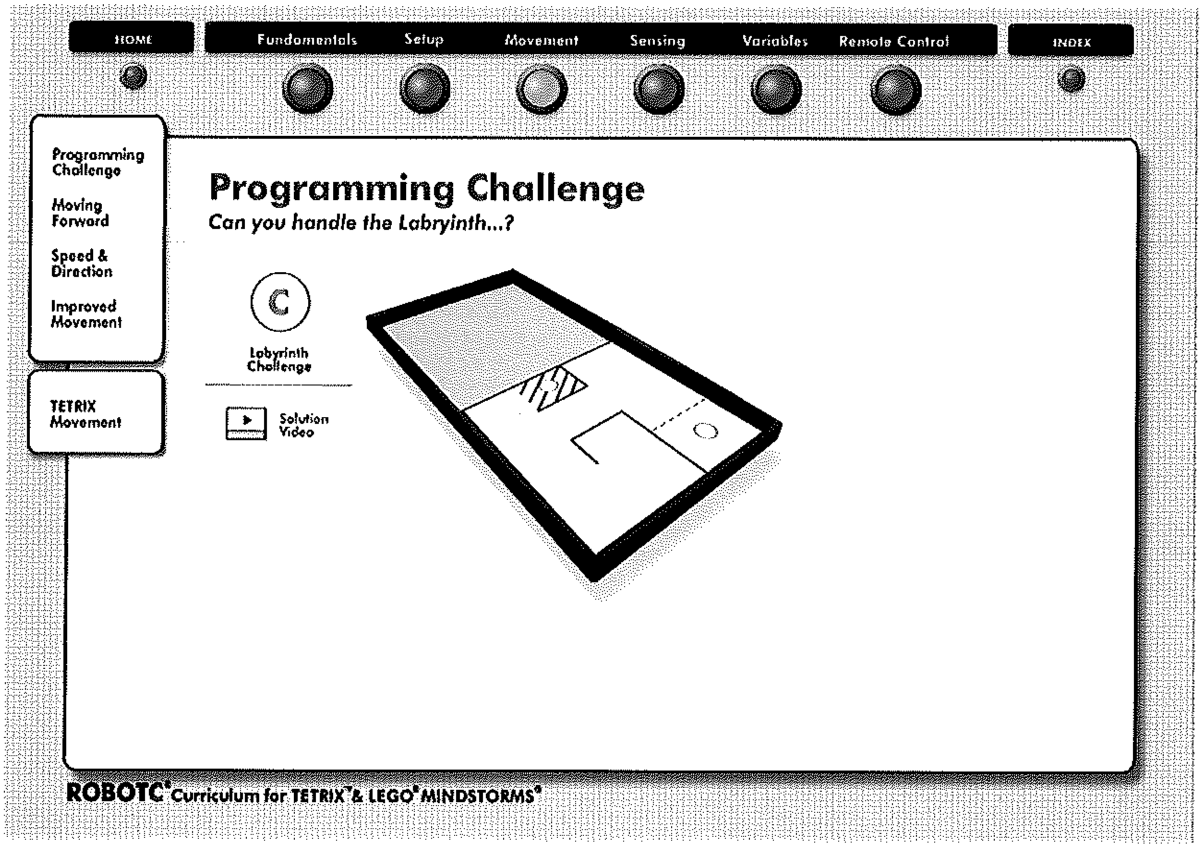
The Movement Unit

The Movement Unit is taught using three Lesson Sets and a programming challenge. The Lesson Sets begin using sample code that is already included in ROBOTC. The first Lesson Set, Moving Forward, teaches students in a very lockstep manner what each line of code does while introducing them to moving motors for specific amounts of time. The second Lesson Set, Speed and Direction, explains motor power levels and how to reverse polarity. The second Lesson Set includes several "engineering labs" that the students will complete. The engineering labs place students in the role of engineer where they run their robots, measure results, iteratively test the results to determine reliability, and then extrapolate from their data set to predict new robot behaviors. The third Lesson Set, Improved Movement, begins to teach very important lessons about PID control, motor synchronization, and setting motor targets.

The Movement Unit also includes several programming challenges where students are challenged to solve simple movement programming challenges.

It will be important to remind students that although the initial work may seam easy, that the skills that they learn in the movement unit are foundational pieces that they must understand before they move to the sensing unit.

Introduction to Programming/Movement/Programming Challenge



Labyrinth Programming Challenge

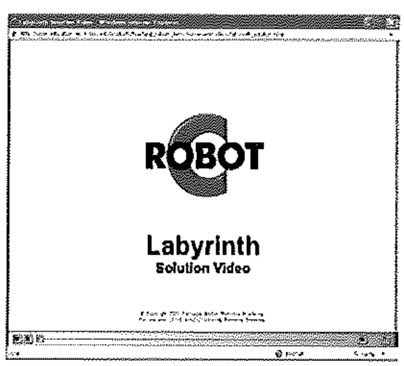
Each Programming Unit (Movement, Sensing, Variables and Remote Control) contains a programming challenge that is designed to place the learning into an interesting context. In the "Movement" Lesson Set the programming challenge is the "Labyrinth Challenge".

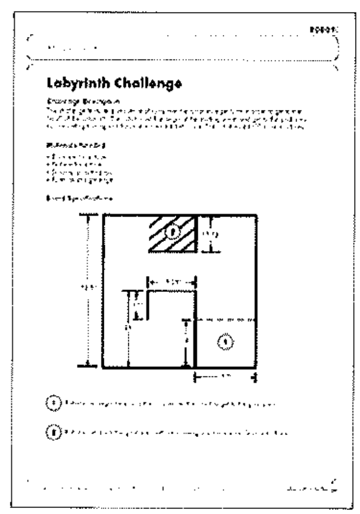
In this challenge, students will learn:

- Behavior based programming logic
- How to program their robots to accurately move forward, backward and turn
- The syntax rules related to programming using ROBOTC

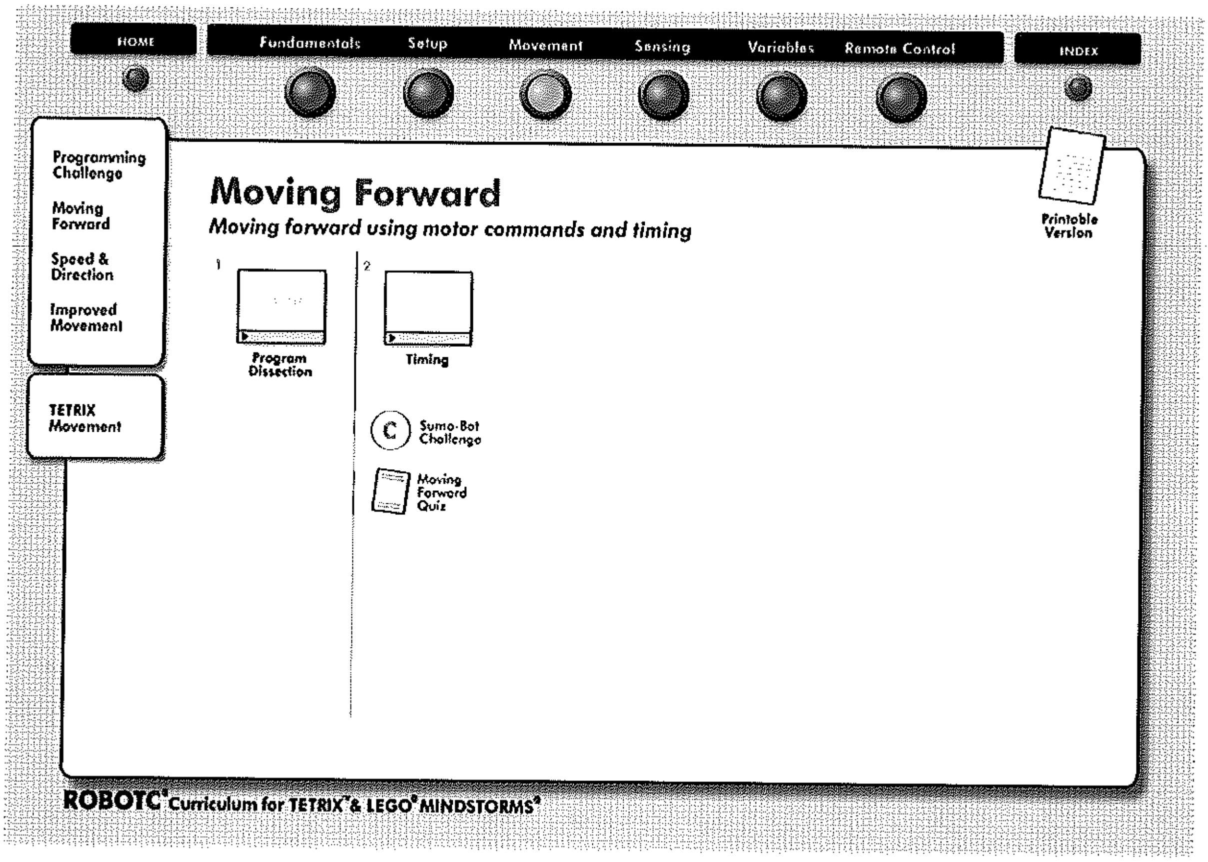
Labyrinth Challenge Teacher Resources

Each programming challenge comes with a PDF that explains the rules to the challenge as well as a video solution. These Labyrinth challenge resources are pictured on the left.





Introduction to Programming/Movement/Moving Forward



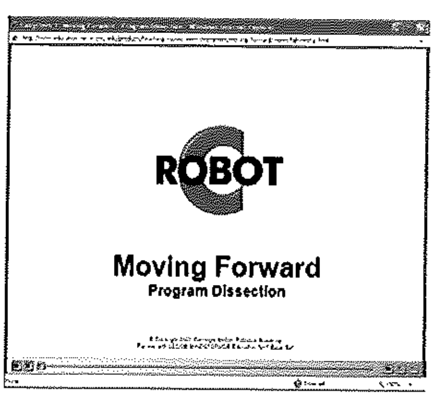
The Moving Forward Lesson Set

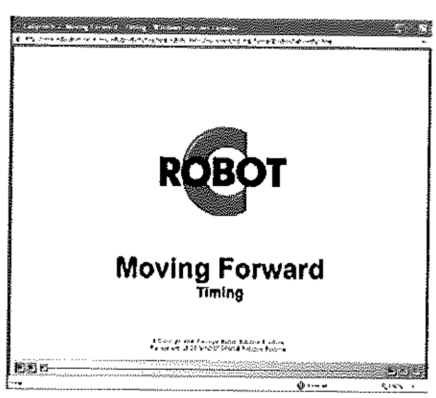
Each Lesson Set is designed to teach a related set of programming concepts, and is designed to give students confidence opening a program and understanding what the individual lines of code mean. Every set is supported with the following video and print resources:

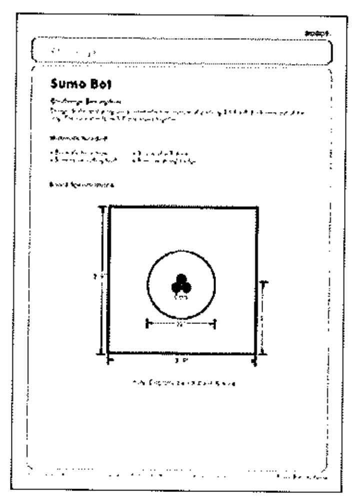
Program Dissection Video - Students are given a line by line description of the code used in the first sample program.

Timing Video - Timing offers the least accurate way of programming a robot to move from point to point. It is also the simplest method of programming. Students are introduced to wait-states.

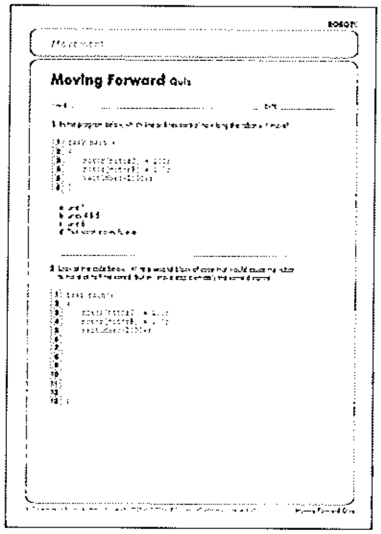
Sumo-Bot Challenge - This fun challenge involves developing a programming/mechanical solution to push as many cans as possible out of a ring.

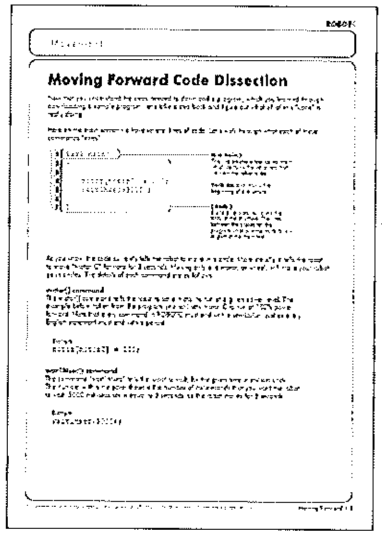






Introduction to Programming/Movement/Moving Forward continued


Moving Forward Quiz


Moving Forward Code Dissection

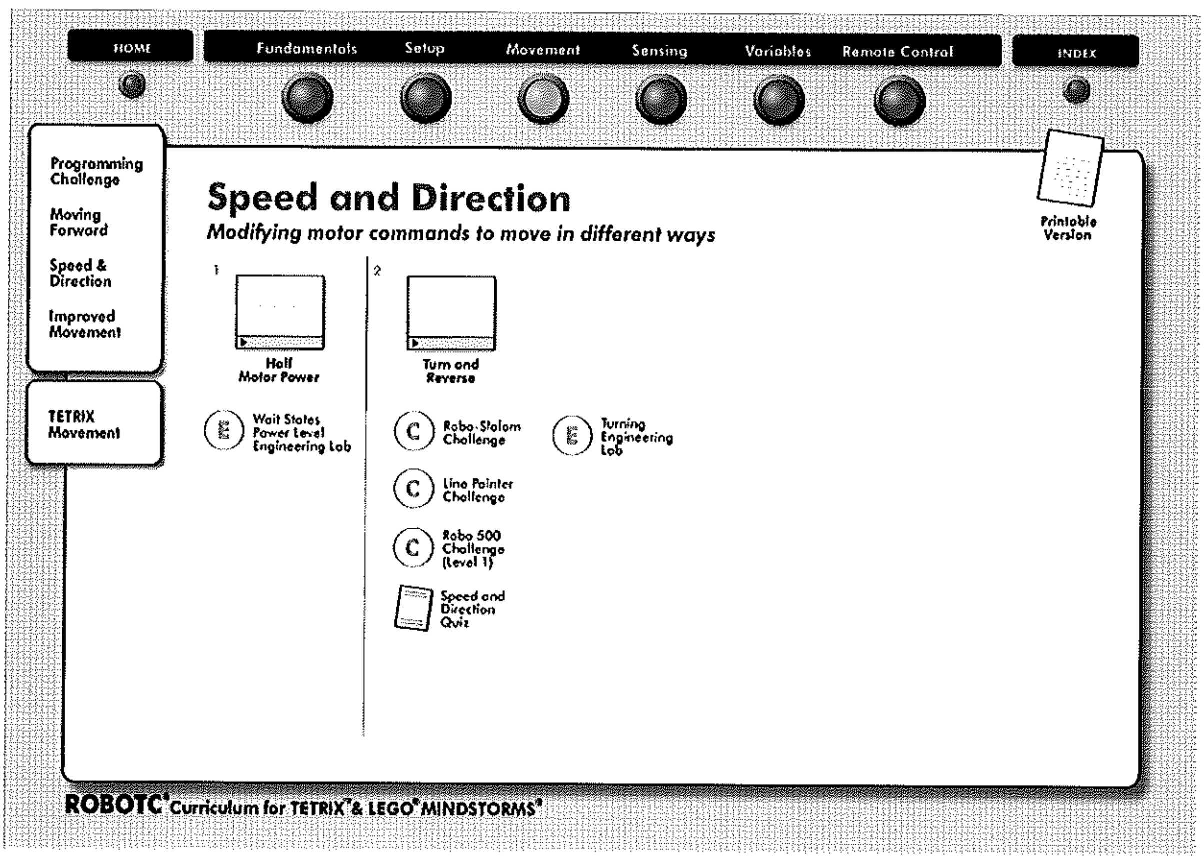
Additional Moving Forward Lesson Set Resources

Pictured at the left are two additional resources that accompany the Moving Forward Lesson Set.

The Moving Forward Quiz

The Moving Forward PDF - Each set of videos is accompanied by a PDF version of the script. The PDF version includes lots of pictures and text to describe everything that is shown in the videos. The PDF can be used either to accompany the video instruction or as a study guide.

Introduction to Programming/Movement/Speed and Direction



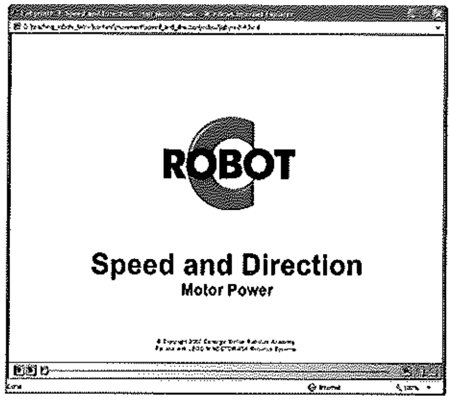
The Speed and Direction Lesson Set

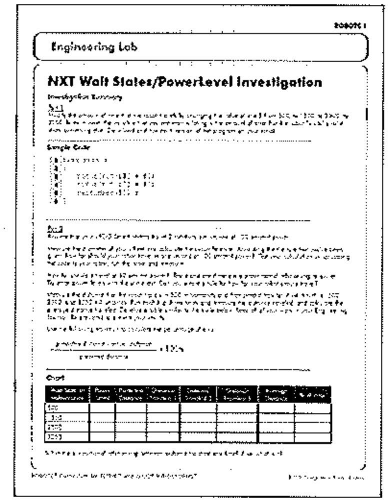
The Speed and Direction Lesson Set consists of two video lessons, two engineering challenges, three open-ended programming challenges, and a quiz. The resources are shown and explained in on the next page.

Introduction to Programming/Movement/Speed and Direction cont.

Motor Power Lesson

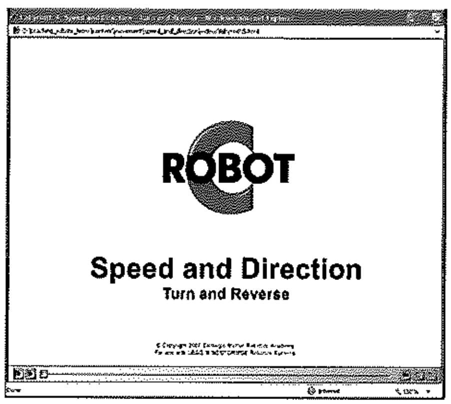
The first video lesson, Motor Power, teaches students how to change the power level on the robot. Students learn that as they change the power level, they are in effect changing the robot's speed. They will also complete an Engineering Lab named "NXT Wait States/Power Level Investigation". In this investigation, students program their robots at a variety of power levels and keep the amount of time the robot runs constant. In the investigation students identify if there is a proportional relationship between power levels and speed.

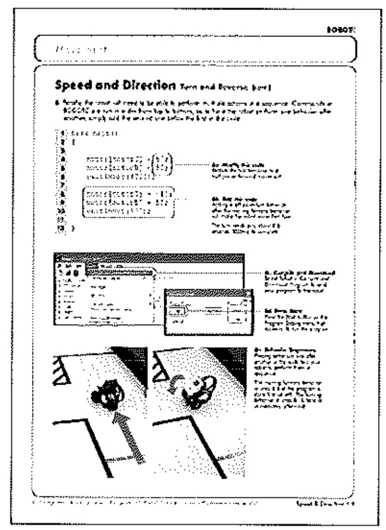


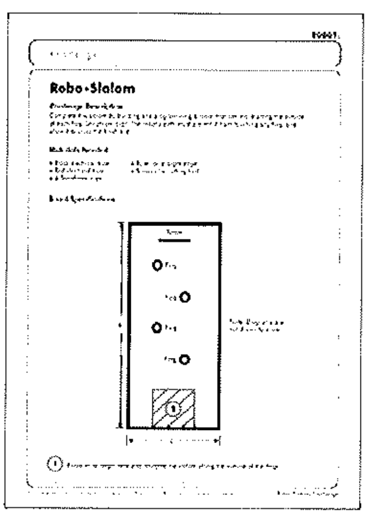


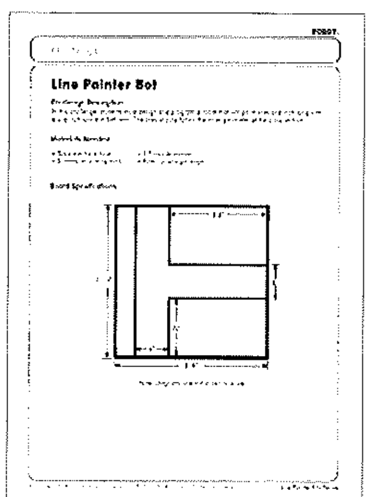
Turn and Reverse Lesson

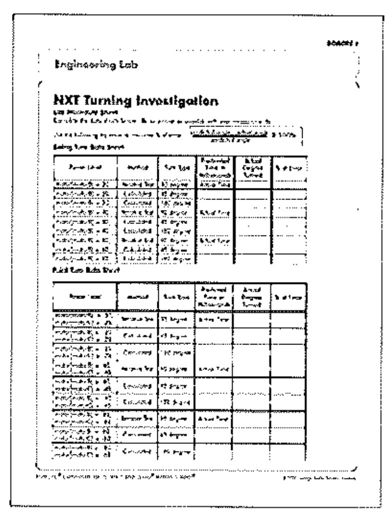
In the "Turn and Reverse" lesson, students learn about polarity. The Lesson Set includes a 10 page PDF, shown at the right, designed to complement the videos. It also includes 3 open ended programming challenges. Two of the programming challenges are shown below: Robo-Slolom and Line Painter Bot. Students complete the lesson with an Engineering Challenge, where they are asked to iteratively test robot turns given a specific power level and a target angle and then use that data to predict what the "wait state" will be to complete other turns.



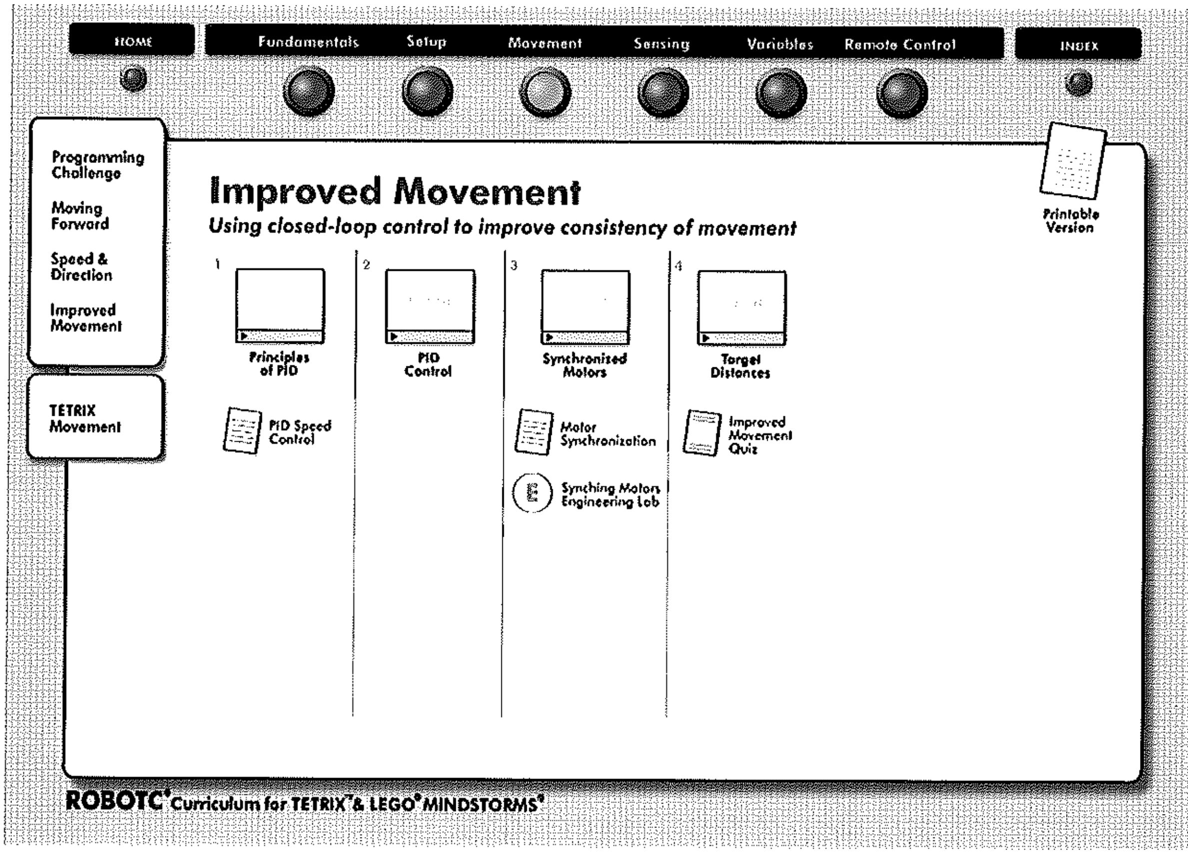








Introduction to Programming/Movement/Improved Movement



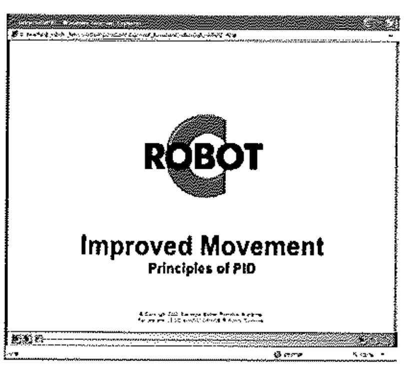
Improved Movement Lesson Set

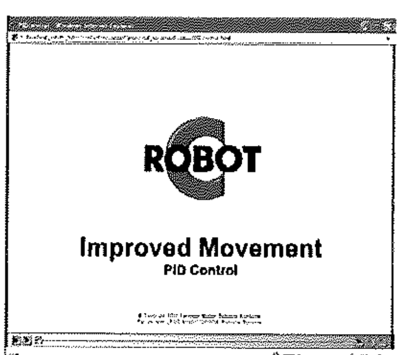
The first half of the Improved Movement Lesson Set teaches students about PID speed control as well as how to us the Motor and Sensor Setup Window, the Debug Windows, and the NXT Devices window. The following resources are available to teach PID control:

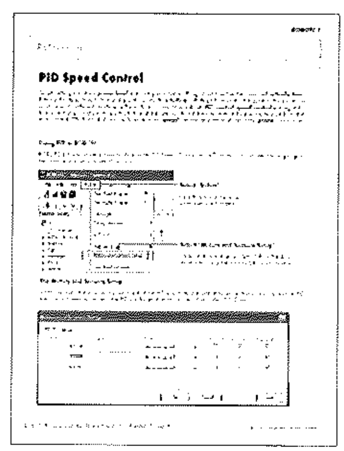
The Principles of PID Video - This video teaches students what PID (Proportional Integral Derivatives) is and how it uses a closed loop control system to regulate speed control.

The PID Control Video - This video teaches students how to use ROBOTC's debugger to see the NXT's speed regulation. Students will use the debugger windows to watch the internal feedback mechanisms built into the system.

PID Speed Control Reference Page - This two page handout explains PID, and shows how to monitor PID using ROBOTC's debugging window.



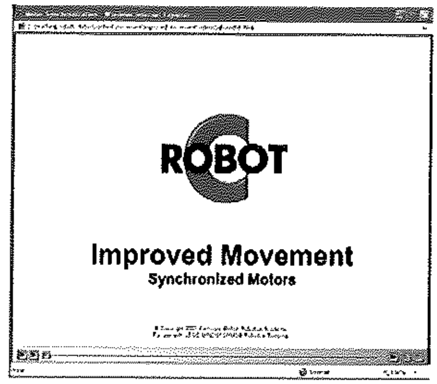




Introduction to Programming/Movement/Improved Movement cont.

Synchronized Motors Lesson Set

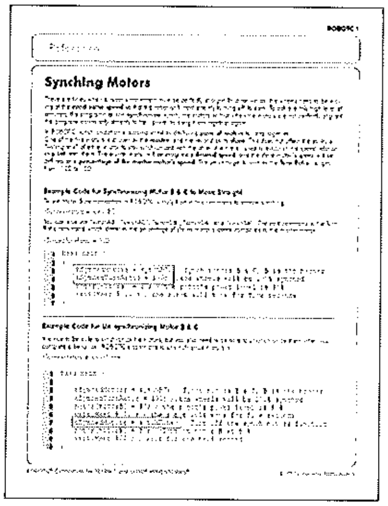
ROBOTC enables the programmer to synchronize the robot's wheel movements. The Lesson Set contains the following resources:

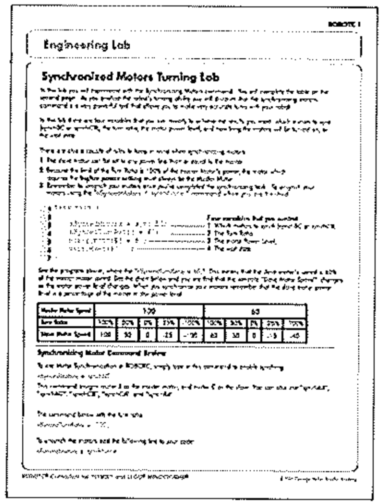


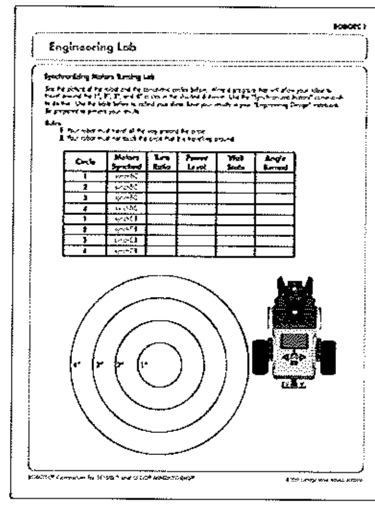
Synchronized Motors Video - Teaches students how to use ROBOTC reserved words to control their robots.

Synchronized Motor Reference Page - Can be used as a handout for a study guide or as a reference page.

Synchronized Motors Engineering Lab - Students perform a set of iterative experiments where they test robot performance and collect data designed to promote understanding of robot synchronization.





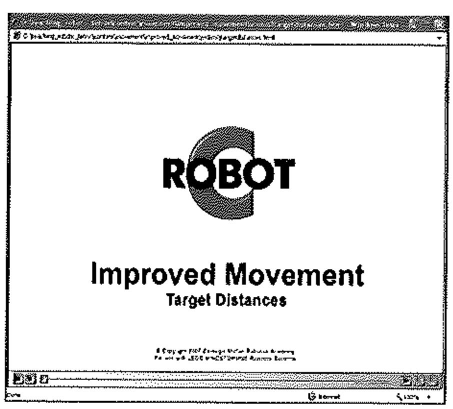


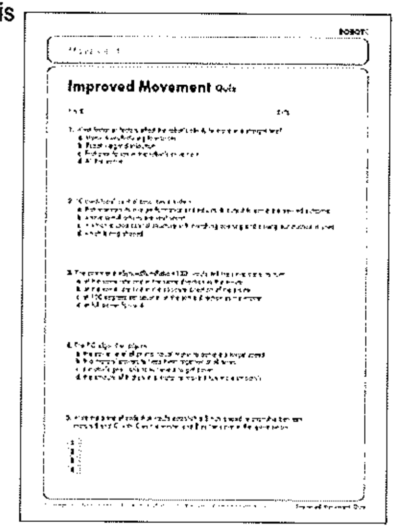
nMotorEncoder Command and Target Distances Lesson Set

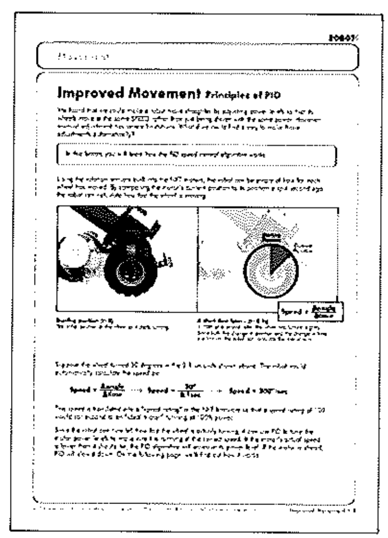
Encoders are used by the robot to count how many times a wheel on the robot turns. Students are introduced to encoders in this lesson allowing them to achieve better control of their robot.

The Target Distance Video - Teaches students how encoders work and gives them a naive understanding of the nMotorEncoderTarget function.

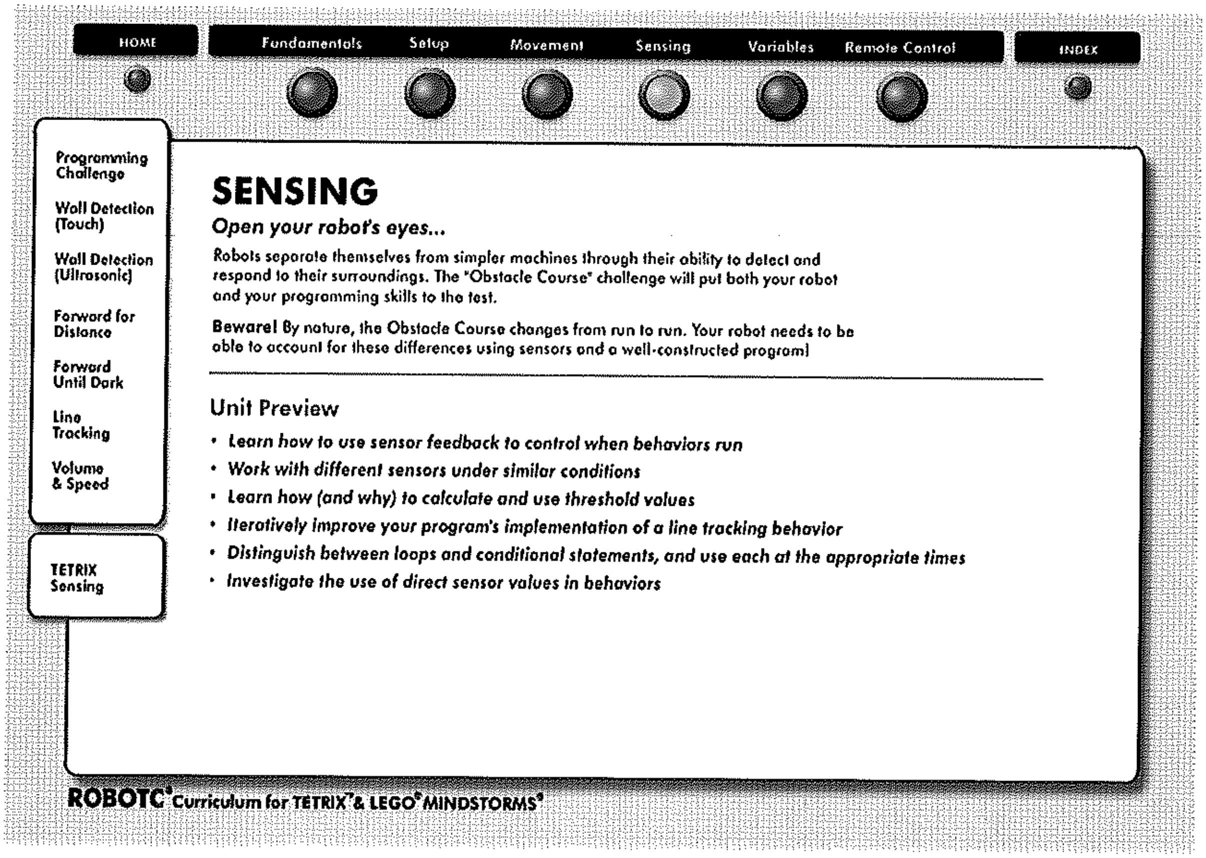
Improved Movement Lesson Set PDF - This PDF complements the videos used to teach the Improved Movement Lesson Set.







Introduction to Programming/Sensing

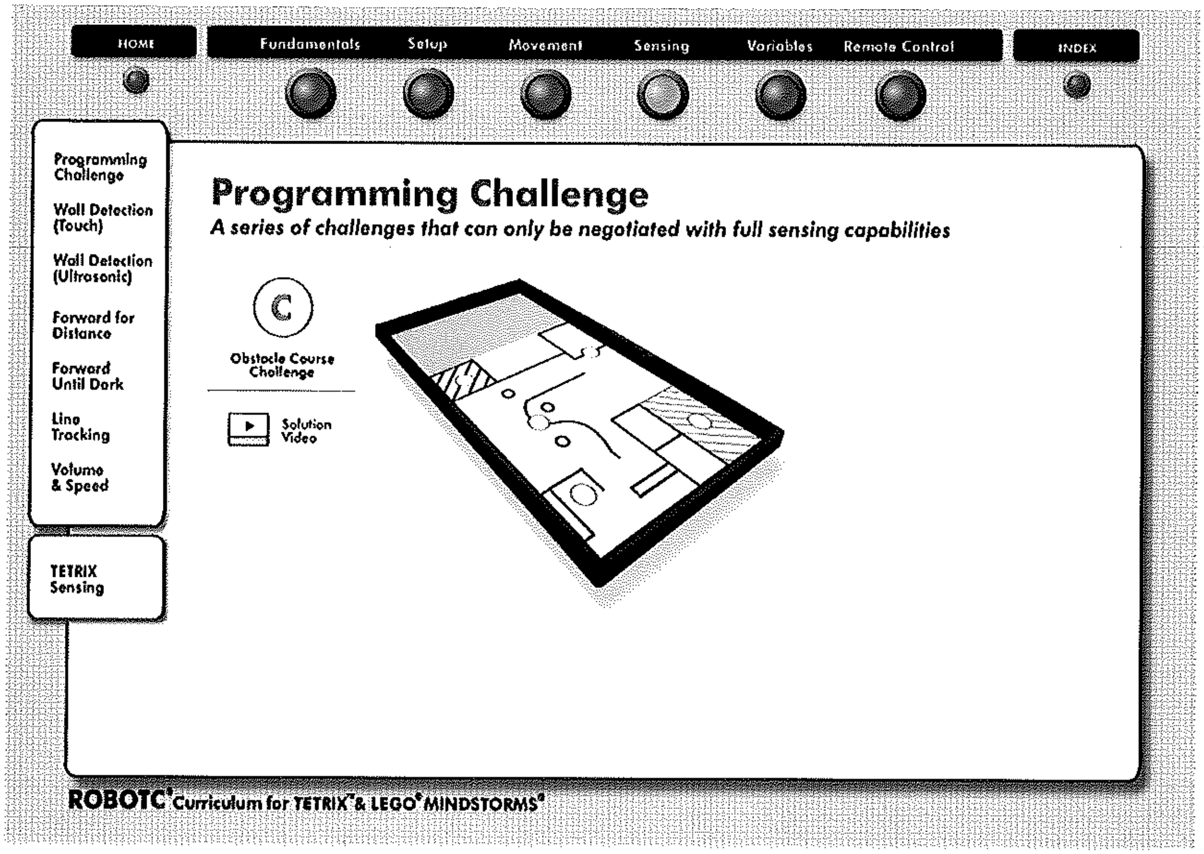


Sensing

The Sensing Unit consists of six Lesson Sets for the NXT and one Lesson Set for TETRIX. Everything that a student learns about programming sensors for the NXT systems can be applied to the TETRIX system.

The lessons are designed to be taught in a sequential order from top to bottom. The lessons start with the touch sensor because of its simplicity, then move to the ultrasonic and sound sensors. If students skip one of the Lesson Sets, then they run the risk of missing a programming concept that was taught in a prior lesson. Do the lessons in sequence.

Introduction to Programming/Sensing/Programming Challenge

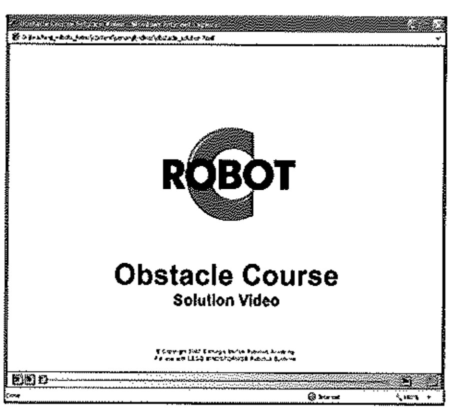


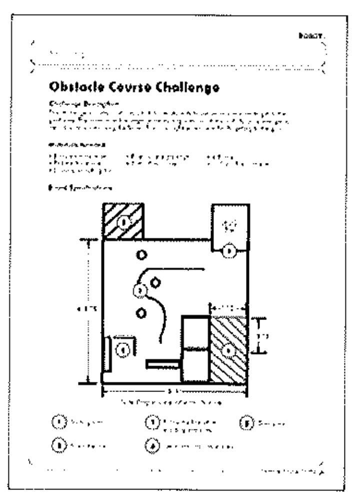
The Obstacle Course Programming Challenge

Students are required to use feedback from all sensors to complete the obstacle course. There is more than one way to solve this programming challenge, and individual students will develop their own programming style. For beginners, it will be important for the teacher to reinforce breaking robot behaviors down into their simplest parts.

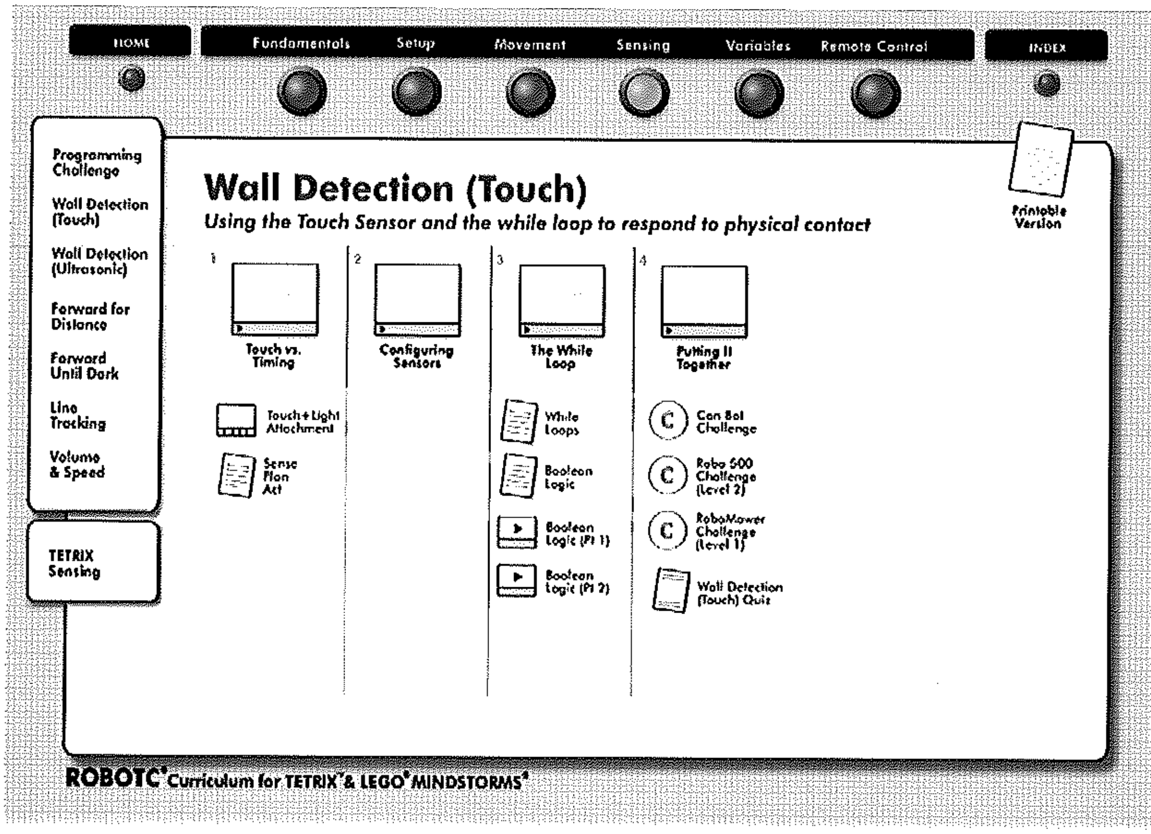
The Obstacle Course Video - Shows a video solution to the programming challenge.

The Obstacle Course Handout - PDF that describes the challenge in terms of robot behaviors.





Introduction to Programming/Sensing/Touch Sensor



Sensing - Touch Sensor

The Wall Detection Lesson Set provides a comprehensive set of materials designed to introduce students to sensors. Students begin to solve the obstacle course by learning how a touch sensor works, how to configure the touch sensor using the motors and sensors setup windows, how to name sensors, and how to build a new program from scratch. As they learn about touch sensors, they will also learn about while loops, structures, boolean logic, conditional statements, ROBOTC reserved words, and how to use ROBOTC's built-in debugger windows to see sensor feedback values. Students will have access to the following video and print resources:

The Touch Versus Timing Video - This video introduces the touch sensor and explains how it will be used to help solve the obstacle course challenge.

The Configuring Sensors Video - This video shows students how to configure sensors using ROBOTC's Motors and Sensors Configuration Menu. It also shows students how to use the debugger screens to see sensor feedback.

The While Loop Video - Teaches students about conditional statements and how they control the while loop structure.

The Putting It All Together Video - This video is a step-by-step tutorial that begins with a blank program, then builds a program starting with configuring the sensors through setting up conditional statements and controlling motors.

Touch and Light Sensor Attachment - Instructional slide show that shows how to connect the sensor to the robot.

Sense Plan Act Reference Page - One page handout that describes the Sense-Plan-Act algorithm.

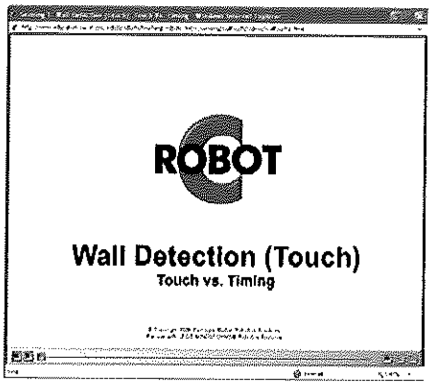
While Loop Reference Page - One page handout that describes the "while loop" structure.

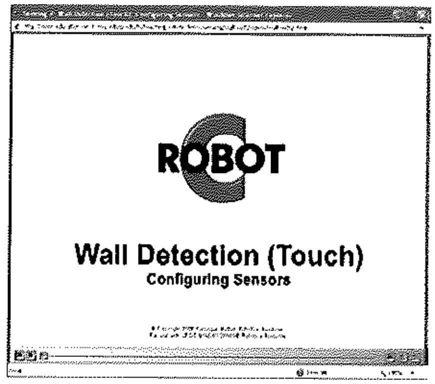
Boolean Logic Videos 1 & 2 - The first video teaches students how conditional statements work. The second teaches them about logical operators. There is also a Boolean Logic 3 page PDF that complements the videos.

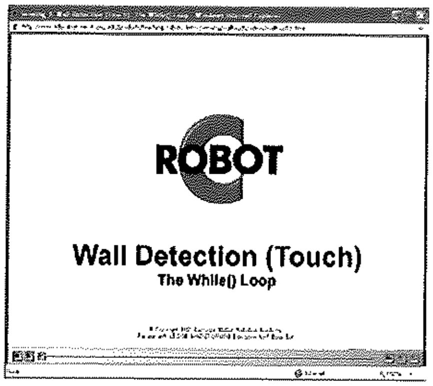
Robot Programming Challenges - This Lesson Set includes three open-ended programming challenges that can be solved by students: the Can Bot Challenge, Robo500 Challenge (Level 1) and the RoboMower Challenge (Level 1).

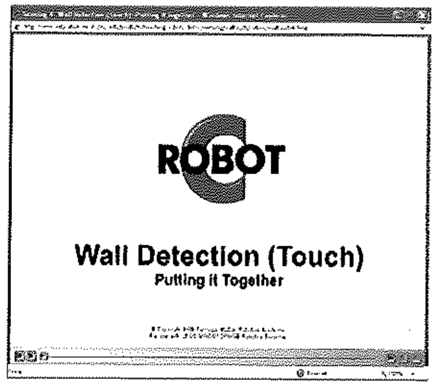
Introduction to Programming/Sensing/Touch Sensor

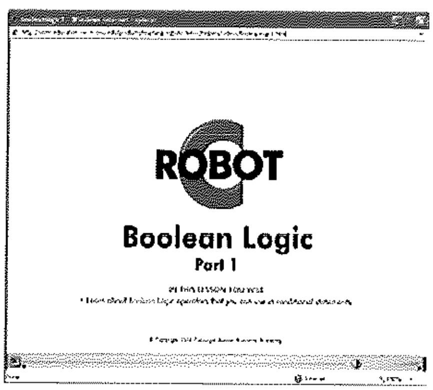
Sensing - Touch Sensor - Video Resources

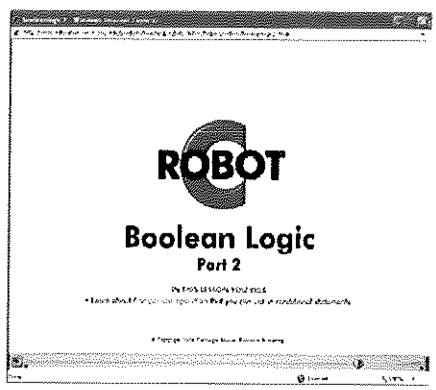


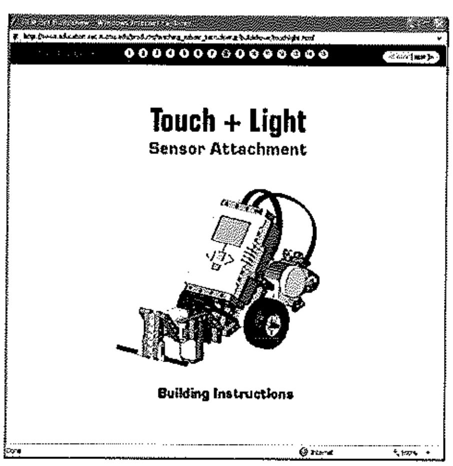






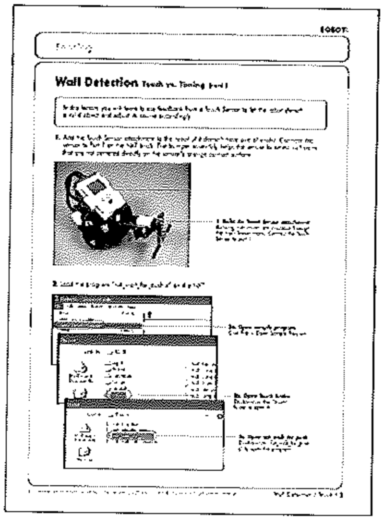


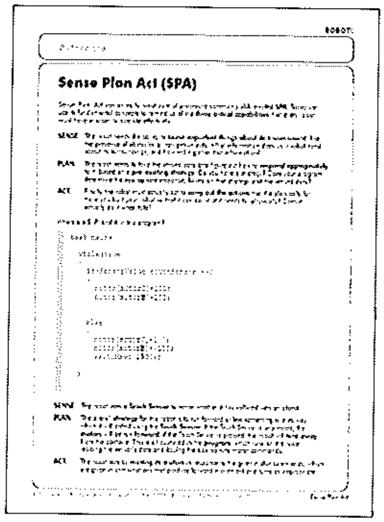


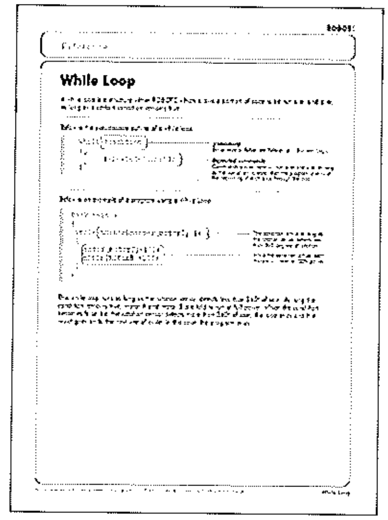


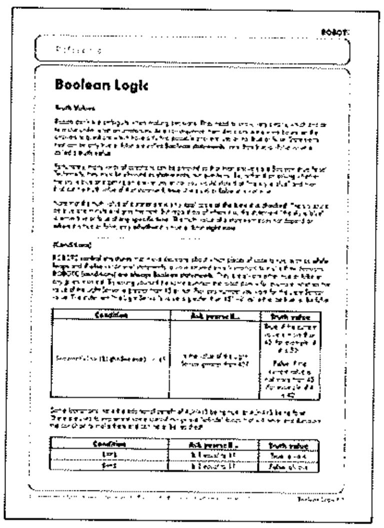
Introduction to Programming/Sensing/Touch Sensor

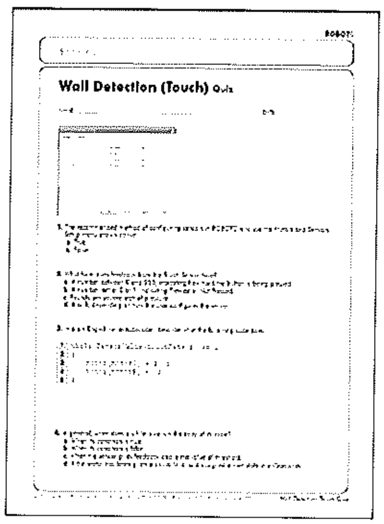
Sensing - Touch Sensor - Print Resources

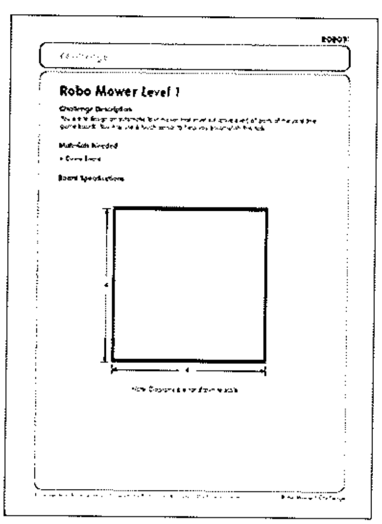


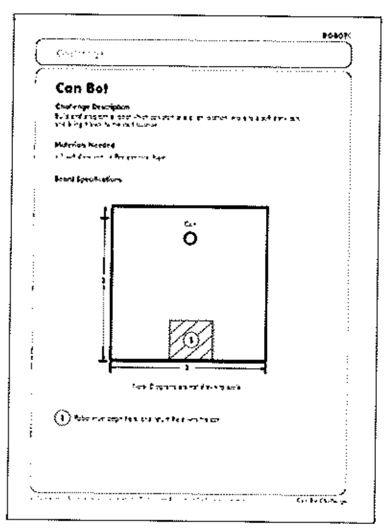


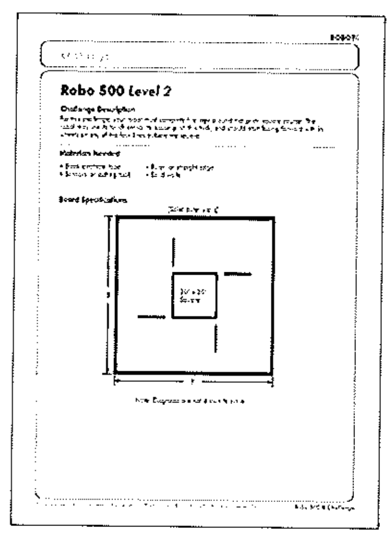




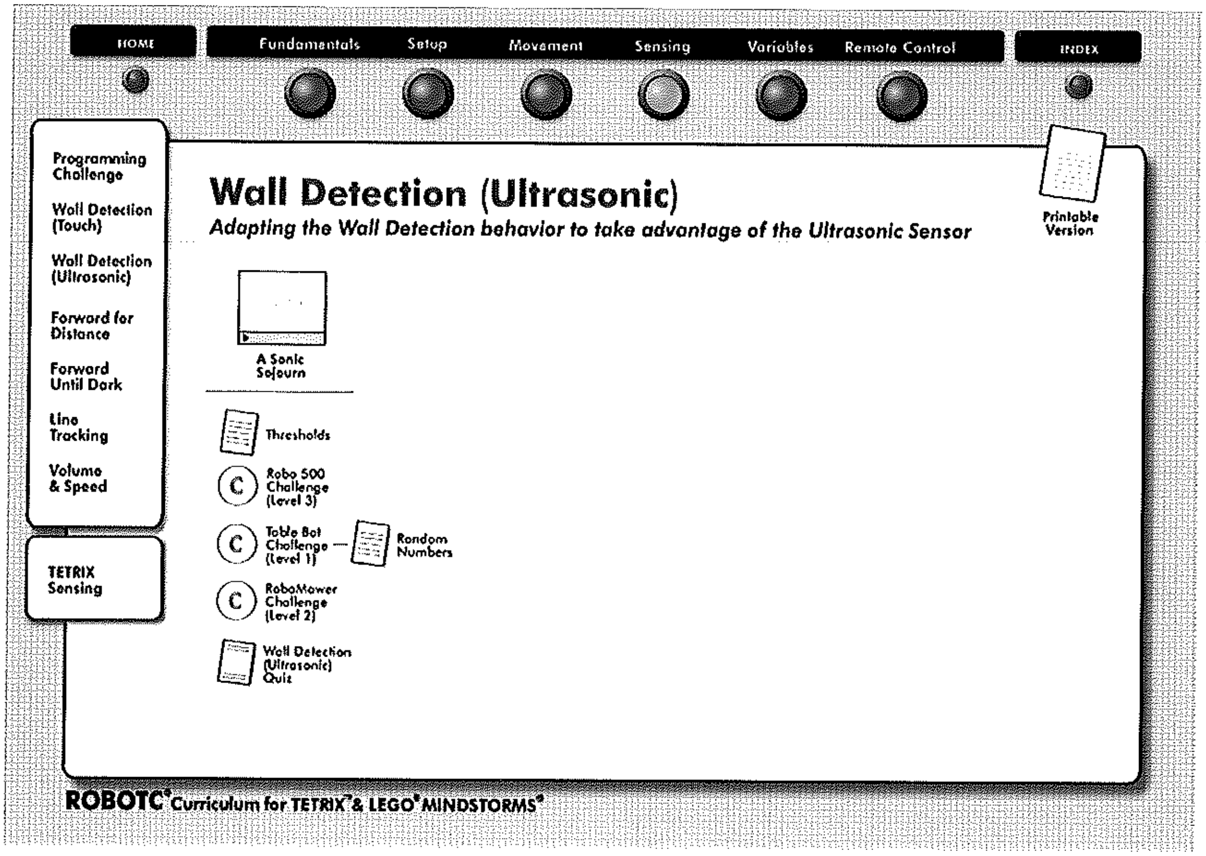








Introduction to Programming/Sensing/Ultrasonic Sensor



Sensing - Ultrasonic Sensor

The Wall Detection Ultrasonic Sensor Lesson Set builds on what students learned in the Wall Detection Touch Sensor Lesson Set. This Lesson Set teaches students how ultrasonic sensors work, how to measure distance using sound, how to use thresholds to program the ultrasonic sensor, and how to re-configure the motors and sensor setup window. The lesson is also designed to review how programming loops work.

The Sonic Sojourn Video - This video describes how the ultrasonic sensor works.

The Threshold Reference Page - This handout describes what thresholds are, how they are used in programming, and how to calculate them for the ultrasonic sensor.

Random Numbers Reference Page - This handout describes how to write programs that use random number values using ROBOTC.

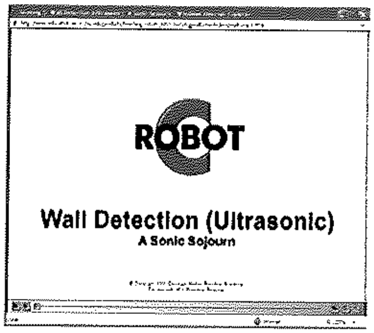
The Ultrasonic Sensor PDF Lesson - A printed version of the video designed to complement the video instruction.

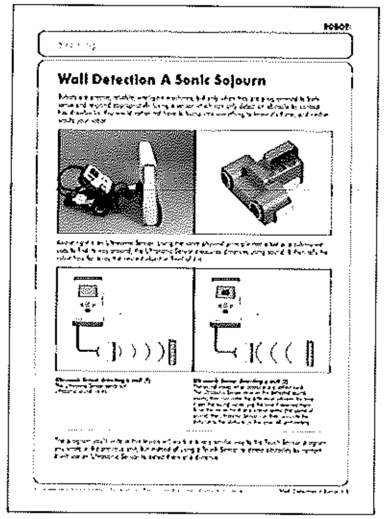
Ultrasonic Programming Challenges - This Lesson Set includes three different programming lessons: The Robo500 Challenge (Level 2), The Table Bot (Level 1) Challenge, and the RoboMower Challenge (Level 2). The challenges are designed so that a teacher can use the same "setup" for multiple challenges. Some challenges get progressively more difficult, while other challenges are designed so that the student completing it is able to quickly solve the same challenge with a different sensor.

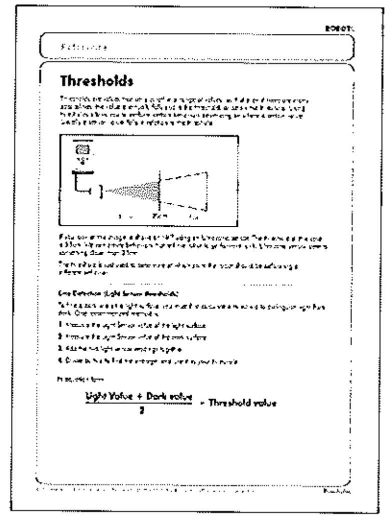
Ultrasonic Quiz - Designed to check students understanding of the concept.

Introduction to Programming/Sensing/Ultrasonic Sensor

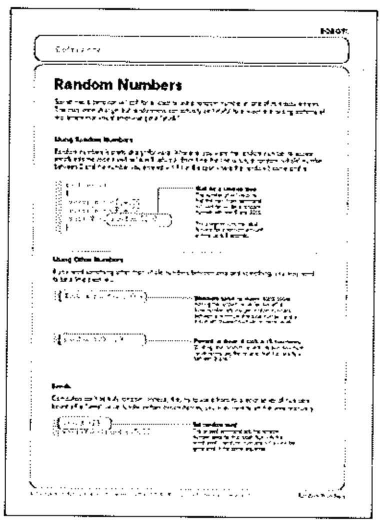
Sensing - Ultrasonic Sensor Resources

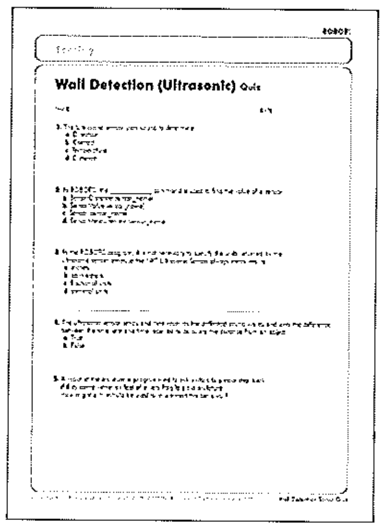


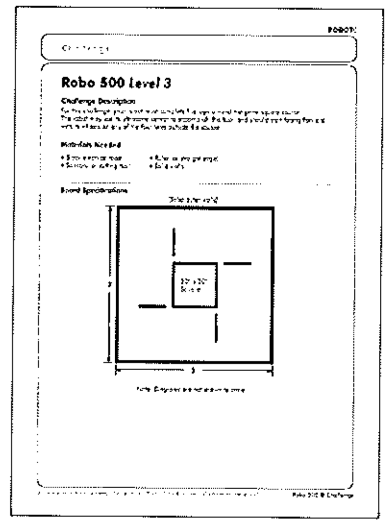

Wall Detection A Sonic Sojourn


Thresholds

Light Value + Dark value / 2 = Threshold value


Random Numbers


Wall Detection (Ultrasonic) Quiz


Robo 500 Level 3

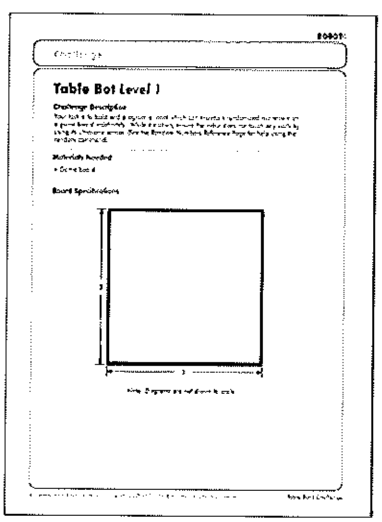
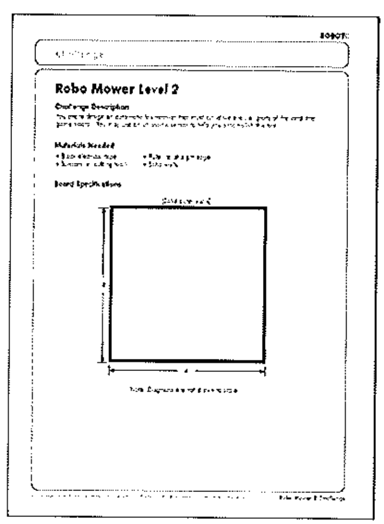
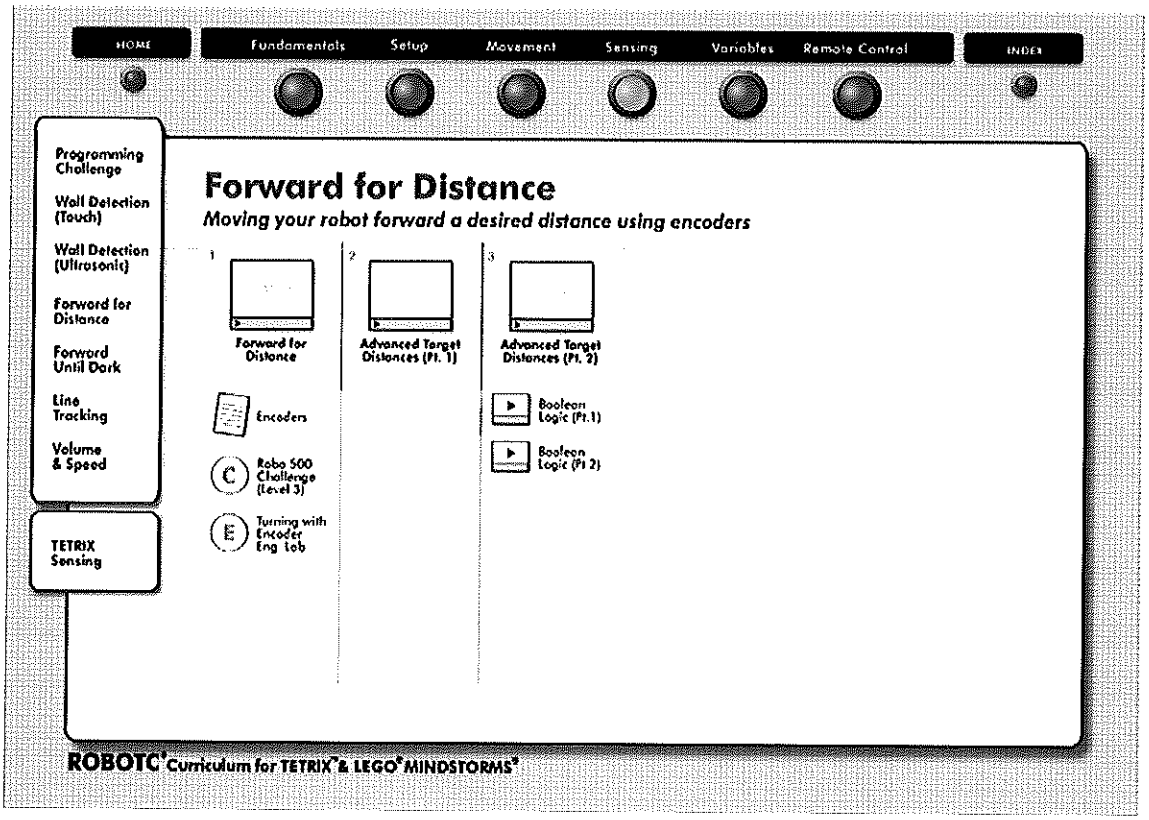


Table Bot Level 1


Robo Mower Level 2

Introduction to Programming/Sensing/Encoder



Sensing - Encoders

In the Forward for Distance Lesson Set, students learn advanced features of the nMotorEncoder function, allowing them to make very precise movements. The NXT smart motors have encoders built into them that allow the robot to move point-to-point in a very accurate manner. In the first video, students learn a simple method of moving point-to-point. In the second and third video set, students learn how to use the nMotorEncoderTarget function.

Forward for Distance Video - This lesson teaches students about the encoders built into the NXT smart motors, and the nMotorEncoder function.

Advanced Target Distance Part 1 Video - This lesson teaches students about the difference between the nMotorEncoder function and the nMotorEncoderTarget function. It also explains how the nMotorEncoderTarget function is programmed. Students will also learn about a new function that watches the motors "run state".

Advanced Target Distance Part 2 Video - This lesson shows students how to write the nMotorEncoderTarget program.

Boolean Logic Videos - Comparison operators and logical operators are key elements that all students must know. This video set is included at several spots throughout the curriculum for student review.

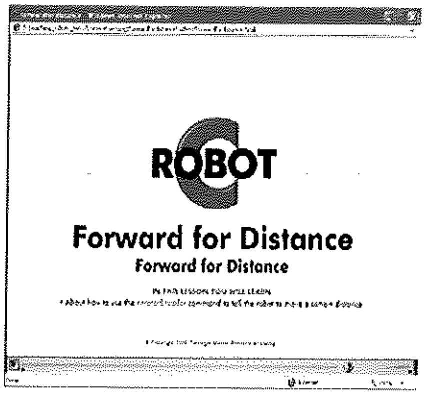
Encoders Reference Page - The encoders reference page is a handout that can be used as a reference or study guide.

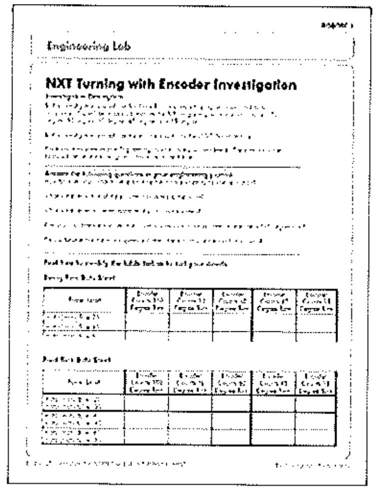
Turning with Encoder Engineering Lab - The Encoder Engineering Lab has students calculate encoder counts to turn specific angles. This data will help them with all programming moving forward.

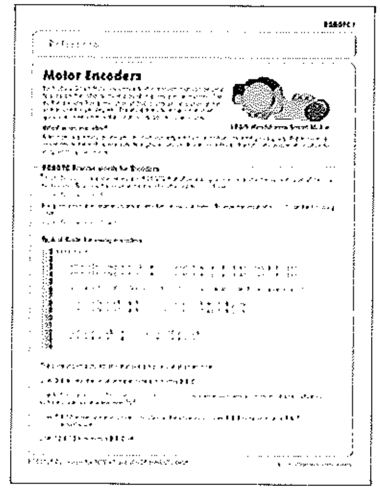
The Robo500 (Level3) Programming Challenge - Students have seen this challenge before. Now they will be able to apply what they've learned in the encoder lessons to solve the problem more perfectly.

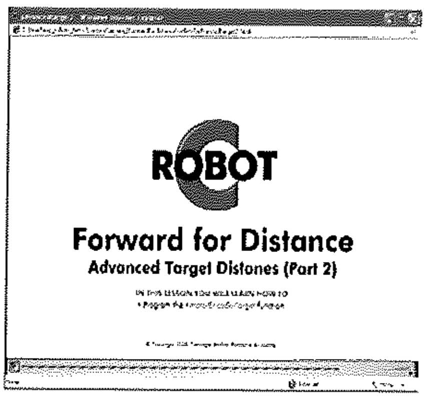
Introduction to Programming/Sensing/Encoder

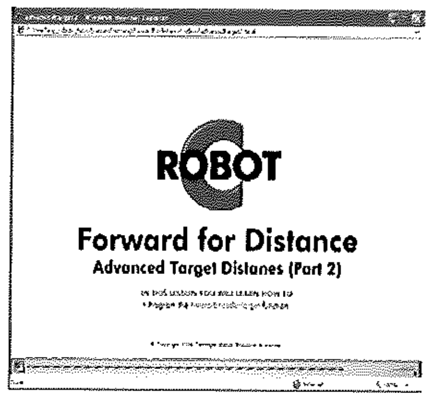
Sensing - Encoder Resources

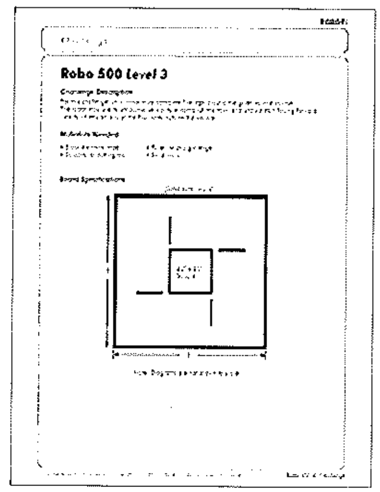


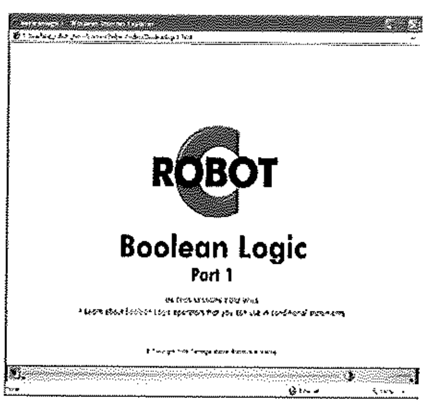


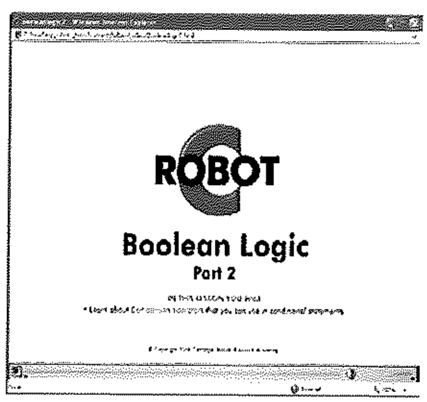




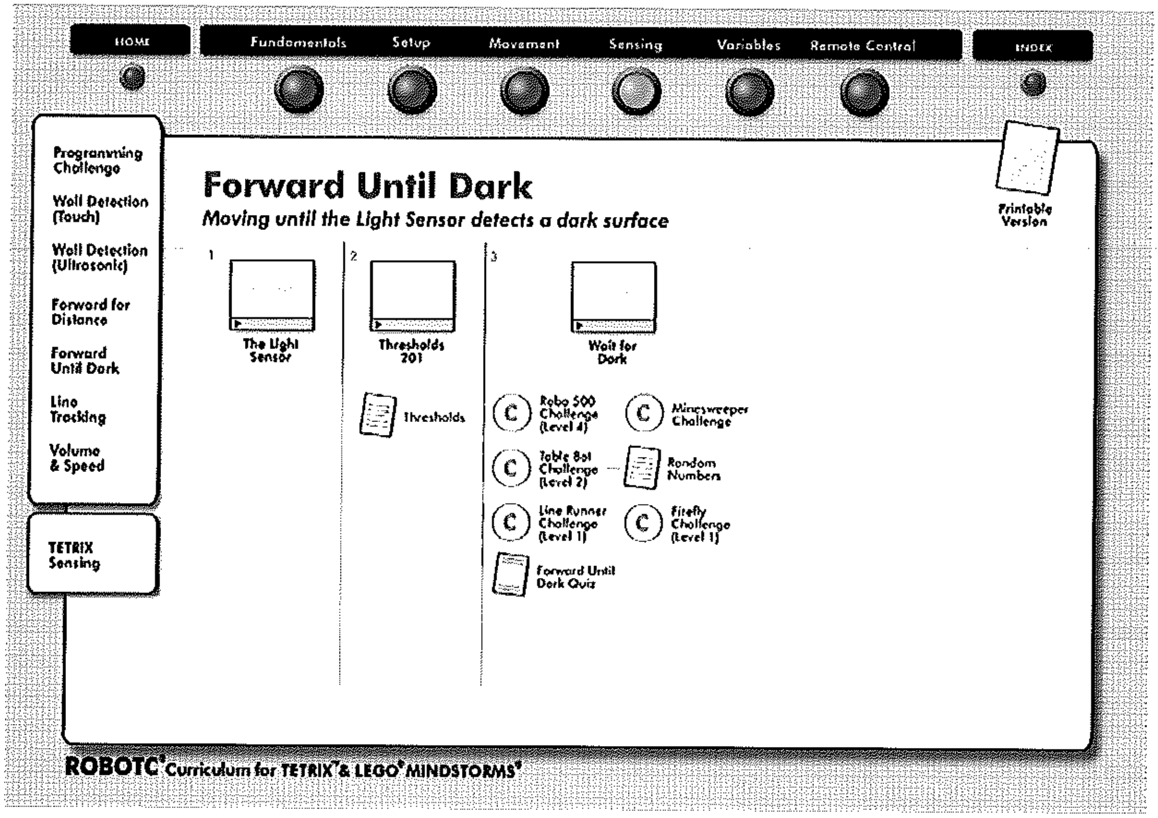








Introduction to Programming/Sensing/Light Sensor



Sensing - Light Sensor

The Forward Until Dark Lesson Set introduces students to how the light sensor works, how to troubleshoot programs that use the light sensor, and how to calculate threshold values for light sensors. The Lesson Set has the following resources:

The Light Sensor Video - The light sensor video reviews how the touch and ultrasonic sensors work and then describes how the LEGO light sensor works. The video also describes things to consider to optimize how the sensor works.

The Thresholds 201 Video - This lesson describes how to calculate thresholds for the light sensor. It also demonstrates the physical steps that a programmer needs to do to calculate a light sensor threshold value.

The Wait for Dark Video - This lesson begins with a prior program, then adapts the program to use the light sensor. Students will learn how to configure the Motors and Setup Configuration menu for the light sensor, and then are given directions that allow them to complete the program.

The Threshold and Random Numbers Reference Pages - These handouts are the same handouts used in the previous lesson and are useful to students still learning these foundational programming concepts.

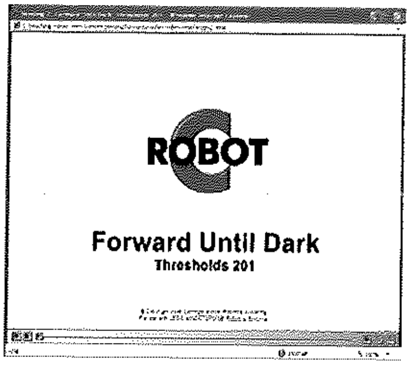
The Forward Until Dark Printable PDF - This document is a printed version of the three video lessons in the Forward Until Dark Lesson Set.

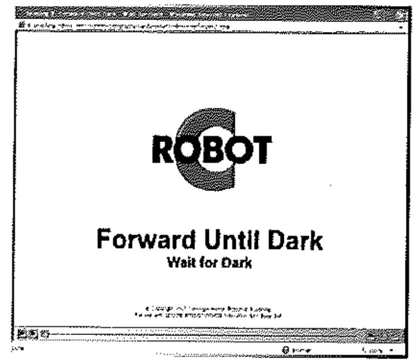
The Programming Challenges - There are five programming challenges with this lesson: The Robo500 Challenge (Level4), the Table Bot Challenge (Level 2), the Line Runner Challenge (Level1), the Minesweeper Challenge, and the Firefly Challenge (Level1). All students may not complete all programming challenges.

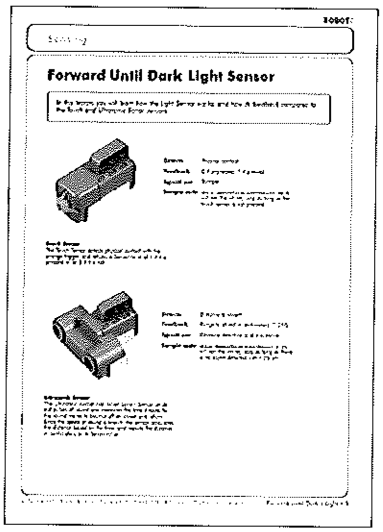
Forward Until Dark Lesson Set Quiz - A quiz to check student's understanding.

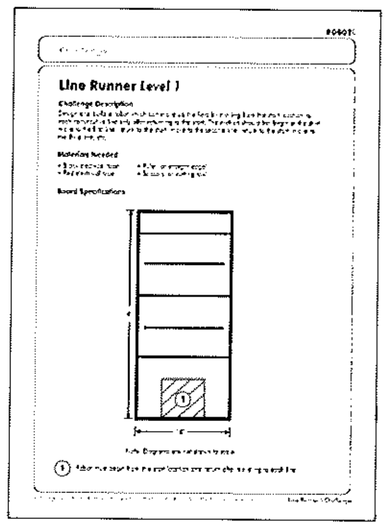
Introduction to Programming/Sensing/Light Sensor

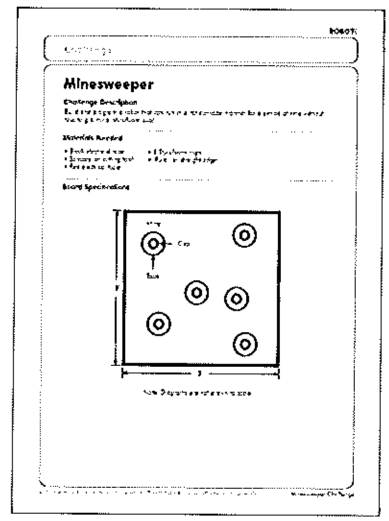
Sensing - Light Sensor Resources

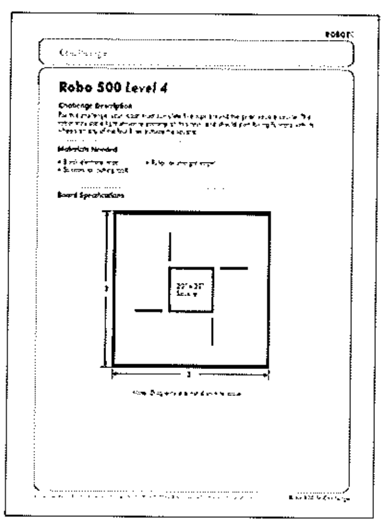


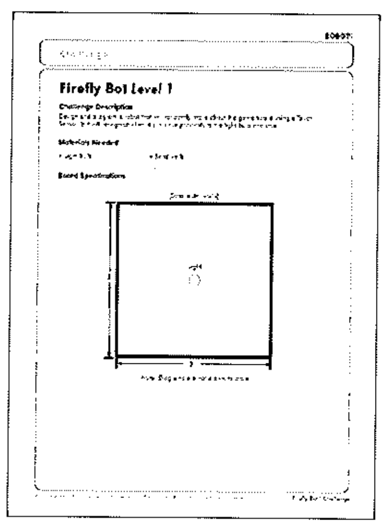


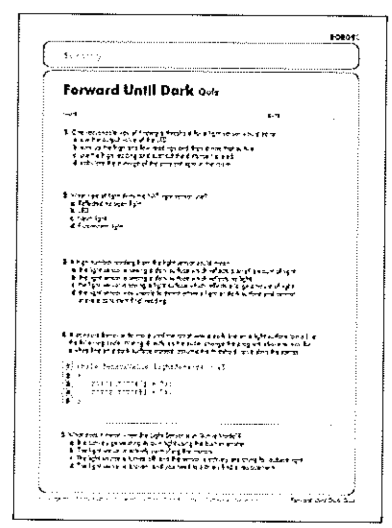




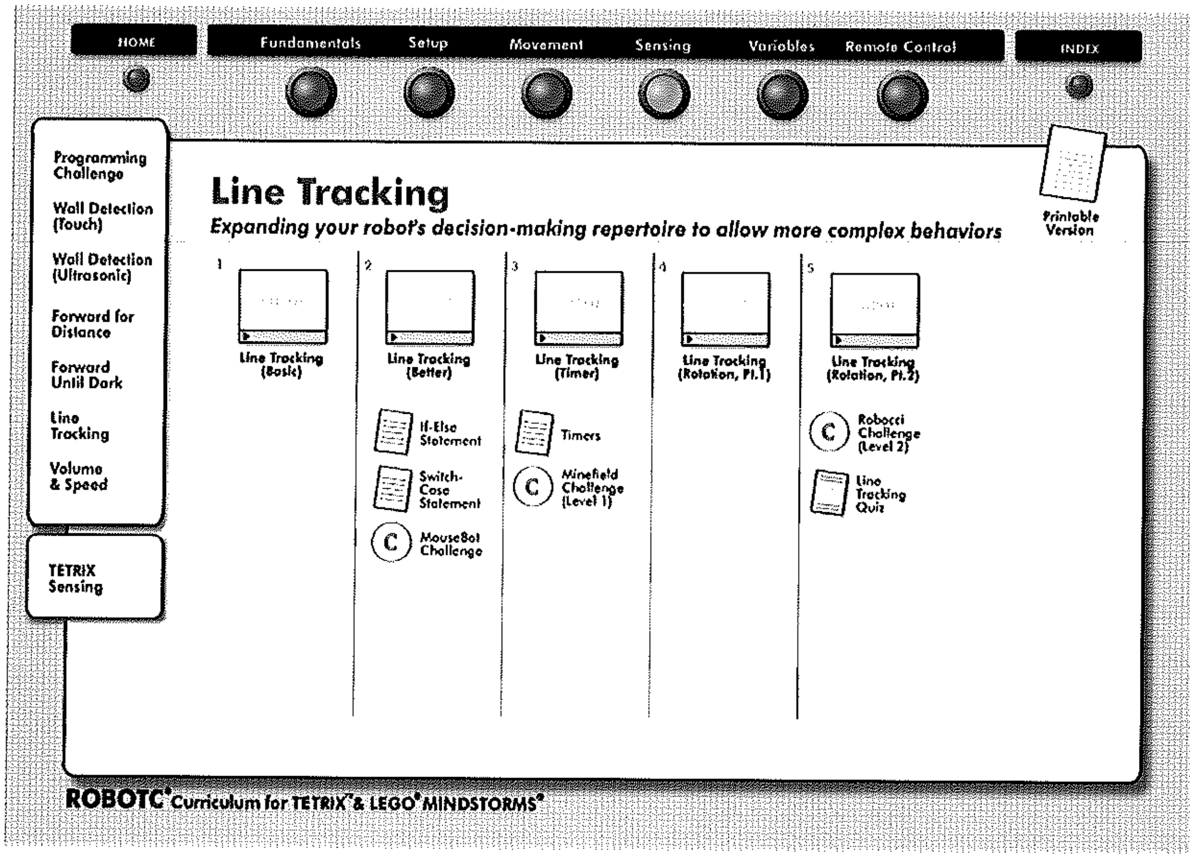








Introduction to Programming/Sensing/Light Sensor/LineTracking



Sensing - Light Sensor LineTracking

The Line Tracking Lesson Set breaks line tracking, a seemingly complex behavior, into a set of simple robot behaviors. It introduces students to a new structure, the if-else structure. Students learn to use multiple sensor feedback when they first use feedback from internal timers and light sensors to control how far their robot moves. Once they solve that problem, they then use feedback from the NXT smart motors and the light sensor to determine how far their robot travels. At the end of this Lesson Set, students will have all of the tools that they need to complete the obstacle course challenge. This Lesson Set uses the following video resources:

The Line Tracking (Basic) Video - This video teaches students how line tracking works, and how to break complex behaviors into simple behaviors. It also introduces the students to a naive way to solve the line track programming problem using while loops. This solution works, but has serious limitations.

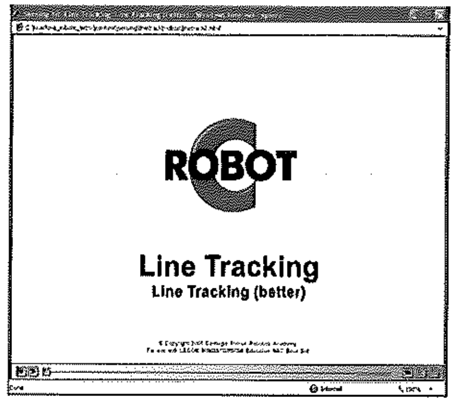
Line Tracking (Better) Video - This lesson teaches students how to use feedback from multiple sensors with their robot. They discover that their naive solution using only "while loops" doesn't always work. The video explains if/else structures, explaining the code as it talks students through the solution.

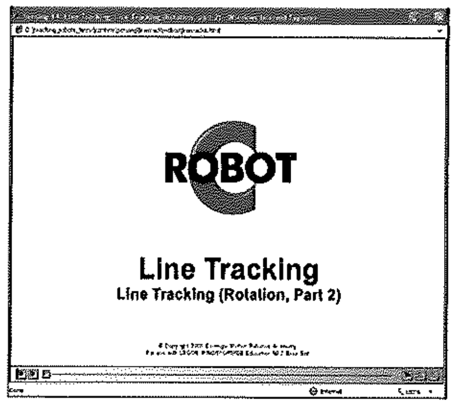
The Line Track Timer Video - This video teaches students how to use the internal timers built into the NXT to control how long the robot does something. This is a very valuable tool that the student will be able to use in many other situations.

The Line Tracking Rotation Parts 1 & 2 Videos - Teaches the student to use feedback from the encoders built into the NXT smart motors to determine when to stop tracking a line.

Introduction to Programming/Sensing/Light Sensor/LineTracking

Sensing - Light Sensor LineTracking Video Resources





Sensing - Light Sensor LineTracking Print Resources

If-Else Reference Page - Students will use the if-else structure from this point forward in their programming career. This is a one page reference sheet that shows them how it works.

Switch Case Statement - Another option for programmers that have to control multiple conditions is the switch case. This resource is a multi-page handout that students can reference when using switch cases.

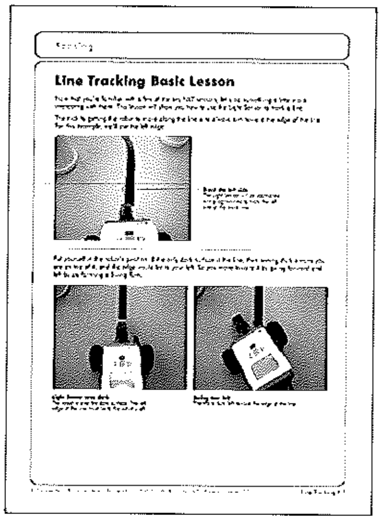
Timer Reference Page - The timer reference page demonstrates specific reserved words used in ROBOTC to control the internal timers built into the NXT.

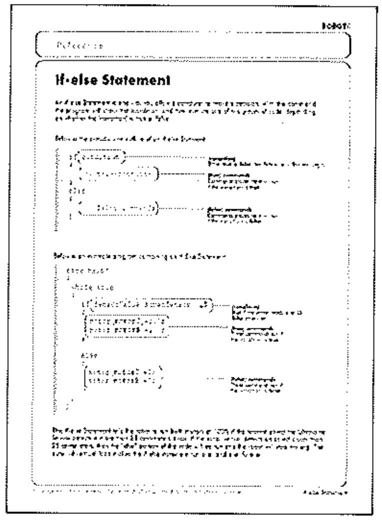
Line Tracking Programming Challenges - This Lesson Set includes three open-ended challenges designed to support the lesson: the MouseBot Challenge, the Minefield Challenge (Level1), and the Robocci Challenge (Level2). All students may not complete every programming challenge.

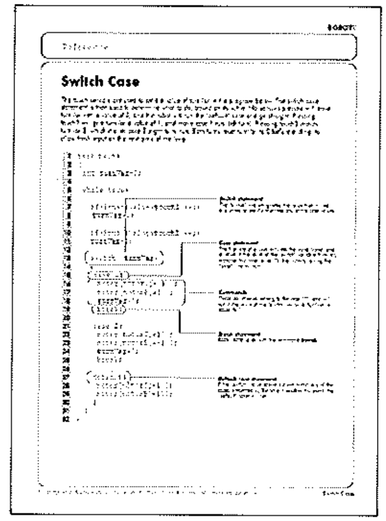
Line Track Quiz - The line track quiz is included to check student's understanding.

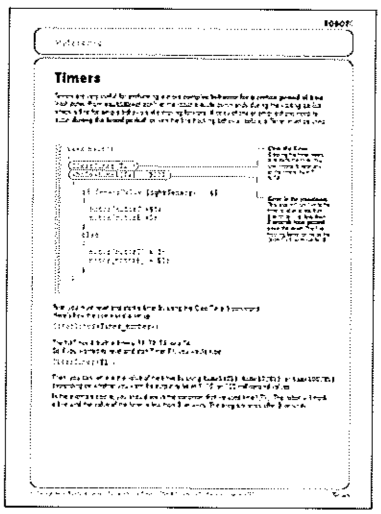
Introduction to Programming/Sensing/Light Sensor/LineTracking

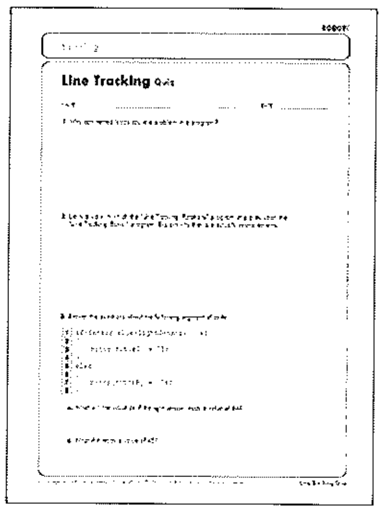
Sensing - Light Sensor LineTracking Print Resources

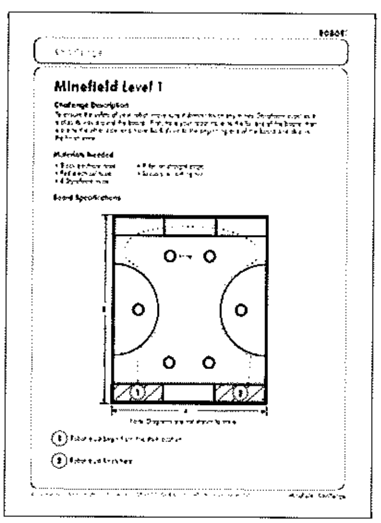


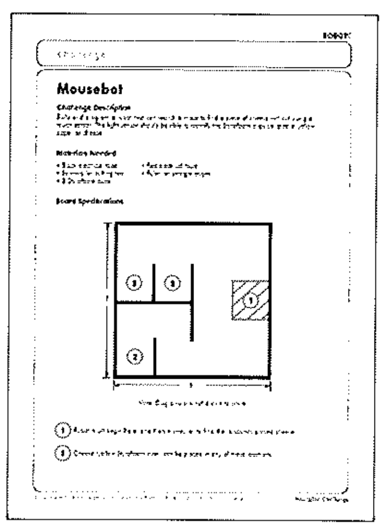


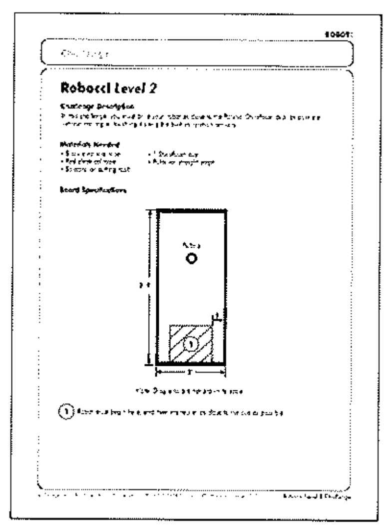




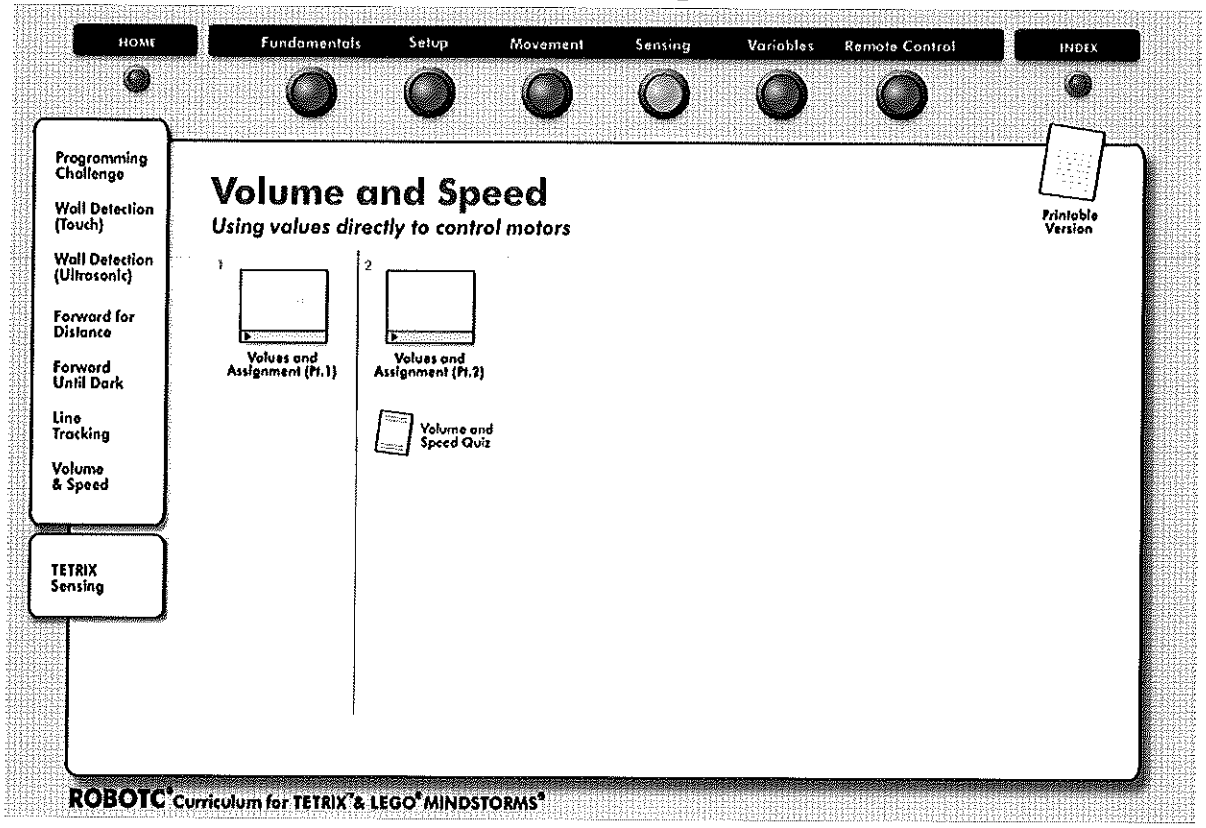




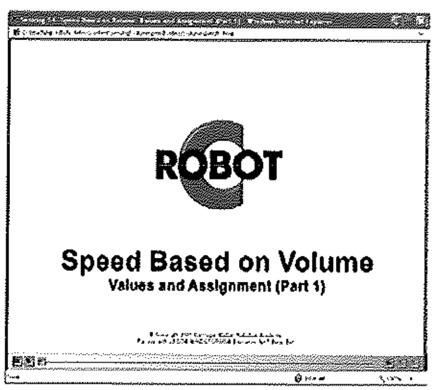


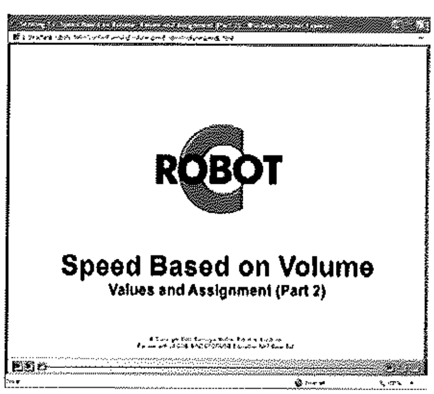


Introduction to Programming/Sensing/Sound Sensor

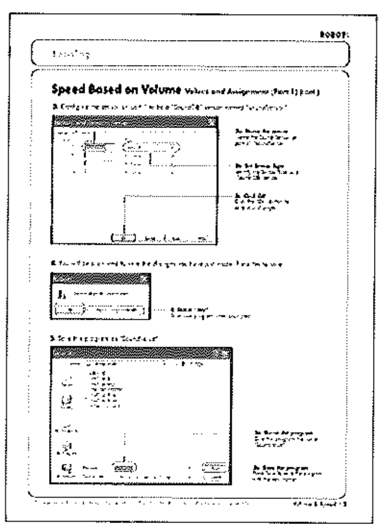


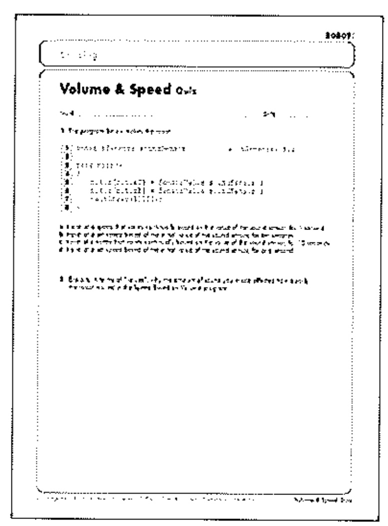
Sensing - Sound Sensor



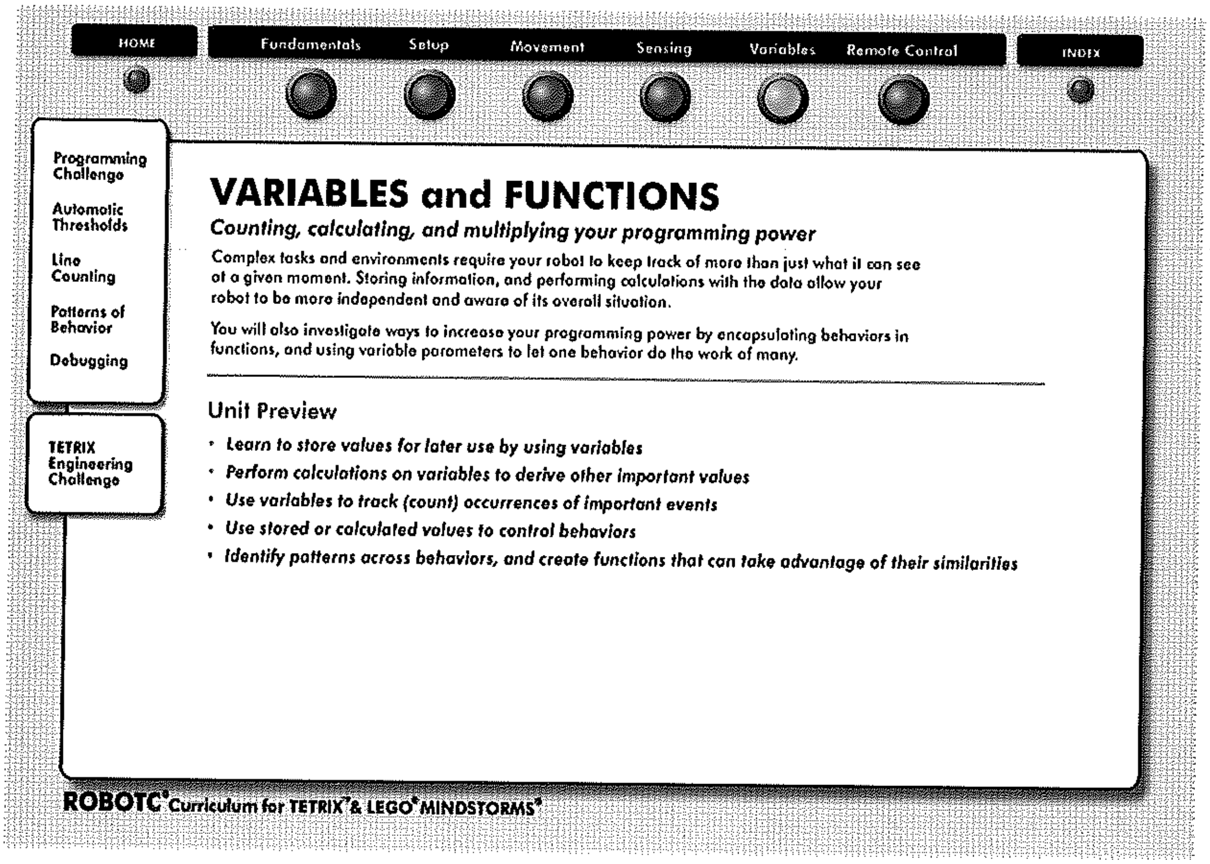


In the Speed Based on Sound Lesson Set, students are challenged to map the values of the sound sensor to the motor powers so that they can control the motors speed based on sound. This lesson reinforces the idea that a programmer needs to continually update the sensor value if they want to use the sensor value to control something real time. This is a very important concept that beginning programmers often miss. In this lesson, students also practice using the internal timers and the reserved words that are associated with it. The Lesson Set includes: two videos, a 9 page PDF that aligns with the video, and a quiz.





Programming/Sensing/Variables and Functions

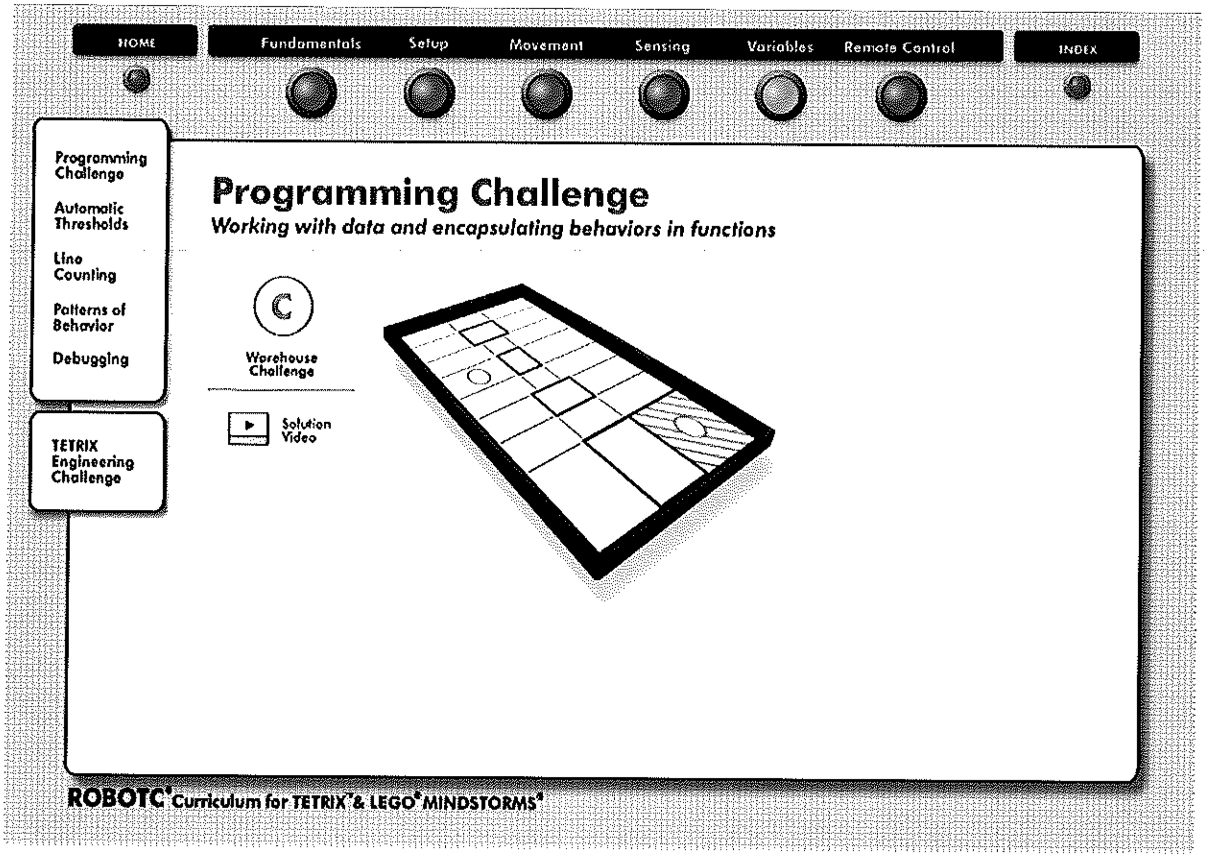


Sensing - Variables and Functions

The Variables and Functions Unit contains four Lesson Sets: Automatic Thresholds, Line Counting, Patterns of Behaviors and Debugging. Each of these Lesson Sets teaches a major programming concepts. Automatic Thresholds introduces the concept of variables, variable types, how to name variables, and how to manipulate them. The Line Counting Lesson Set builds on the variable concept and teaches students how they can manipulate the value of variables. Patterns of Behaviors introduces functions, how to pass parameters in functions, and how functions can be used to simplify programs. And finally, the Debugging Lesson Set, offers two lessons on how to use ROBOTC's debugger to troubleshoot programs.

The previous programming units, Movement and Sensing, introduce basic robot programming concepts. These lessons begin to introduce basic programming concepts!

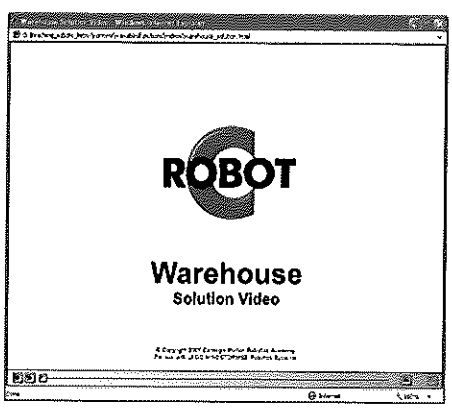
Programming/Variables and Functions/Programming Challenge

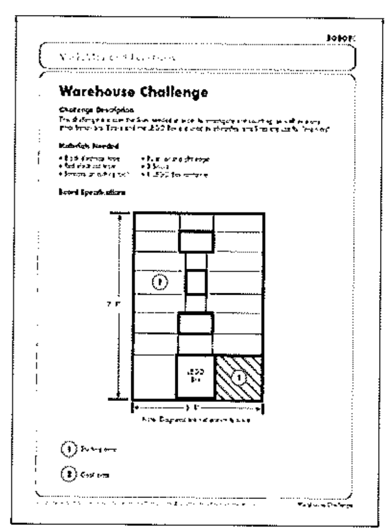


Sensing - Variables and Functions/Programming Challenge

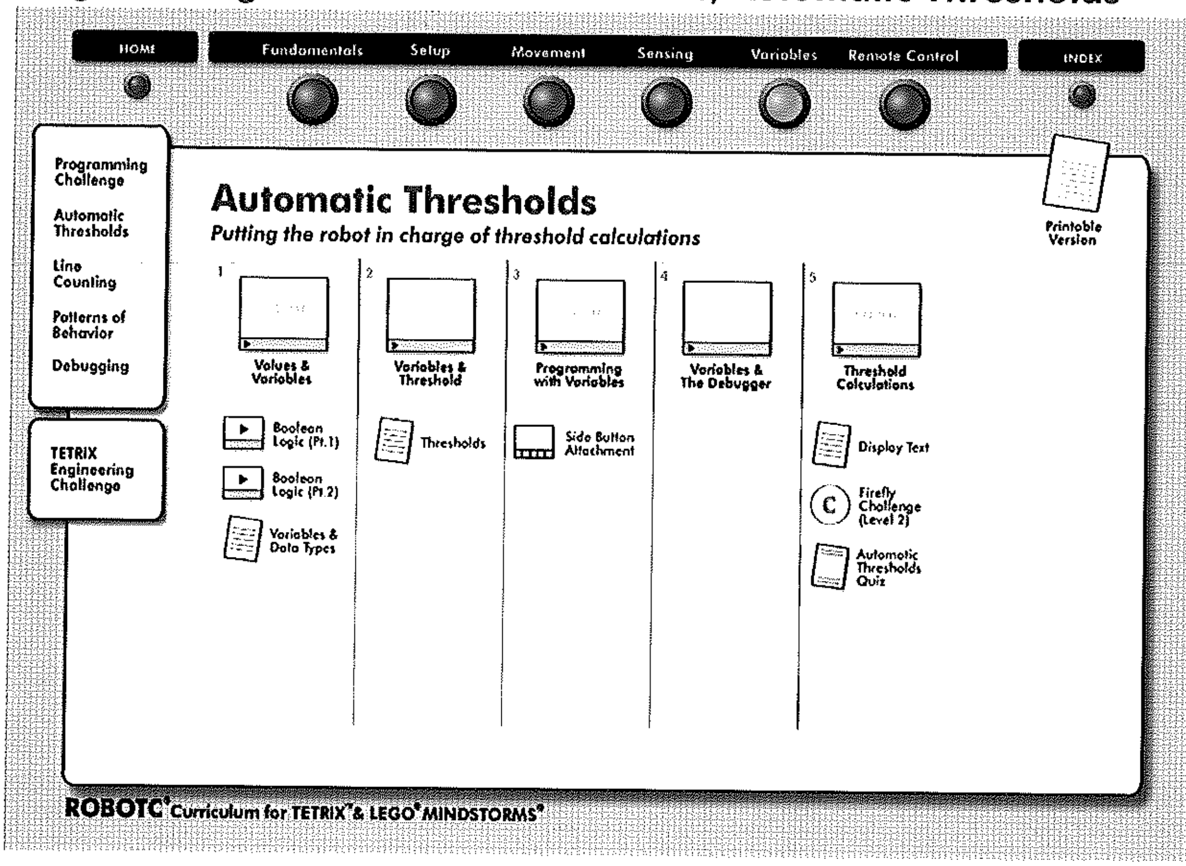
The Warehouse Programming Challenge asks students to developed a customizable program that allows them to program their robot to move to any spot in the warehouse. As students move through the Automatic Thresholds, Line Counting and Patterns of Behavior Lesson Sets they will gain the skills needed to solve the programming challenge.

There are two resources available to introduce the programming challenge: ***the Warehouse Challenge PDF*** and ***the Warehouse Challenge Solution Video***.





Programming/Variables and Functions/Automatic Thresholds



Sensing - Variables and Functions/Automatic Thresholds

The Automatic Thresholds Lesson Set introduces a variables; a very large concept in computer programming. The step-by-step guided lesson will allow students to solve this programming problem, but the concept will need to be revisited multiple times before students become competent using variables.

Values & Variable Video - This video introduces variables, variable types, and how to name variables.

Variables and Thresholds Video - This video reviews how to calculate thresholds for the light sensor, the programming problem that students will solve in this Lesson Set, and defines the initial variables used to solve this problem.

Programming with Variables Video - This video walks students through the automatic threshold calculation problem beginning with configuring the light and touch sensor and continuing through the initial setup of the problem.

Variables and the Debugger Video - This video shows students how to use ROBOTC's debugger to find the problem in their initial programming solution. They will discover how fast computer processors work, and be shown a solution.

Threshold Calculations Video - This video shows students how to do calculations using variables and how to display values to the NXT display screen.

The Boolean Logic Video Set - Students have seen this set in an earlier lesson; this is a good time to review.

Variable and Data Types Reference - This is a multiple page handout that students can use as a study guide.

Threshold Values Reference - One page reference guide that students can use to review threshold values.

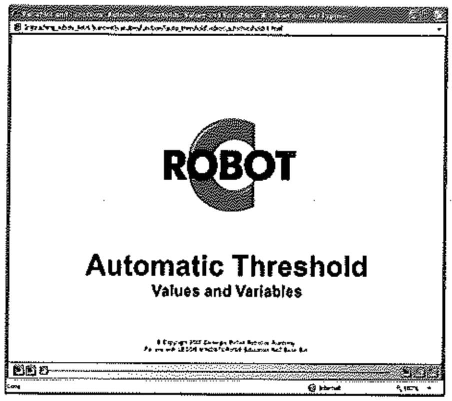
Display Text Reference - This multiple page lesson shows students step-by-step how to display text on their screens.

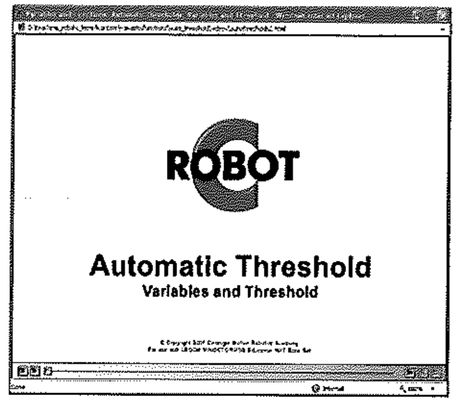
Firefly Challenge (Level2) - This challenge requires students to find a light value and report the value to their screen.

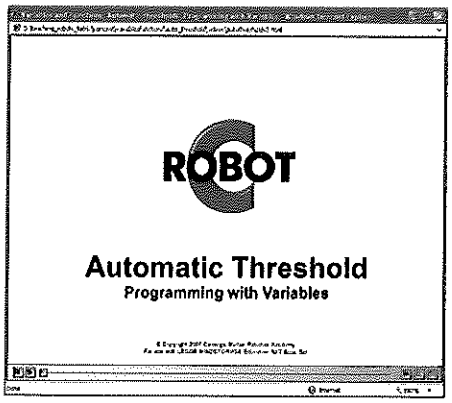
Automatics Thresholds PDF - A 36 page PDF that covers what was taught in the video lessons in a print format.

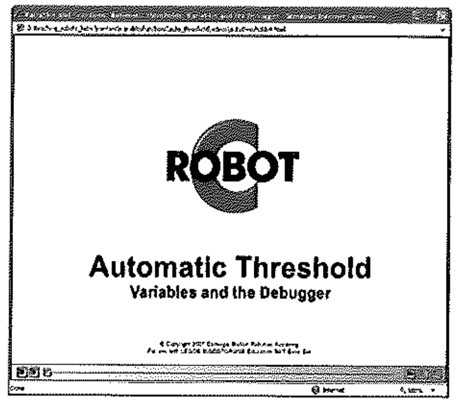
Programming/Variables and Functions/Automatic Thresholds

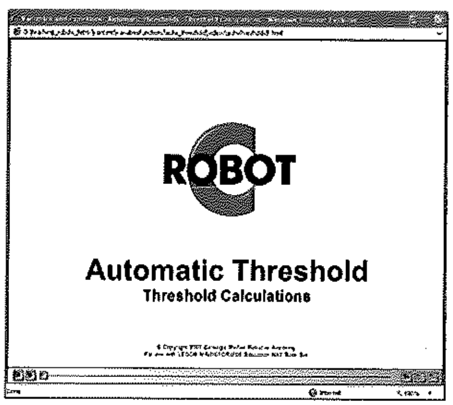
Sensing - Variables and Functions/Automatic Thresholds - Video Resources

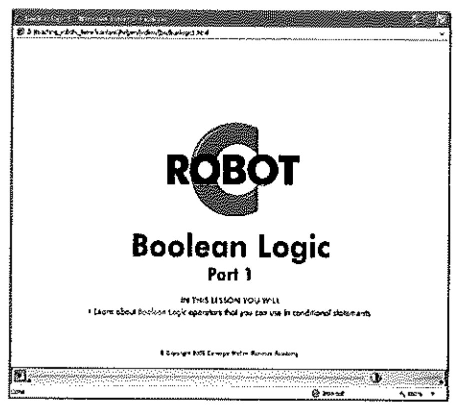


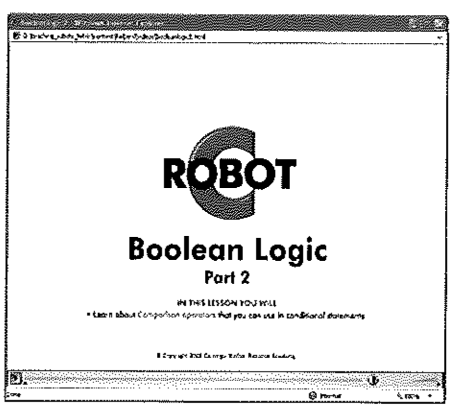






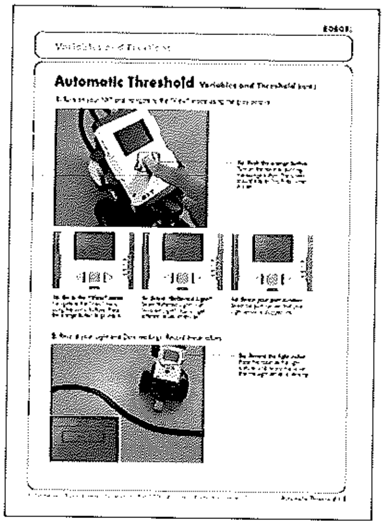


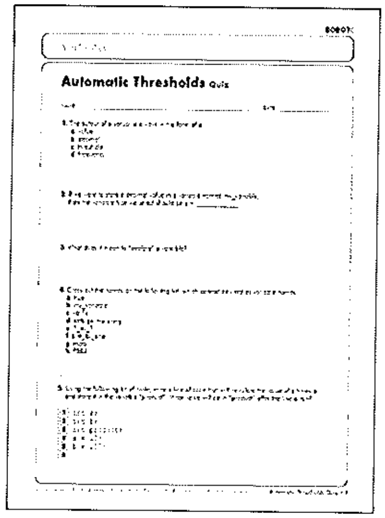


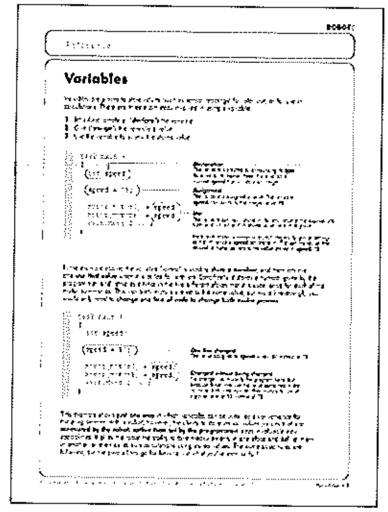


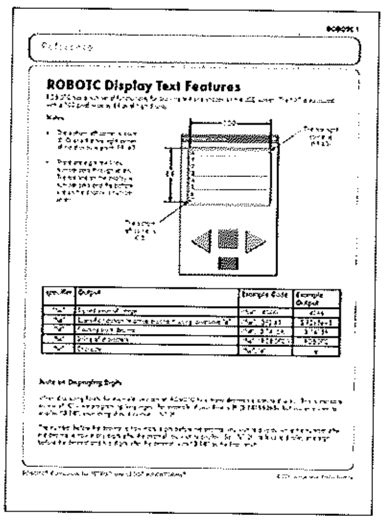
Programming/Variables and Functions/Automatic Thresholds

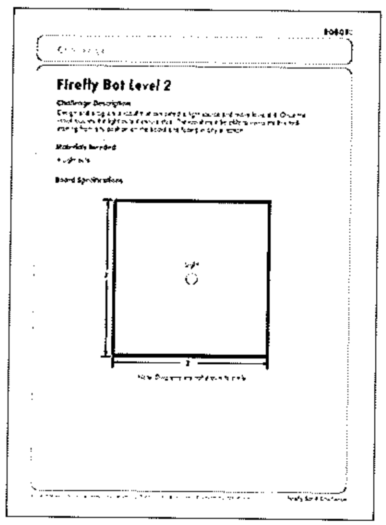
Sensing - Variables and Functions/Automatic Thresholds - Print Resources

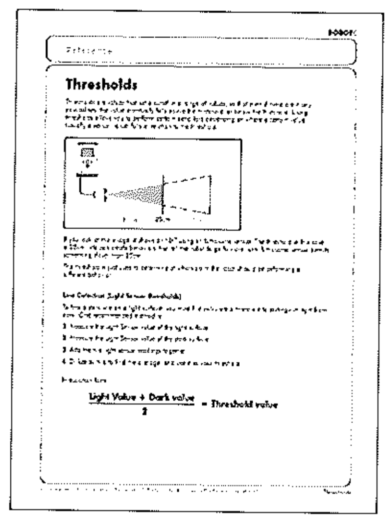

Automatic Threshold


Automatic Thresholds Quiz

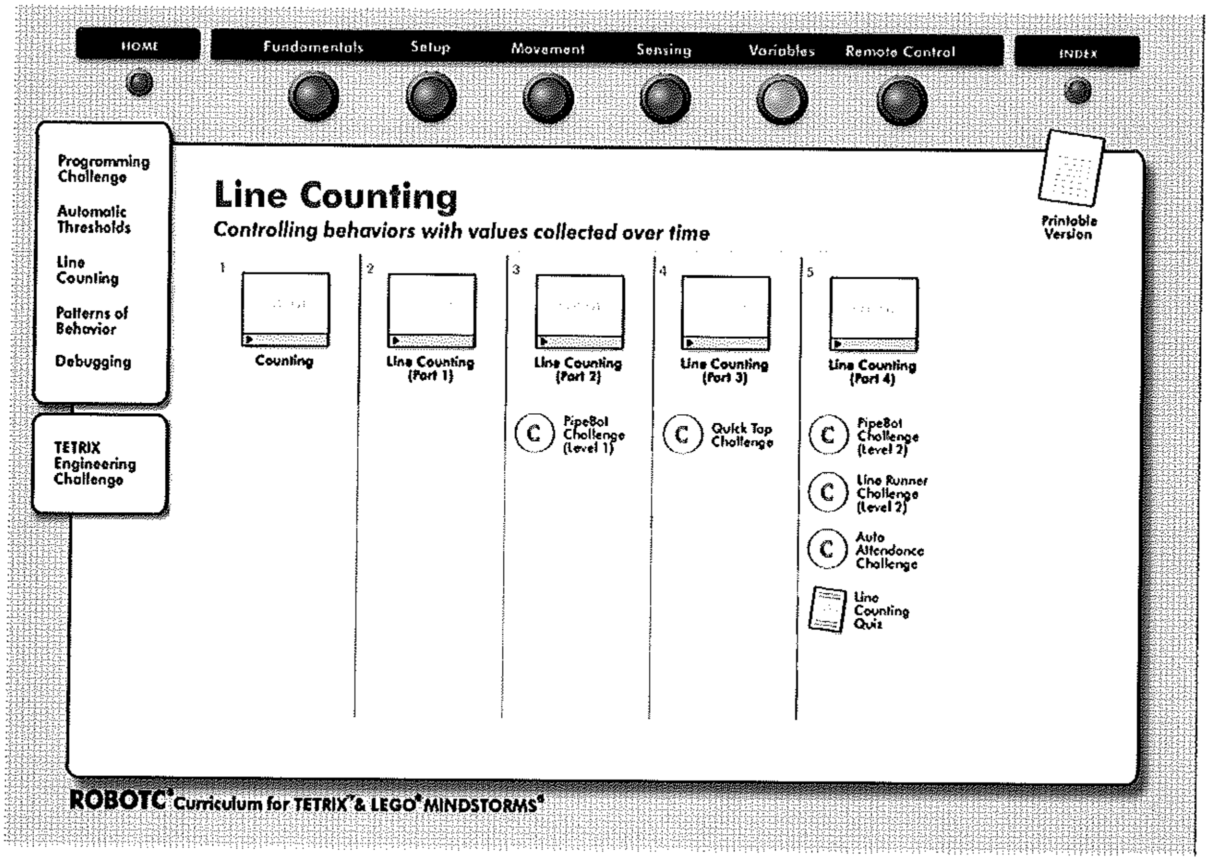

Variables


ROBOTC Display Text Features


Firefly Bot Level 2


Thresholds

Programming/Variables and Functions/Counting



Sensing - Variables and Functions/Counting

The Line Counting Lesson Set introduces students to using variable to store values so that their robots can count. It appears that this would be a very simple task to implement, but there are multiple small problems to consider. Students will learn more about processors and implications of processing speed that they may not have thought about. Students will learn to setup a counter variable, when to count, how to count, and how to stop counting in a program.

The Counting Video - This video introduces students to reassigning values to variables allowing the robot to count.

Line Counting Part 1 Video - This video helps student to identify the problem as well begin to write their code.

Line Counting Part 2 Video - This video introduces students to using the "breakpoint" function built into ROBOTC's debugger allowing students to see how fast the robot's processor loops.

Line Counting Part 3 Video - Students are shown how to create a set of variables and turn them on and off helping them to count or not count at the correct spots in their program.

Line Counting Part 4 Video - The last video in the Lesson Set shows students how they can control when the robot stops.

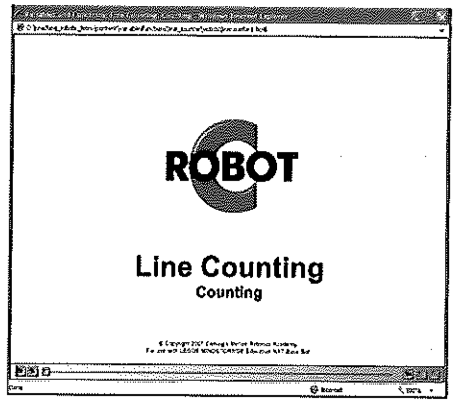
Line Counting PDF Lesson Set - A printed version of everything that was found in the Line Counting video lessons.

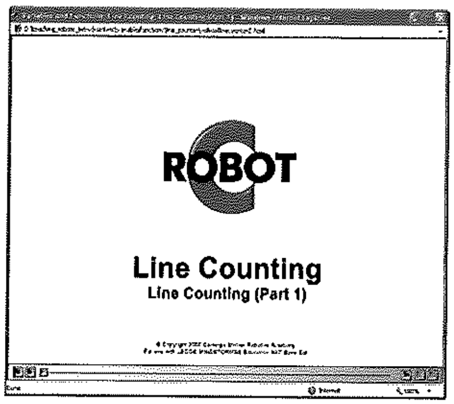
Programming Challenges - Students will begin to separate at this point. There are five programming challenges included in this Lesson Set. The programming challenges are more difficult at this point and not every student will complete every challenge. The challenges are: PipeBot Challenge (Level1), Quick Tap Challenge, The Pipe Bot Challenge (Level2), the Line Runner Challenge (Level 2), and the Auto Attendance Challenge.

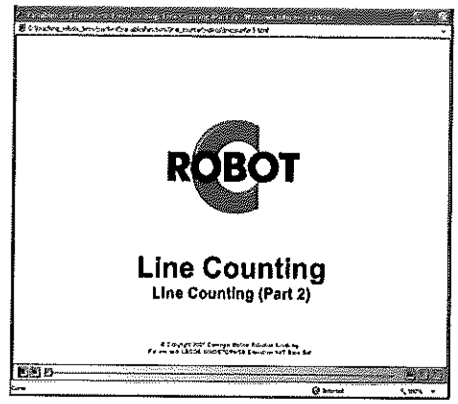
Line Counting Lesson Set Quiz - A quiz designed to check students understanding of these concepts.

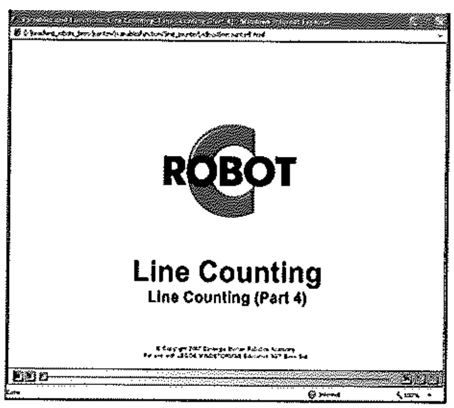
Programming/Variables and Functions/Counting

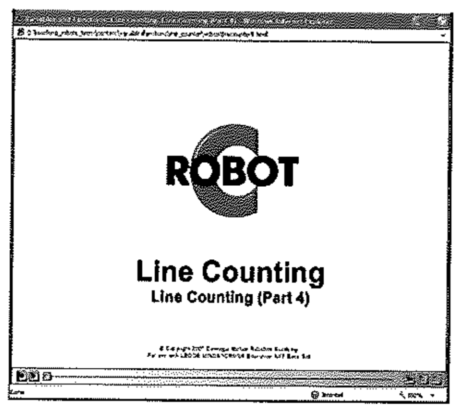
Sensing - Variables and Functions/Counting - Video Resources





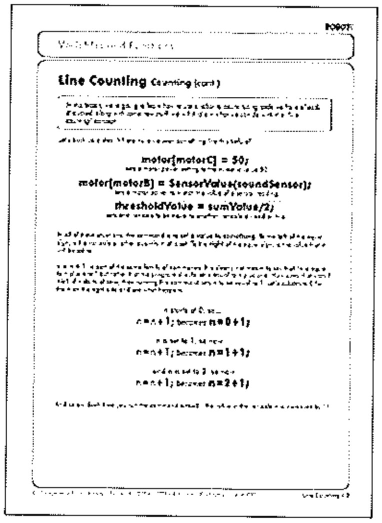






Programming/Variables and Functions/Counting

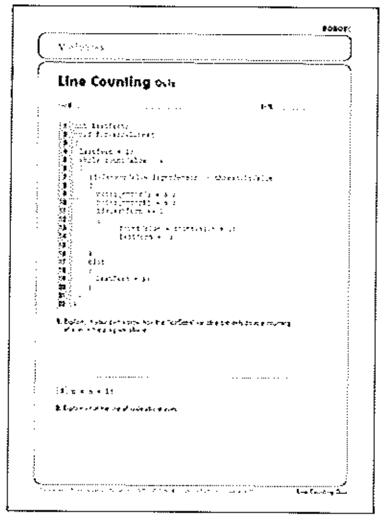
Sensing - Variables and Functions/Counting - Printed Resources

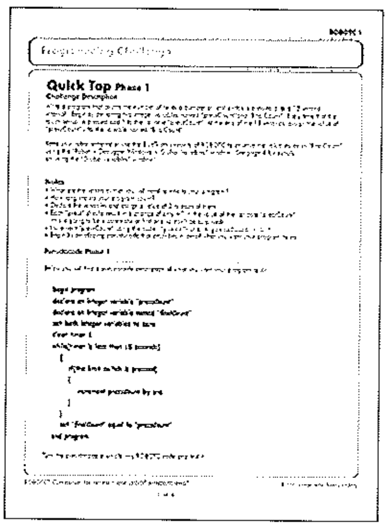

Line Counting Counting (cont)

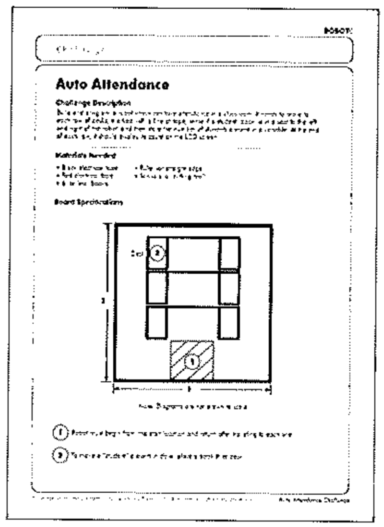
motor[motorC] = 50;

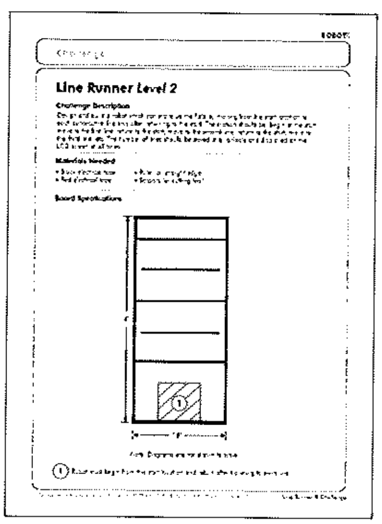
motor[motorB] = SensorValue(soundSensor);

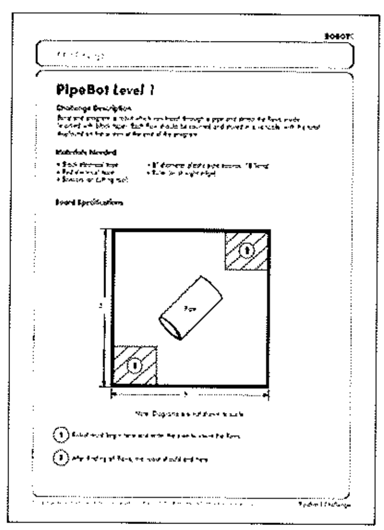
thresholdValue = sumValue/2;

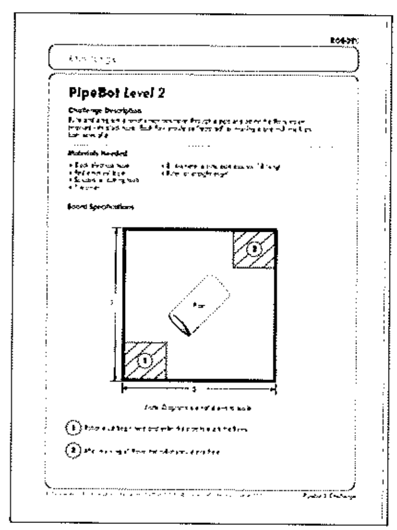

Line Counting Quiz


Quick Tap Phase 1

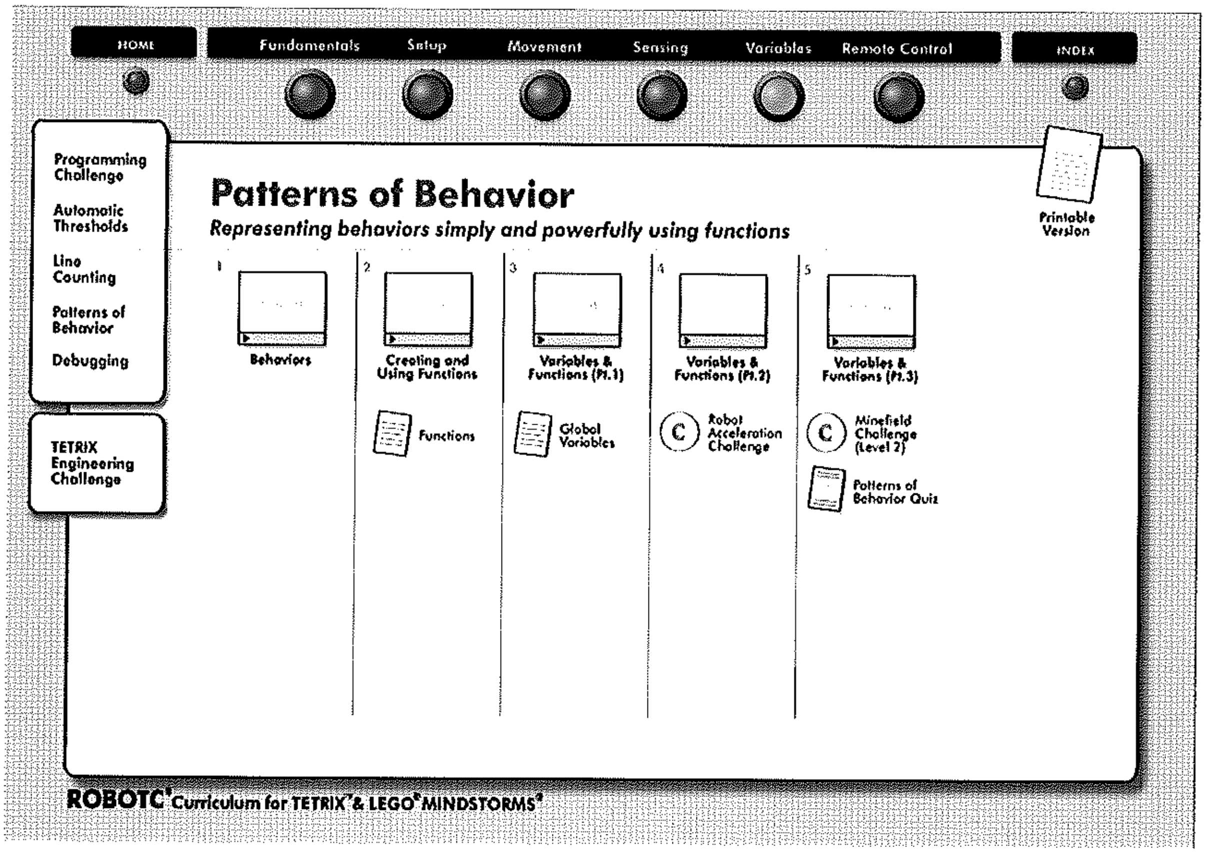

Auto Attendance


Line Runner Level 2


PipeBot Level 1


PipeBot Level 2

Programming/Variables and Functions/Patterns of Behaviors



Sensing - Variables and Functions/Patterns of Behaviors

In the Patterns and Behaviors Lesson Set students learn to program using functions. Functions are very powerful organizers used by programmers that program robots using behavior based programming strategies.

Behaviors Video - Introductory video that explains the value of programming using functions.

Creating and Using Functions Video - In this video students learn the relationship between task main and a function. They learn to declare functions and use them in the task main section of their program.

Variables and Functions Part 1 Video - In this video students learn how to take code from other programs and turn them into functions and then they will take those functions and use them in an easier to read program. They also learn about the scope of variables and how to create global variables.

Variables and Functions Part 2 Video - In this video students continue to write the solution to the "warehouse" challenge using their newly found function tool.

Variables and Functions Part 3 Video - In this video students learn to pass parameters making their functions much more powerful.

Functions Reference Guide - This is a multipage handout that shows students how functions work.

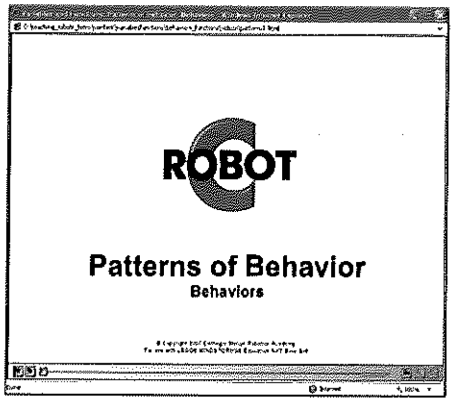
Global Variables Reference Guide - This handout explains what a global variable is and how it can be used.

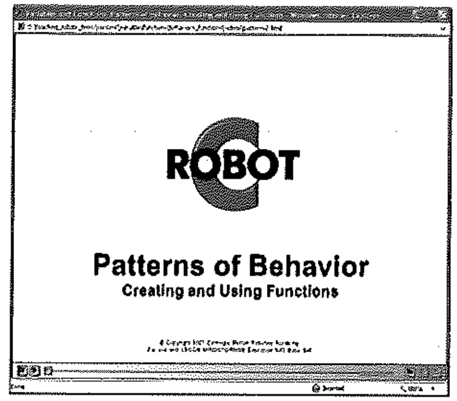
Programming Challenges - This Lesson Set include two advanced programming challenges: the Robot Acceleration Challenge, and the Minefield Challenge (Level2).

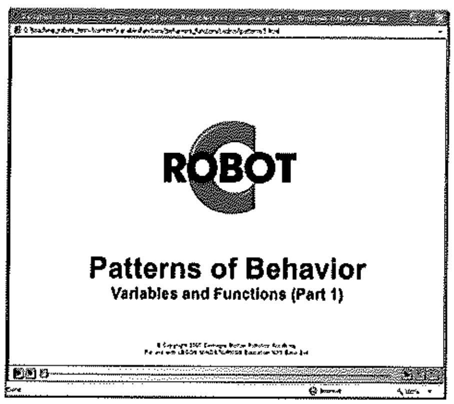
The Patterns of Behaviors Lesson Set Handout - This is a 40 page PDF that complements the videos in this Lesson Set.

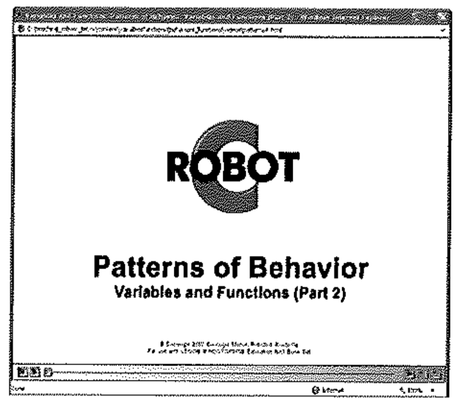
Programming/Variables and Functions/Patterns of Behaviors

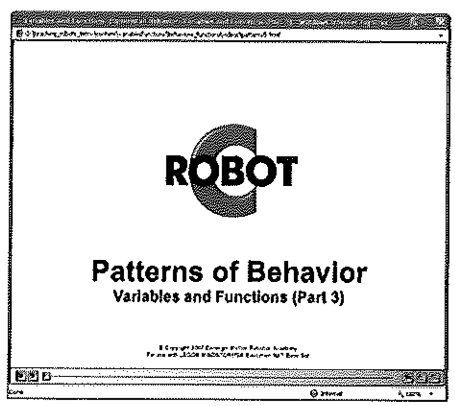
Sensing - Variables and Functions/Patterns of Behaviors - Video Resources





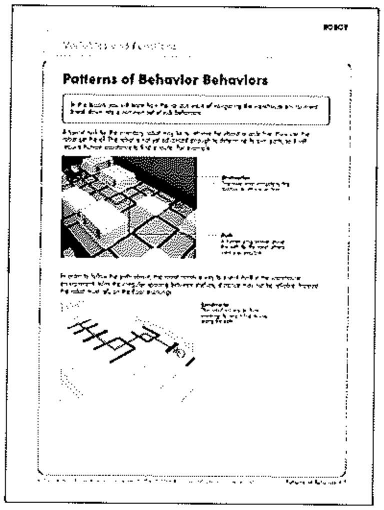






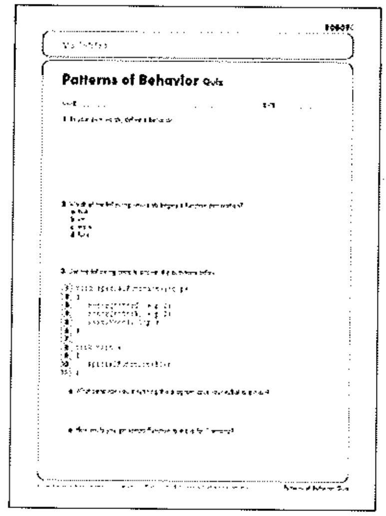
Programming/Variables and Functions/Patterns of Behaviors

Sensing - Variables and Functions/Patterns of Behaviors - Print Resources

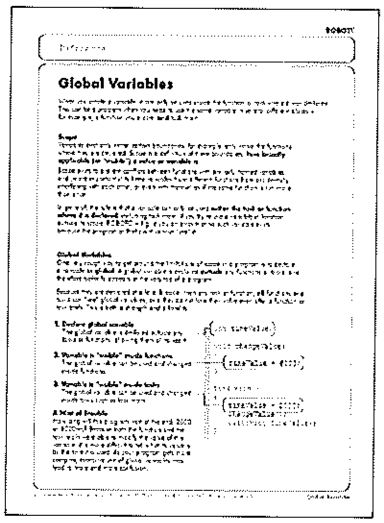

ROBOTC

Variables and Functions

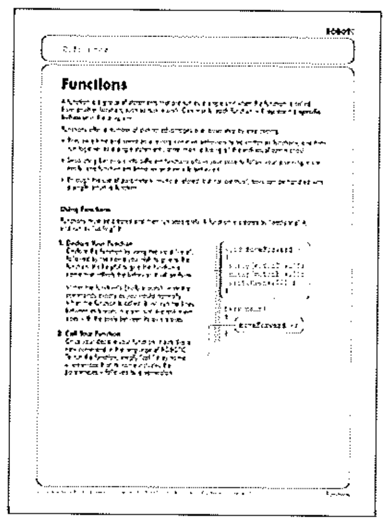
Patterns of Behavior Behaviors


ROBOTC

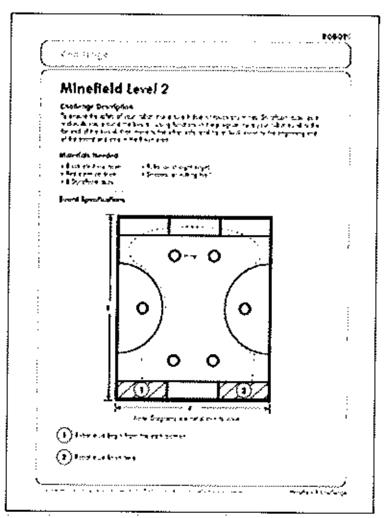
Patterns of Behavior Quiz


ROBOTC

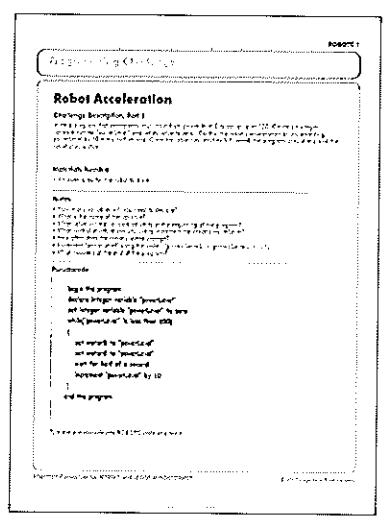
Global Variables


ROBOTC

Functions

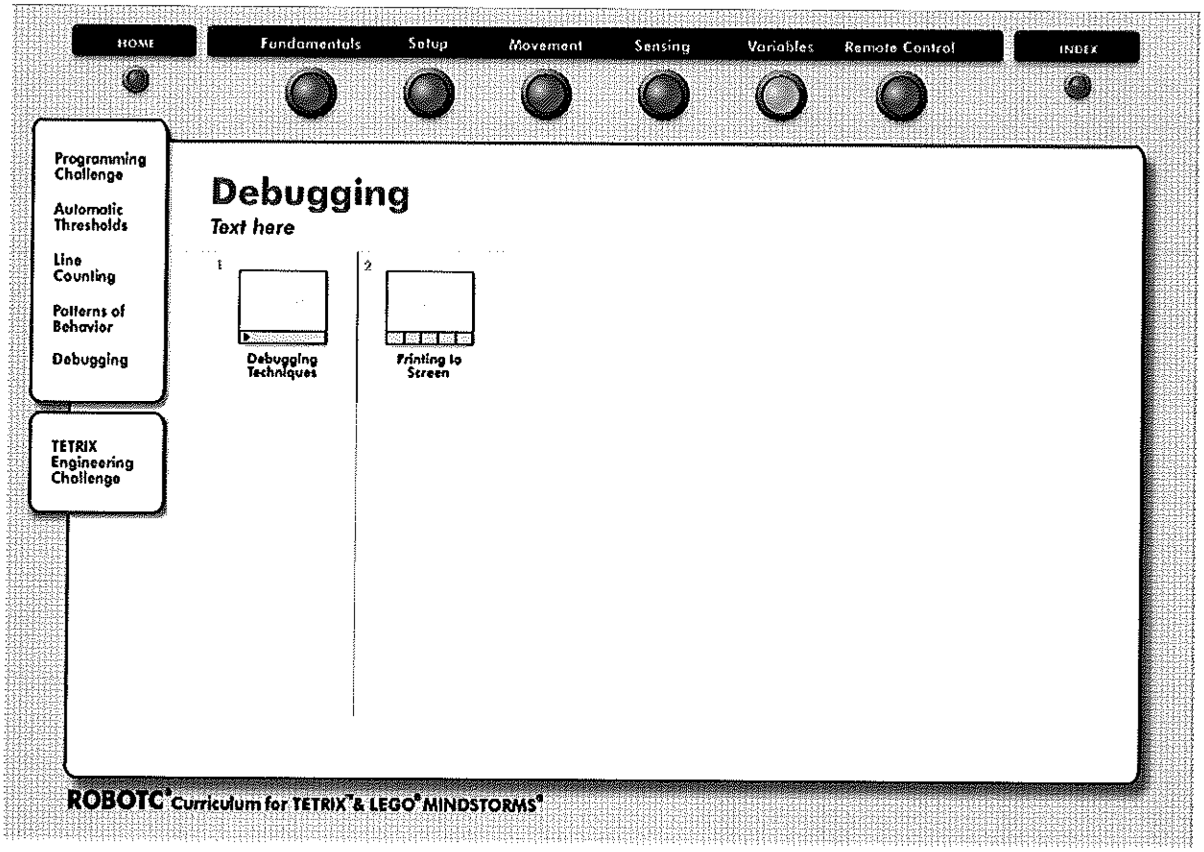

ROBOTC

Minefield Level 2


ROBOTC

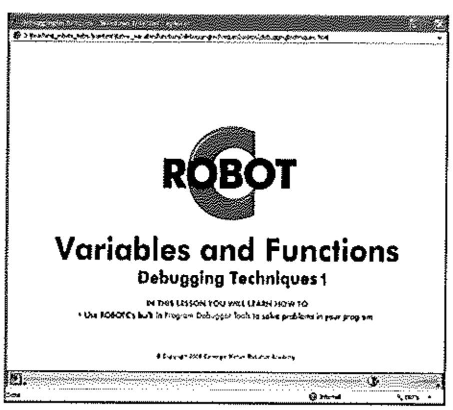
Robot Acceleration

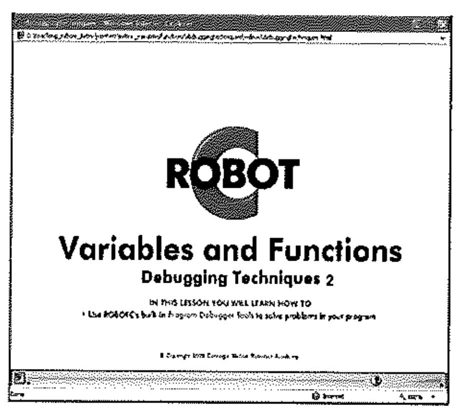
Programming/Variables and Functions/Debugging



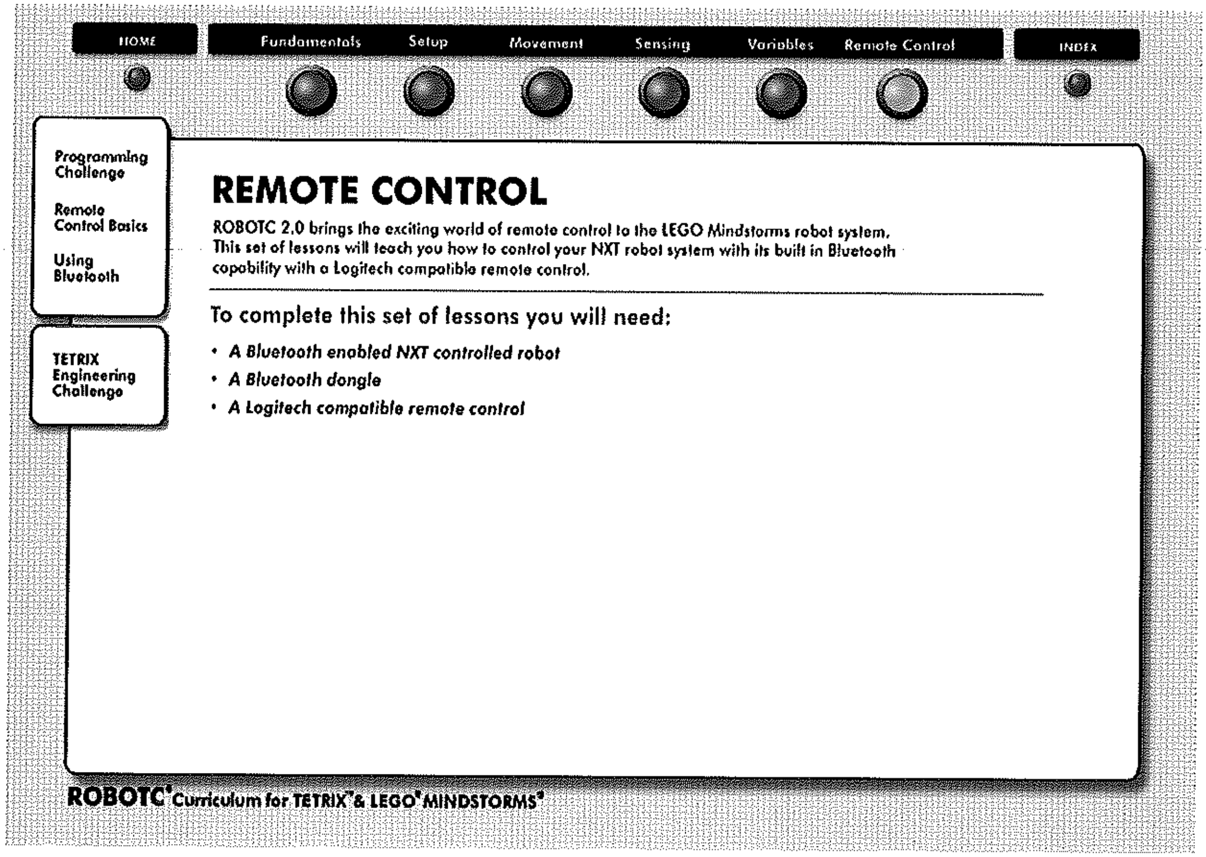
Sensing - Variables and Functions/Debugging

The Debugging Lesson Set consists of a set of videos designed to highlight ROBOTC's debugging screen. The first video, Debugging Techniques has the student open up a sample program that shows them how to open up the expert mode to use the higher level debugging tools available through ROBOTC. Students will learn how to use the step into, step over, step out, breakpoint, and clear all features found on the debug start menu. The second video set, Printing to Screen, highlights the advantage of using the on screen NXT display so that you can see values as you troubleshoot your code.





Programming/Remote Control

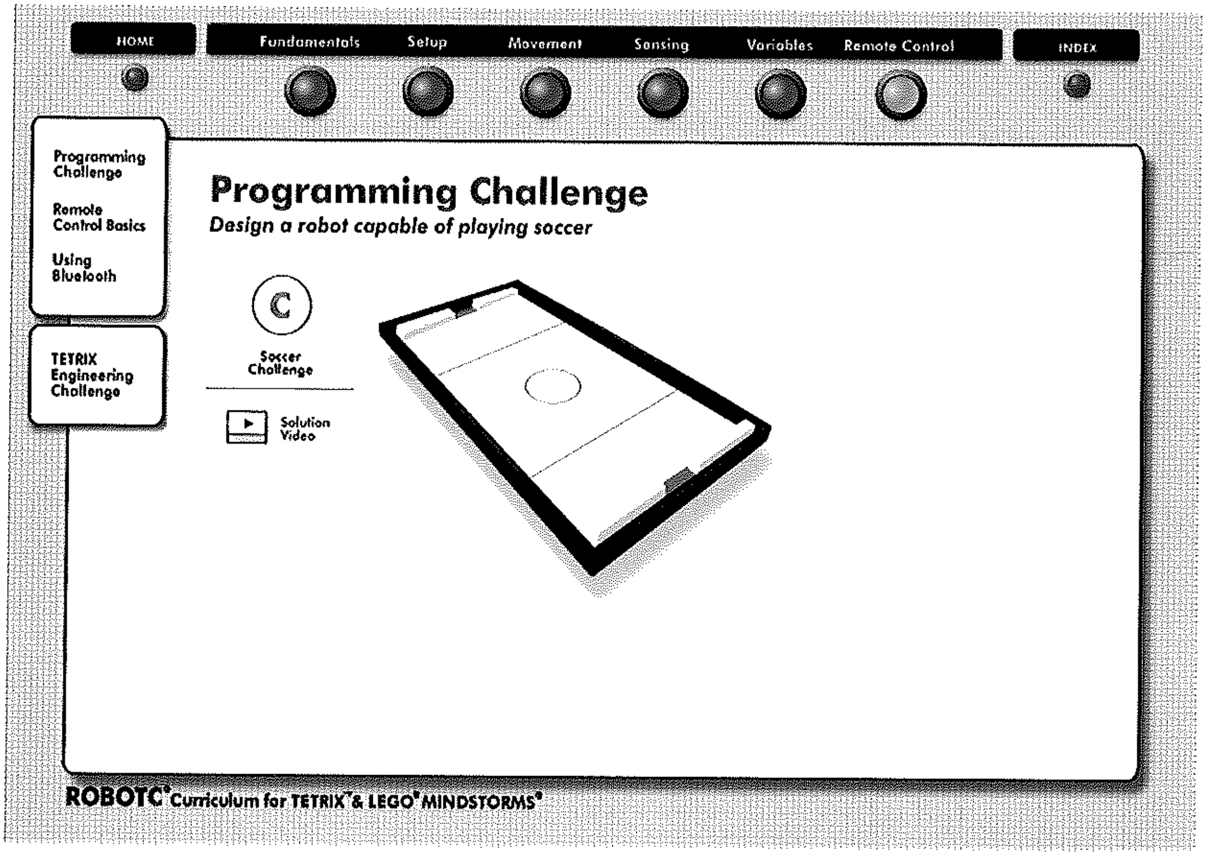


Programming/Remote Control

The Remote Control Unit teaches students how Bluetooth works, how to troubleshoot Bluetooth, and how to program their remote control unit. ROBOTC allows two Logitech remote control units to control one robot. All of the lessons in this curriculum are designed for one remote control unit. For more information on controlling one robot with two remote control units refer to the built in help in ROBOTC.

Everything that works with the NXT robot system with remote control also works with the TETRIX system.

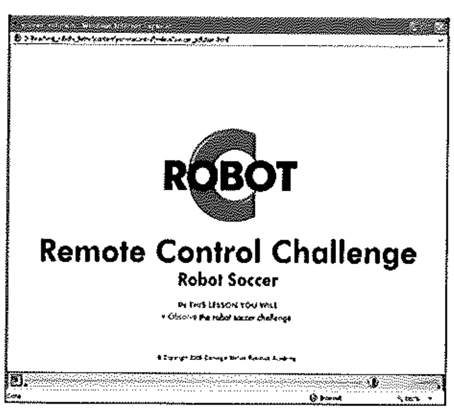
Programming/Remote Control/Programming Challenge

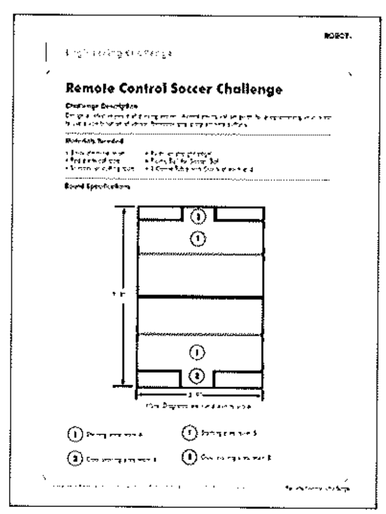


Programming/Remote Control

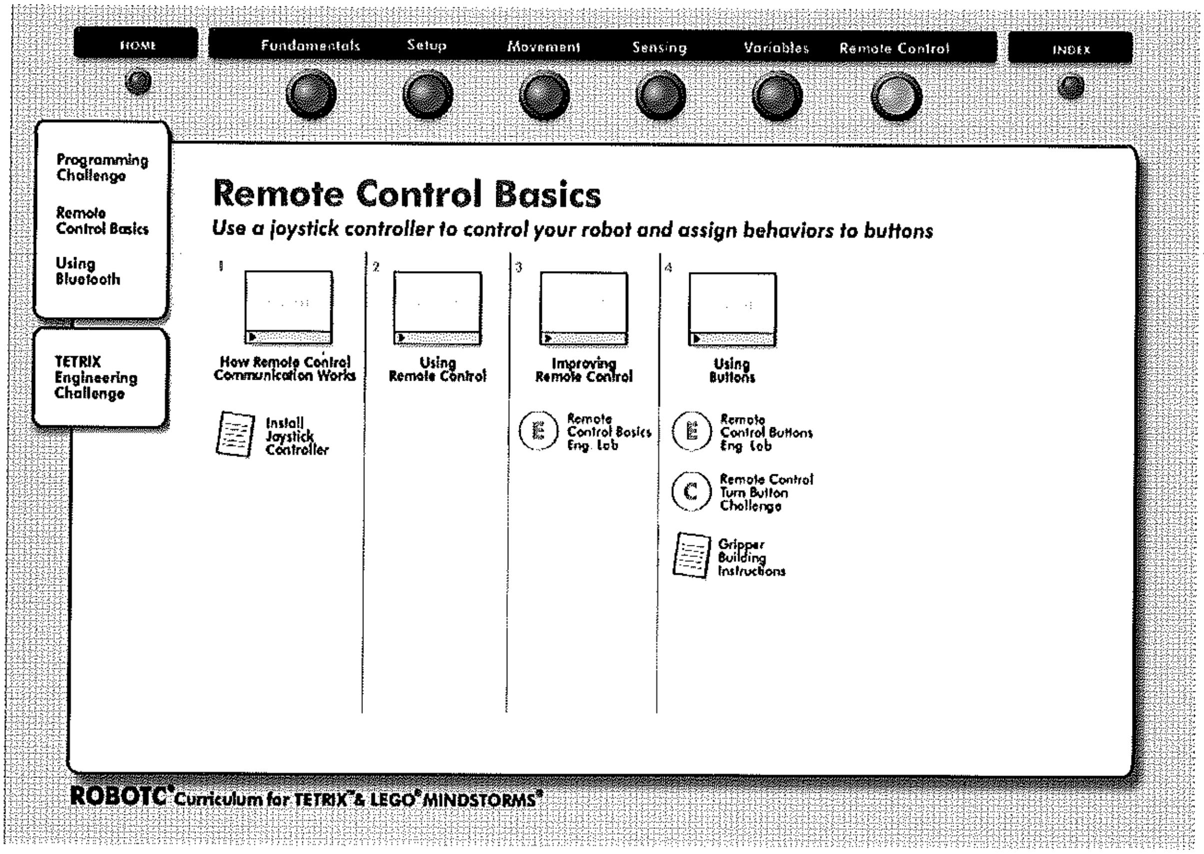
The Remote Control Robot Soccer Programming Challenge provides a fun engineering/programming challenge that students of all levels enjoy. In the Remote Control programming unit, students will learn how to program the joysticks and buttons on their Logitech remote control units to produce desired behaviors like "kick the ball" or "drive straight". They already know how to program using the LEGO sensors, but there are a whole array of other third party sensors available that make the robot soccer challenge a great engineering/programming challenge. Two sensors that come to mind quickly are the compass sensor and the IR sensor. In the TETRIX lessons you will learn to program the IR sensor using ROBOTC and the compass sensor is very easy to program. The soccer challenge is a very good challenge at all levels middle school through adult hobbyist.

The following resources are available to preview the challenge:





Programming/Remote Control/Remote Control Basics



Remote Control Basics

The Remote Control Basics Lesson Set teaches students everything that they need to know to combine autonomous and remote control programming. This is a very powerful addition to the LEGO's already powerful NXT hardware. This Lesson Set contains two Remote Control Engineering Labs where students will be guided step-by-step toward a successful implementation of a combination of remote control and autonomous programming. The following resources are available to support this Lesson Set:

How Remote Control Communications Works Video - This video describes the communications between the Logitech Remote Control, the computer, and the NXT based robot.

Using Remote Control Video - In this lesson, students learn about include files, the new functions that are made available via the include file, and how the new functions map to the Logitech remote control.

Improving Remote Control Video - This lesson teaches students how to improve the joystick control via variable math and creating a dead zone on their remote control.

Using Buttons Video - This lesson teaches students how to program the buttons on the Logitech controller.

Install the Joystick Controller Reference - This is a reference PDF that helps to install and troubleshoot the Logitech remote controller installation.

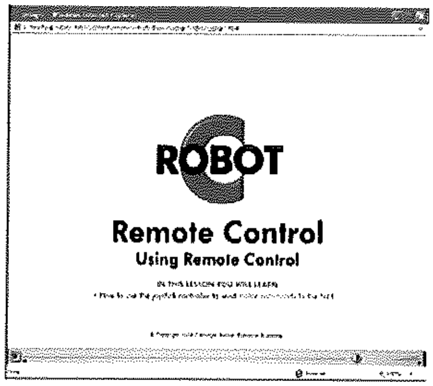
Remote Control Basics Engineering Lab - This lab provides step-by-step instructions designed to help a student to learn how to program the Logitech remote controller joysticks to control the NXT.

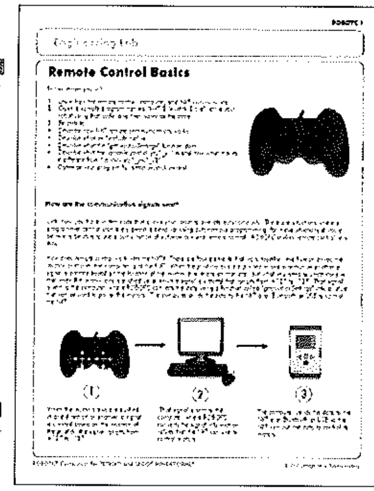
Remote Control Buttons Engineering Lab - This lab provides step-by-step instructions on how to write a program that enables the Logitech remote controller buttons to control the NXT.

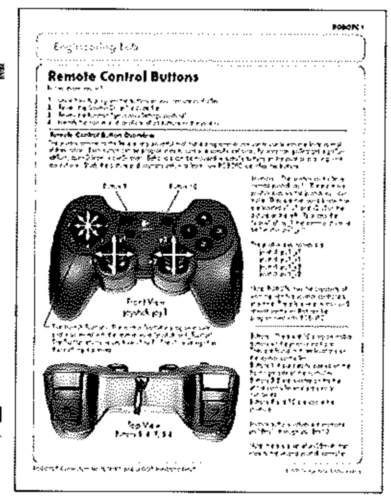
Gripper Building Instructions - A set of instruction for students to use to build a LEGO gripper.

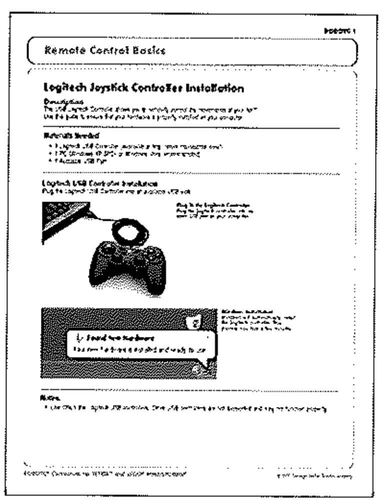
Programming/Remote Control/Remote Control Basics

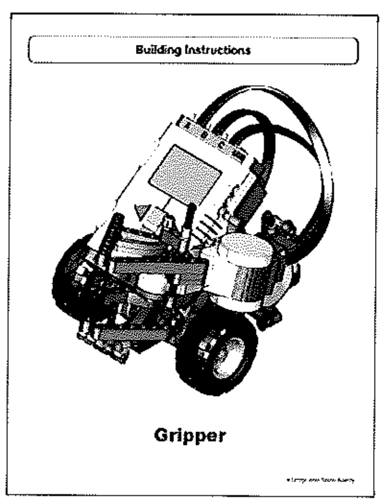
Remote Control Basics Resources

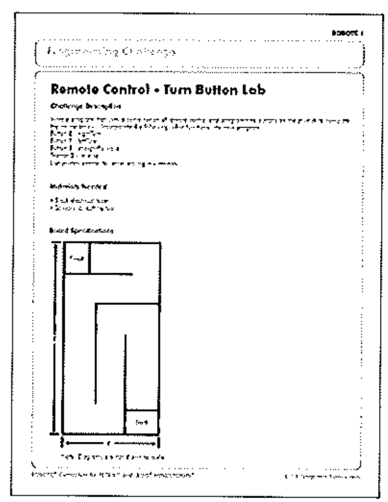




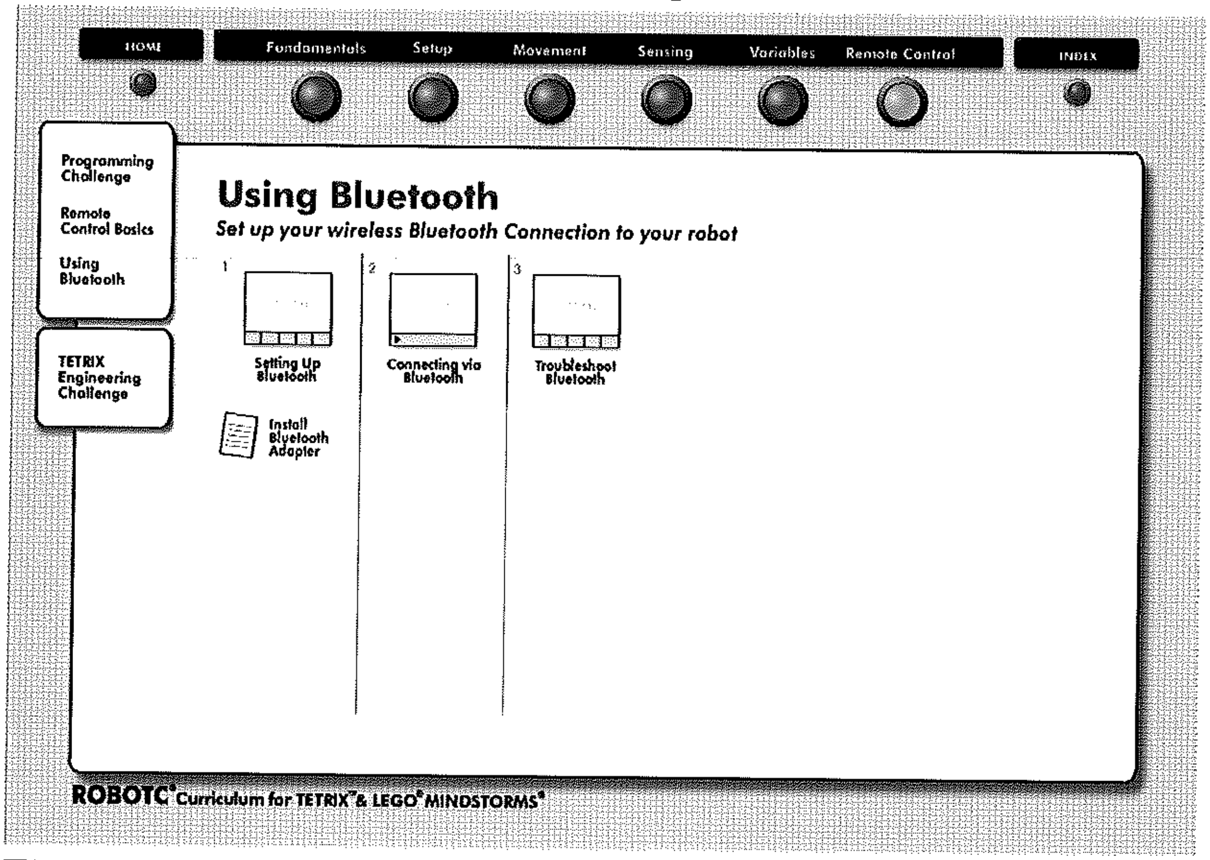








Programming/Remote Control/Using Bluetooth



Using Bluetooth

The Using Bluetooth Lesson Set is designed to help a first time user connect their computer to their NXT. There are four resources available in this section that have multiple components designed to ensure success.

The Setting Up Bluetooth Video Set - This Lesson Set focuses on answering the following questions: What is Bluetooth? How do I rename my NXT so that it is easy for Bluetooth to recognize? and How do I ensure that my NXT is visible to my computer?

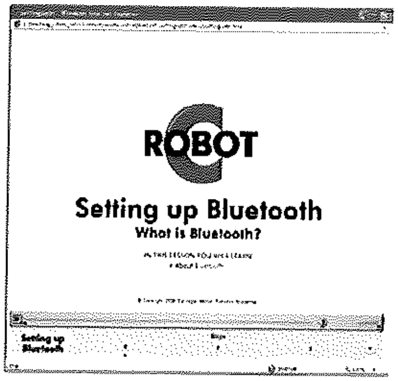
The Connecting Via Bluetooth Video - This video demonstrates step-by-step how to connect via Bluetooth using ROBOTC.

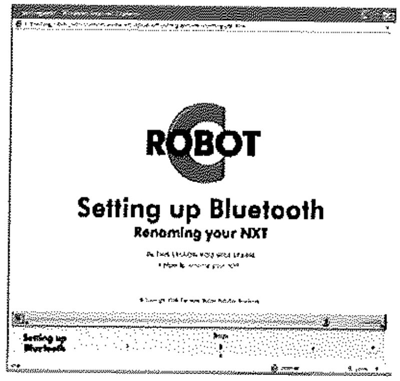
The Troubleshooting Bluetooth Video Set - This troubleshooting guide consists of six things to consider if your Bluetooth connection isn't working.

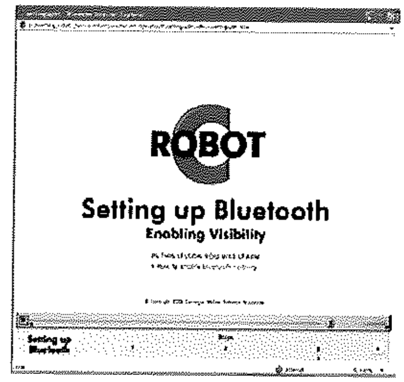
Installing your Bluetooth Adaptor Reference Guide - A one page handout that describes the Bluetooth adaptor.

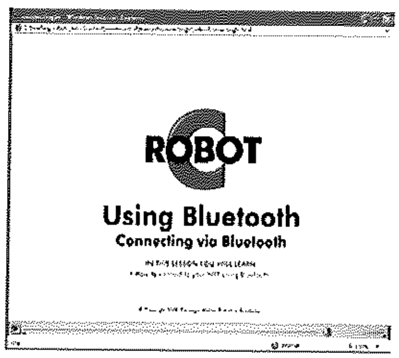
Programming/Remote Control/Using Bluetooth

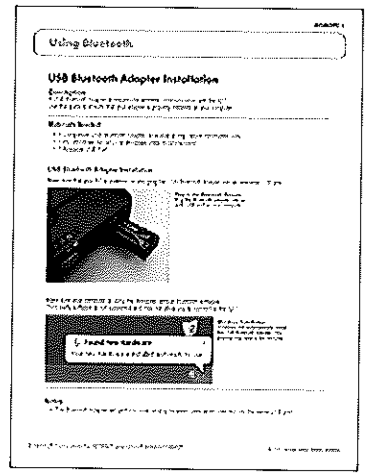
Using Bluetooth Resources

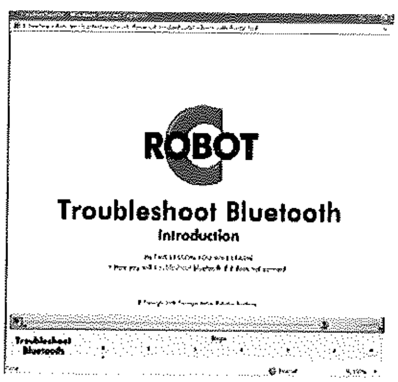


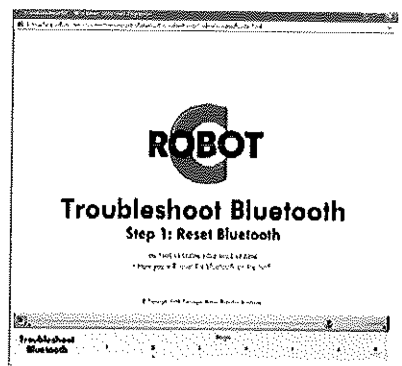


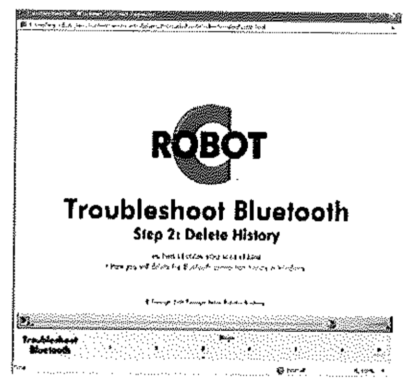


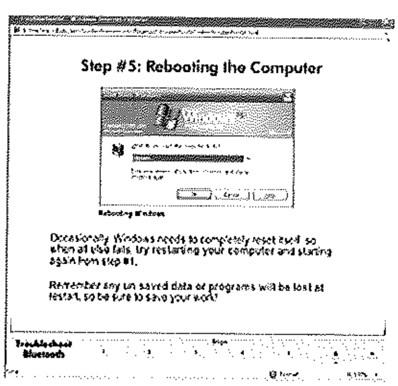


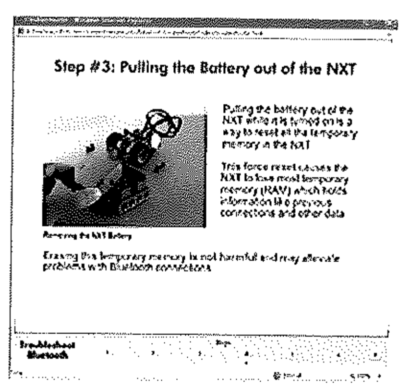


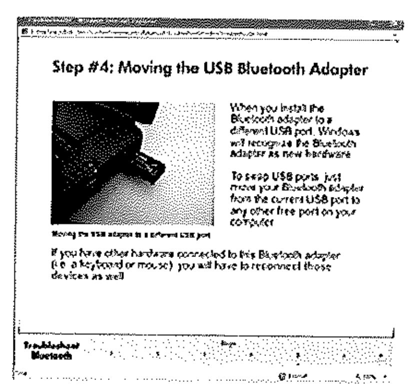




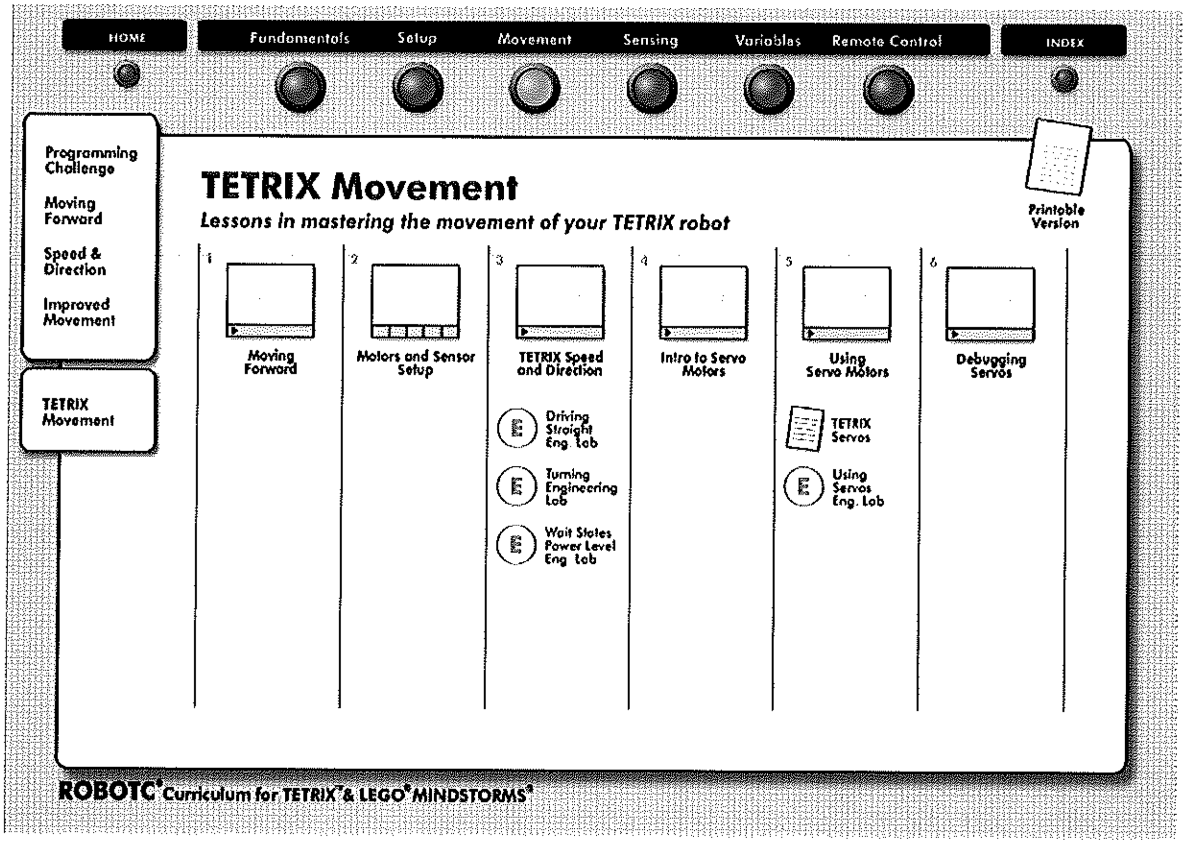








TETRIX Movement



TETRIX

This curriculum assumes that the student has completed all of the NXT lessons ***before*** they start the TETRIX section. We've chosen to introduce the TETRIX training materials that way because it is easier to learn a system with less inputs and outputs before a student begins to learn a more complicated system.

The TETRIX hardware and building system is well supported in this curriculum. The developers of ROBOTC have invested man-years of time developing an interface that uses programming wizards that make the integration of the NXT hardware with the TETRIX controllers and new sensors very achievable for high school level students. The movements section is designed to introduce students to similarities between using ROBOTC with the NXT system and ROBOTC with the TETRIX system. The Movement Lesson Set includes the following video resources:

Moving Forward Video - This lesson is designed to show the easy transition from the NXT robot system to the TETRIX robot system. Students will learn how to change platform types and how to name the TETRIX motors using ROBOTC.

Motors and Sensors Setup Video SET - This Lesson Set is a six video set where students learn to configure the motors and sensors configuration window. In this Lesson Set they will learn: what pragma statements are, how to configure the motor and setup window for the controllers that they are using with their TETRIX robot system, how to enable motors, how to reverse polarity of the motors, and how to rename motors using the motor and setup configuration window.

TETRIX Speed and Direction Video - This lesson teaches students how to change the robot's speed and direction.

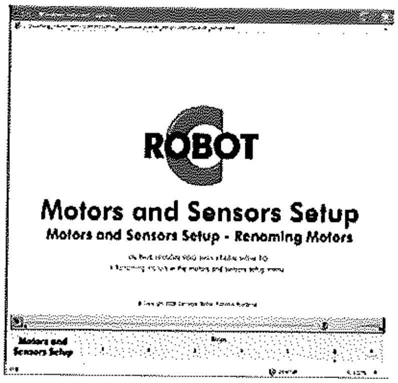
Introduction to Servo Motors Video - This lesson teaches students what servo motors are. They learn the difference between servos and DC motors as well as the servo motor's advantages and limitations.

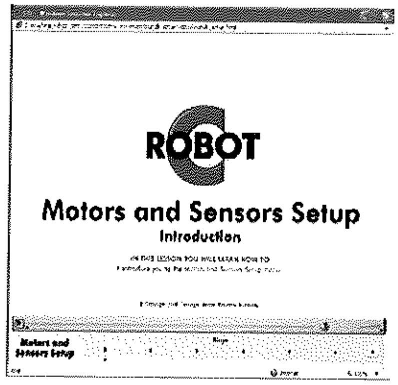
Using Servo Motors Video - This lesson teaches students how to program servos using ROBOTC.

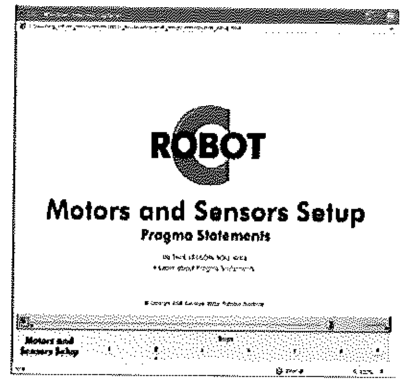
Debugging Servos Video - This lesson teaches students how to use the powerful servo configuration window to program their servos locations.

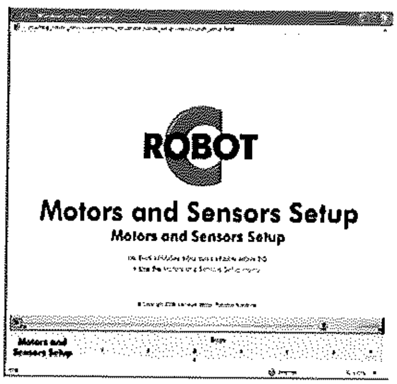
TETRIX Movement

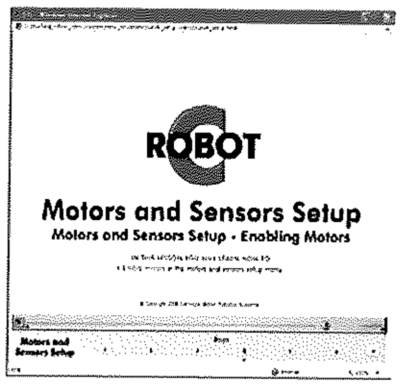
TETRIX Video Resources

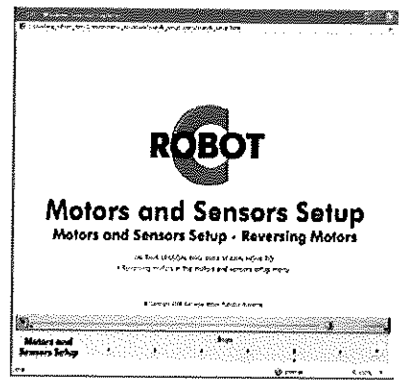


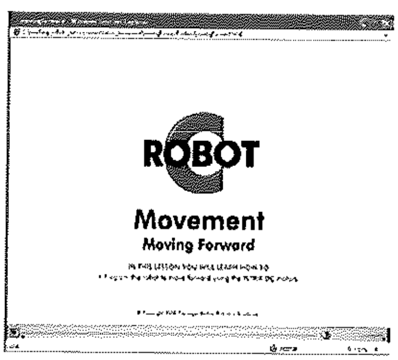


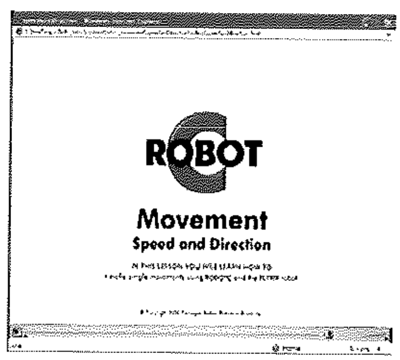


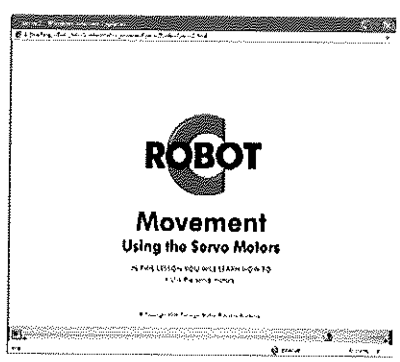












TETRIX Movement

TETRIX Print Resources

TETRIX Movement PDF - This is a printable version of the videos in the TETRIX Movement Lesson Set designed to complement the videos and provide a study guide for students.

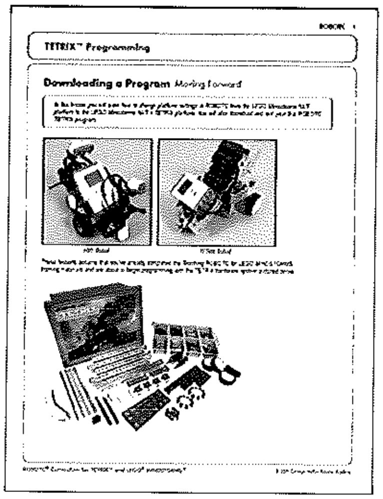
Drive Straight Lab - This lab is designed to introduce students to the difference in control between the NXT robot system and the TETRIX robot system. Without encoders students will need to modify the robot's motor power in order to move straight.

Turning Engineering Lab - This lab enables students to iteratively test their robot's ability to achieve accurate turns.

Wait States Power Level Engineering Lab - The TETRIX motors move much faster than the NXT motors. This engineering lab is designed so that students setup an experiment, collect data, and analyze the difference between the NXT and TETRIX motors.

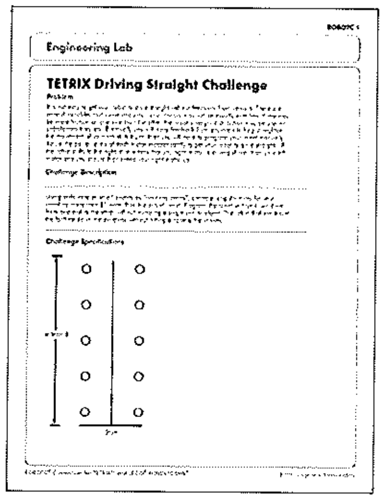
TETRIX Servo Reference Handout - Servos are different than DC motors. This reference explains how servos work.

Using Servos Engineering Lab - This engineering lab is designed to guide students through a step-by-step experience where they learn to use TETRIX servos and ROBOTC's servo configuration menu.



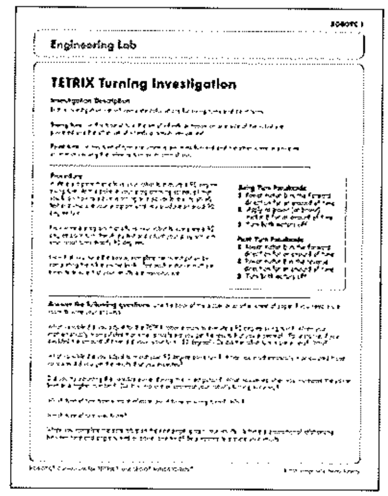
TETRIX™ Programming

Downloading a Program



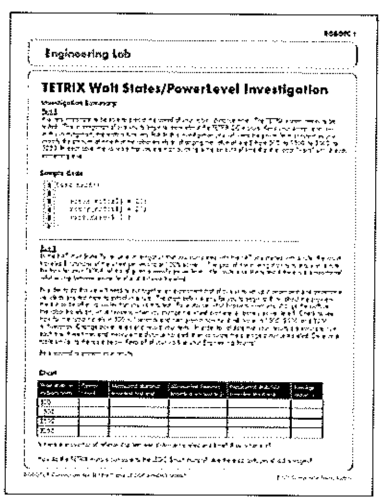
Engineering Lab

TETRIX Driving Straight Challenge



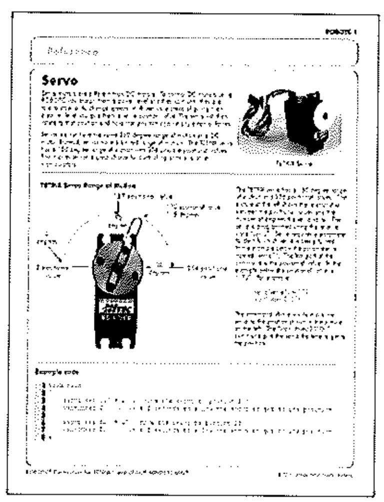
Engineering Lab

TETRIX Turning Investigation

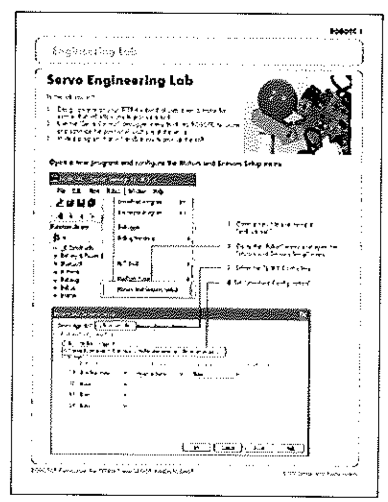


Engineering Lab

TETRIX Wait States/PowerLevel Investigation

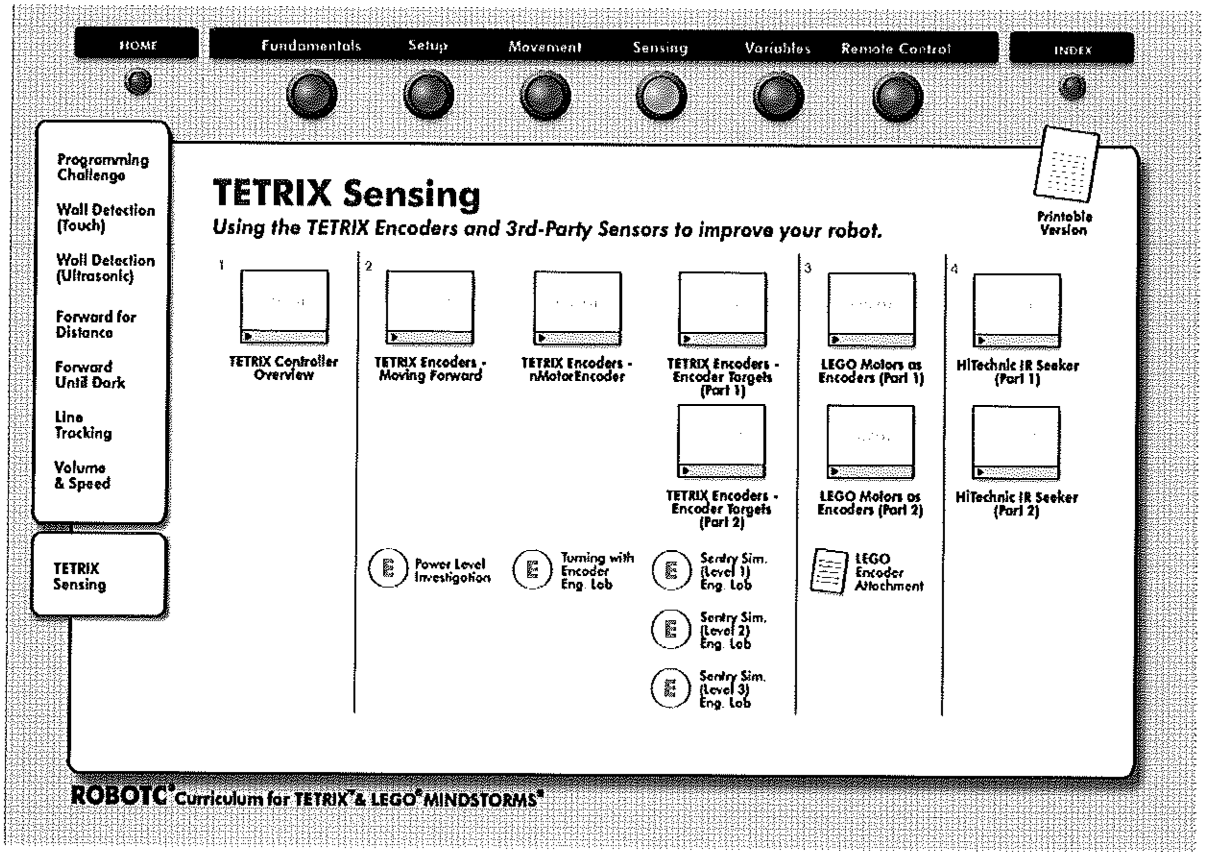


Servo



Servo Engineering Lab

TETRIX Sensing



TETRIX Sensing

The TETRIX Sensing Lesson Set teaches: how the TETRIX controller works, how to program the TETRIX encoders to allow your robot to accurately move point to point, how to use the LEGO smart motors as encoders for the TETRIX DC motors, and how to program the IR sensor to work with the TETRIX robot system. All sensors that work with the LEGO NXT works with the TETRIX system. The following video resources support this Lesson Set:

TETRIX Controller Overview Video - This lesson teaches how ROBOTC, the NXT, and the TETRIX controllers communicate.

TETRIX Encoders Moving Forward Video - This lesson teaches how the TETRIX encoders work.

TETRIX Encoders nMotorEncoder Video - This lesson teaches how to program the TETRIX motors using the nMotorEncoder function.

TETRIX Encoder Targets Part 1 Video - This lesson teaches how the nMotorEncoderTarget function works with the nMotorRunState function to allow very accurate movement of the TETRIX hardware system.

TETRIX Encoder Targets Part 2 Video - This videos show how to program TETRIX using nMotorEncoderTarget.

LEGO Motor as Encoder Part 1 Video - This lesson introduces how you can use the LEGO smart motors as encoders for the TETRIX system if you do not have the TETRIX encoders.

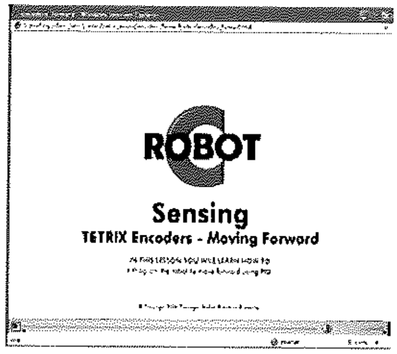
LEGO Motor as Encoder Part 2 Video - This video shows how to write a program that uses the LEGO smart motors as an encoder for the TETRIX system.

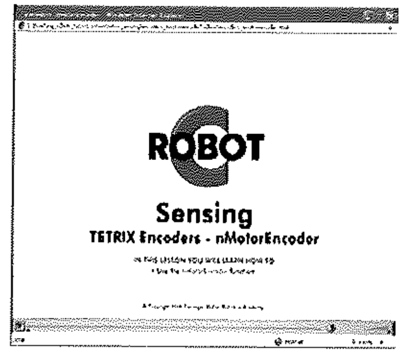
HiTechnic IR Seeker Part 1 Video - This lesson shows conceptually how the IR seeker is programmed.

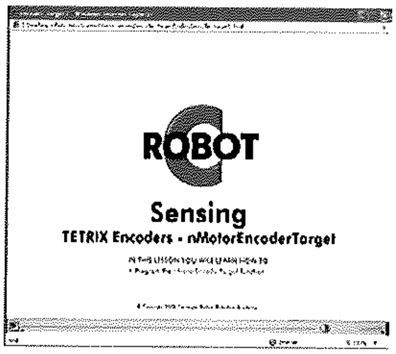
HiTechnic IR Seeker Part 2 Video - This video shows how to write the program for the IR seeker.

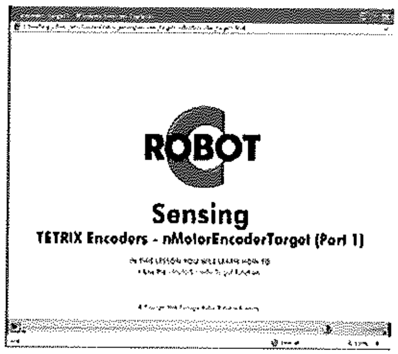
TETRIX Sensing

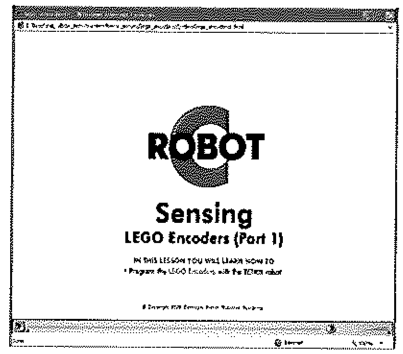
TETRIX Sensing Video Resources











TETRIX Sensing

TETRIX Sensing Print Resources

TETRIX Sensing PDF Print Resources - This PDF is a print version of the videos that are included in the TETRIX Sensing Lesson Set.

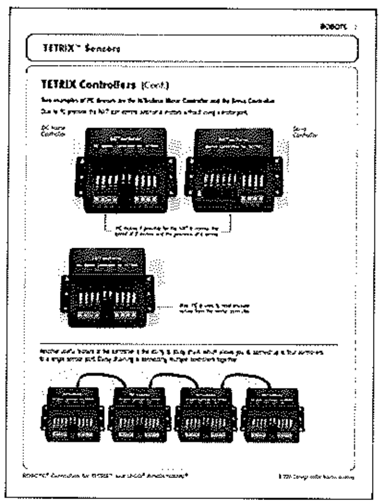
Power Level Engineering Lab - In this lab students will change the power level and keep the TETRIX encoder value the same and see if there is a proportional relationship between power level and distance traveled.

Turning with Encoder Engineering Lab - In this lab students will find the encoder value of a specific angle turn and then predict and test for other encoder values for turns. Students will do this for both point and swing turns.

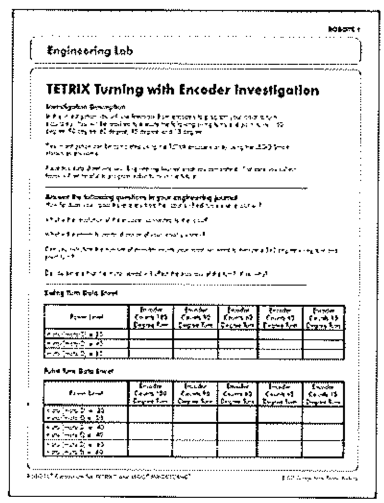
Sentry Simulation Level 1 - Students develop a robot solution of a sentry robot.

Sentry Simulation Level 2 - Students develop a robot solution of a sentry robot that is able to identify objects in the robot's path and react to the objects.

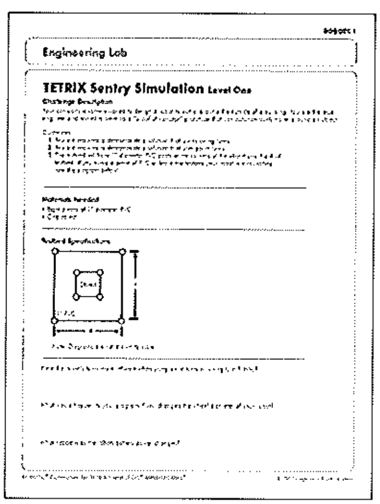
Sentry Simulation Level 3 - Students develop a robotic solution of a sentry robot that identifies intruders, sounds an alarm, and sends data back to the host computer via Bluetooth.


TETRIX™ Sensors

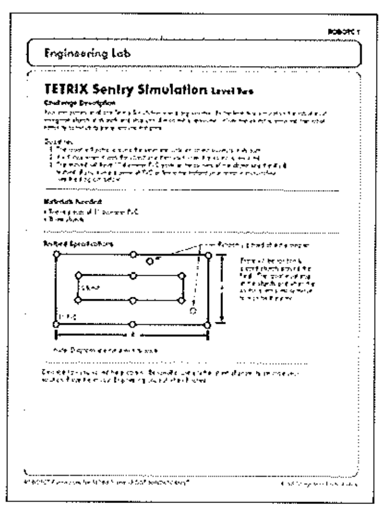
TETRIX Controllers (Cont.)


Engineering Lab

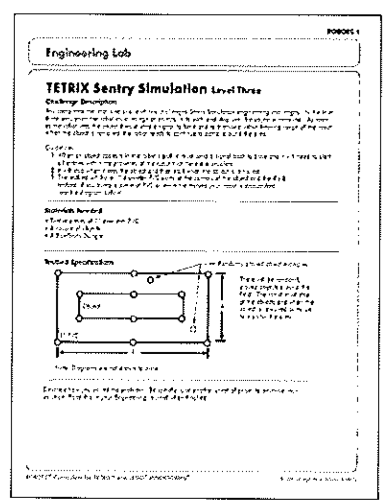
TETRIX Turning with Encoder Investigation


Engineering Lab

TETRIX Sentry Simulation Level One

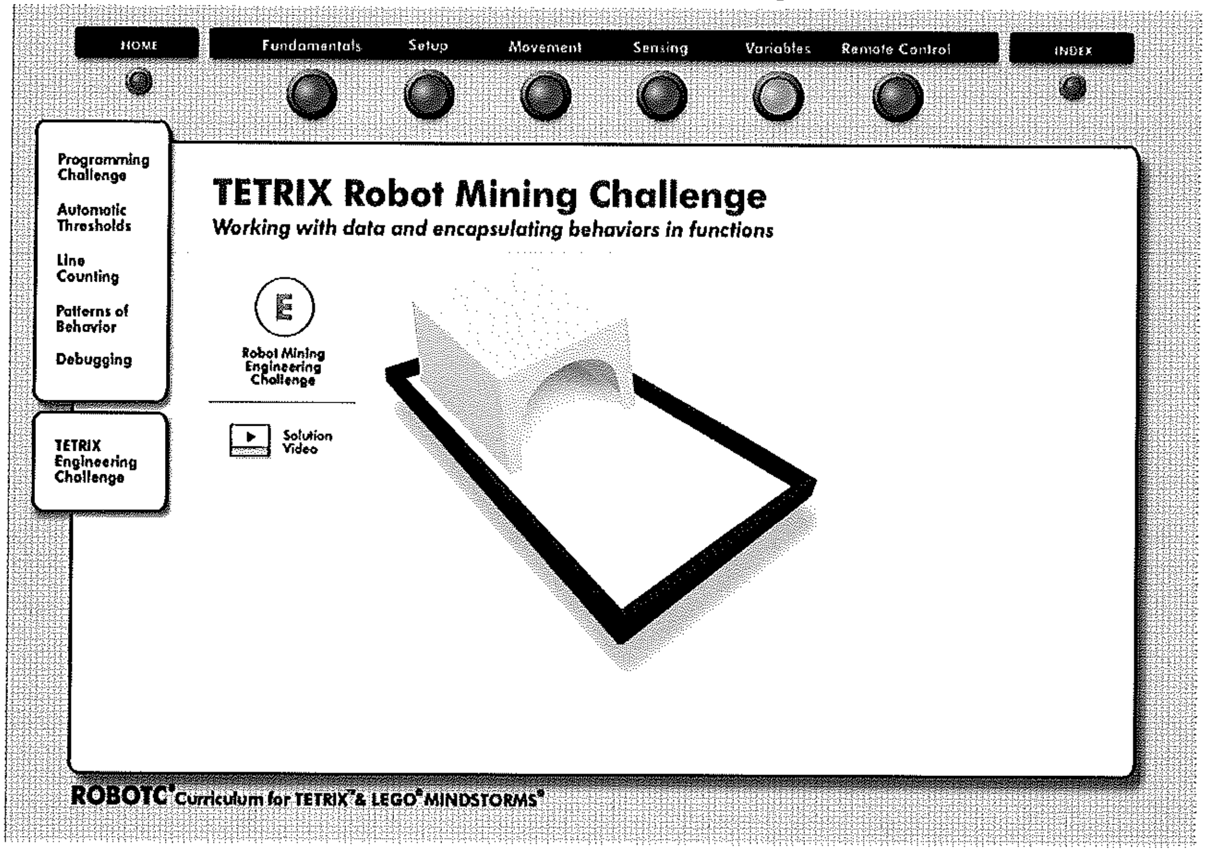

Engineering Lab

TETRIX Sentry Simulation Level Two


Engineering Lab

TETRIX Sentry Simulation Level Three

TETRIX Robot Mining Engineering Challenge



TETRIX Robot Mining Challenge

The Robot Mining Challenge is a 6 - 9 week engineering design problem. This challenge involves both research and engineering. Students are required to think about solving a large problem in the mining industry. They are given an "RFP" (a request for proposal) that they are to respond to. They will conduct research to evaluate the types of solutions currently being employed in the mining industry to map mines and then they are to develop a robotic prototype of their solution. The prototype can be solved using a LEGO NXT only solution or a TETRIX solution. This engineering problem is supported with the following resources:

TETRIX Engineering Challenge Solution Video - This video shows a TETRIX robot going into a simulated mine, the video includes a screen shot of what the command center might see in the student's mapping solution.

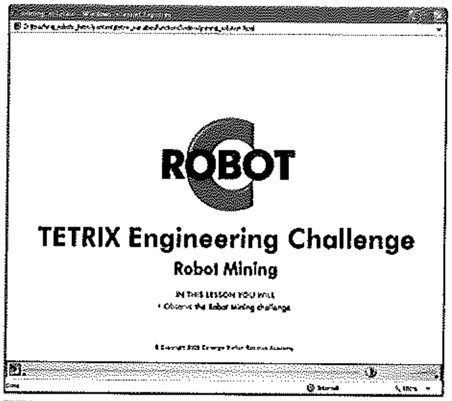
The Robot Mining Engineering Design Challenge - This challenge is build around a four step process: research, plan, prototype, and iteratively test potential engineering solutions. Each section of the engineering problem has a set of resources to support the problem solver as well as a description of what the student should be collecting for their engineering design notebook.

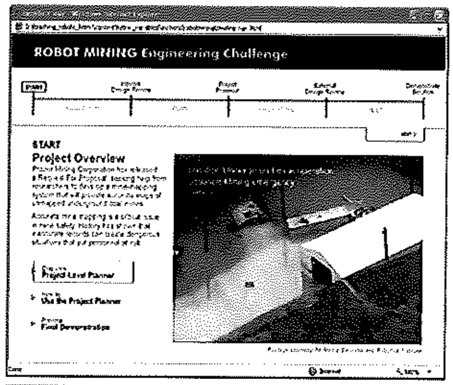
Research Investigations - There are three research investigations that the engineering design team is responsible to complete: Choosing a Sensor, Scanning and Mapping, and Remote Communications. There may be other teacher assigned research if the student has access to the additional resources. For instance, if their solution implemented a camera, then students would need to conduct research on the best camera solution and why.

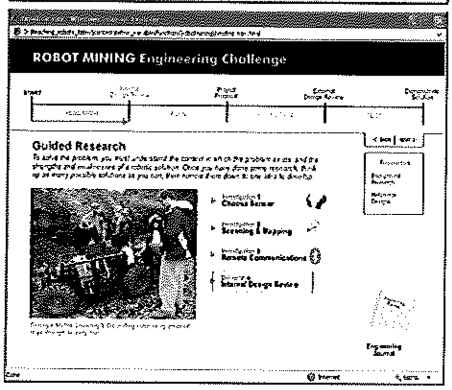
Printed Project Requirements - The Robot Mining Engineering Challenge has a set of embedded print resources to help the student manage the project. The resources include: a project level planner, a preview of the final demonstration deliverables, time management tools, responsibility matrixes, design specifications, a scoring rubric, and more.

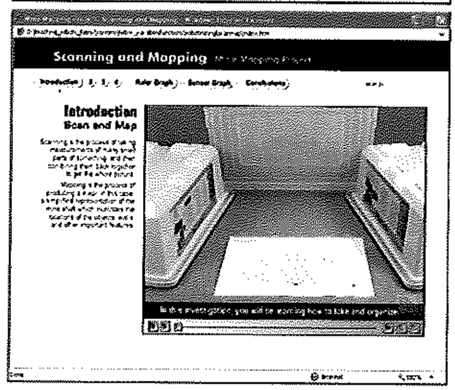
TETRIX Robot Mining Engineering Challenge

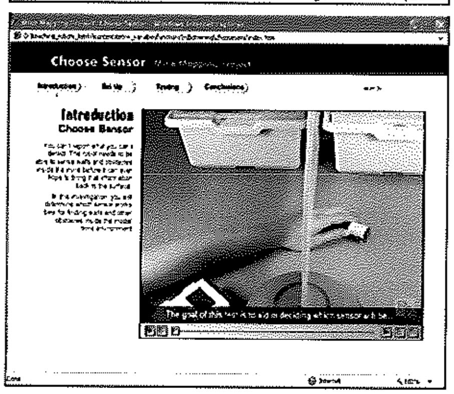
TETRIX Robot Mining Challenge Video Resources

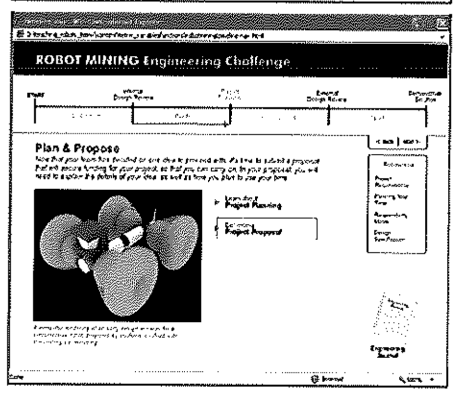


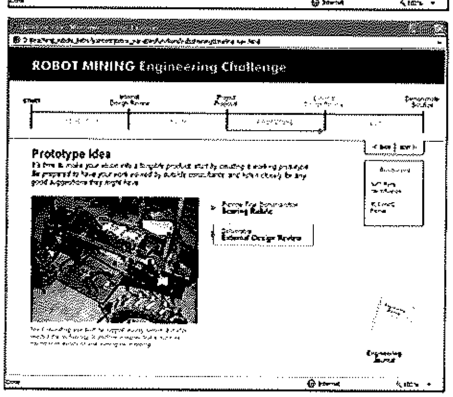


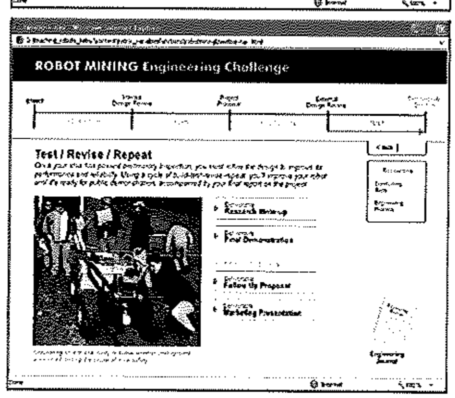




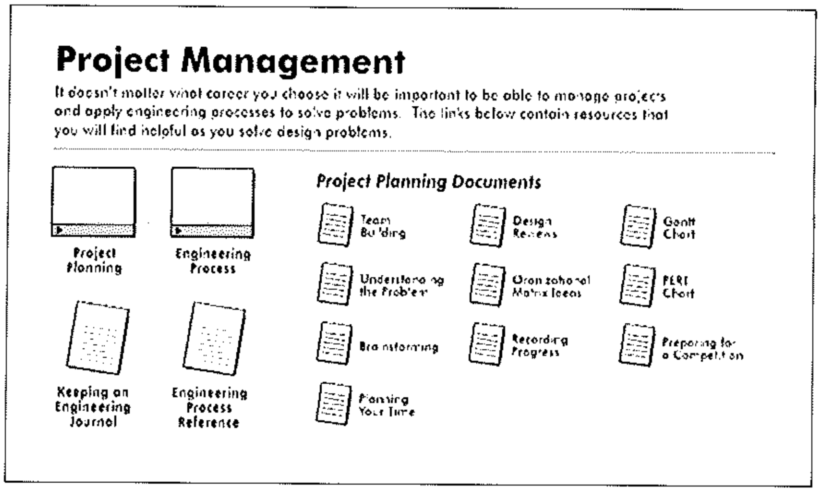








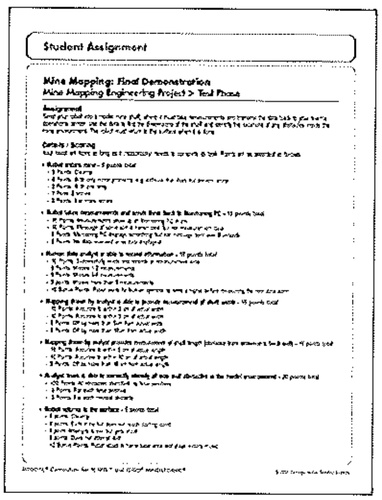
TETRIX Robot Mining Engineering Challenge

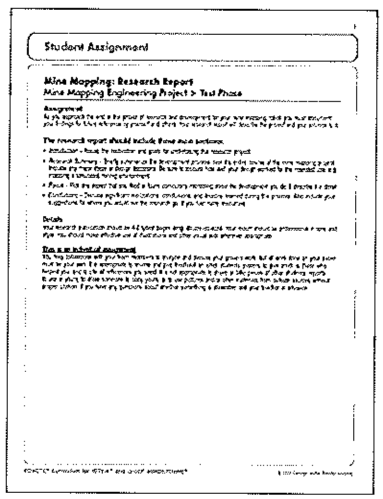


Resources in Fundamentals

The project management resources found in the fundamental section of the curriculum will be used extensively to solve this engineering design problem. Pictured on the left are a list of resources found in the fundamentals section.

TETRIX Robot Mining Challenge Print Resources





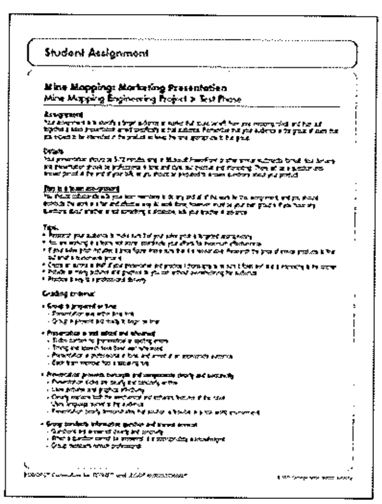
Mine Mapping: Final Demonstration - This handout describes how the solution will be evaluated.

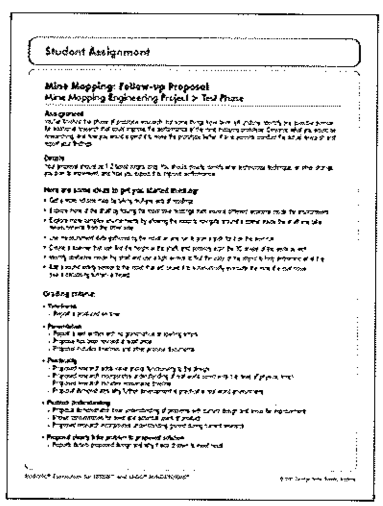
Mine Mapping: Request for Proposal - This document describes the project requirements.

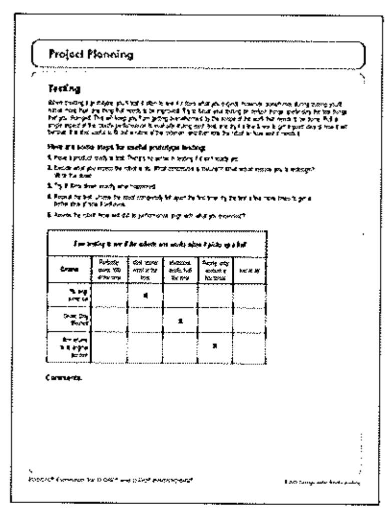
Mine Mapping: Research Report - Describes a student assignment that requires them to write up what they've learned during the project.

Mine Mapping: Marketing Presentation - Describes the requirements for the end of the project presentation.

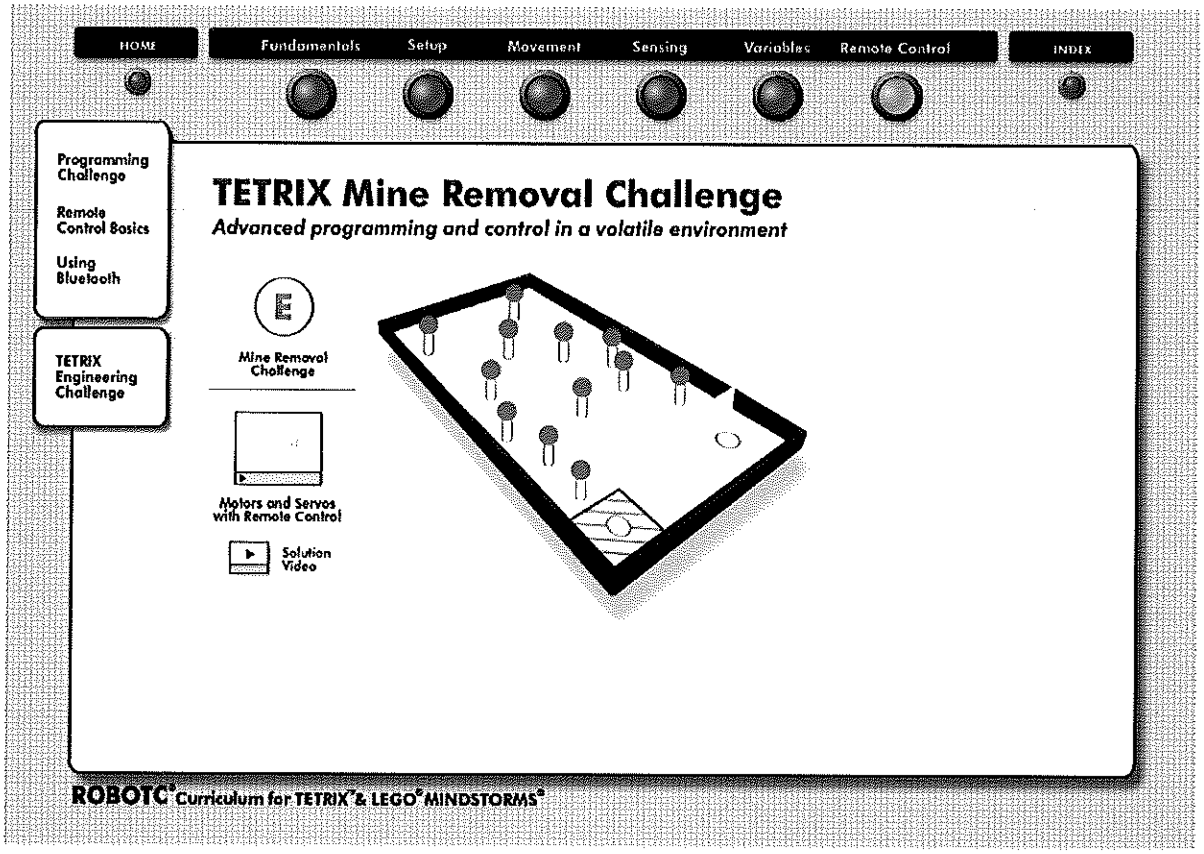
Conducting Tests - A set of guides to setup fair tests to analyze the project prototype's success.





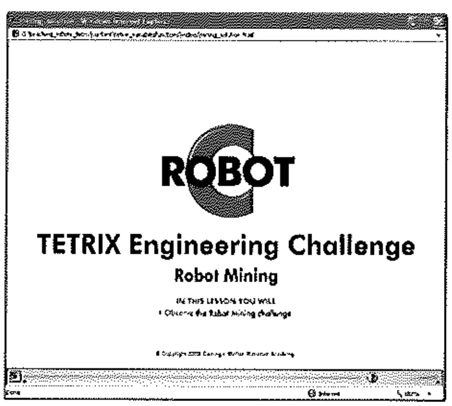


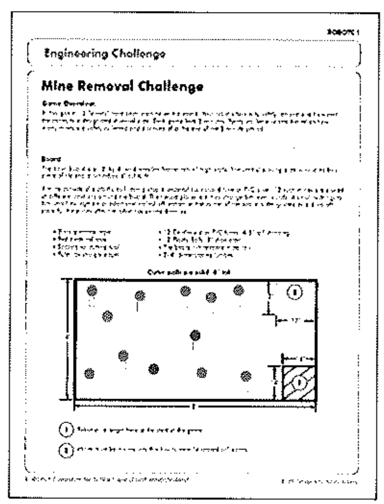
TETRIX Robot Mining Removal Challenge



The TETRIX Mine Removal Challenge

This challenge uses a combination of remote control and autonomy and challenges the student to optimize their TETRIX solution as they solve the engineering challenge.





How Robotics Aligns with Standards

This section describes how robotics as a content area aligns with National Science, Mathematics, Technology, and Communications Standards. Below you will see the format that we use to show how robotics education aligns to national science, technology, engineering, and mathematics (STEM) standards.

Standard	Robotics Link
On the left is a description of the standard or particular point of the standard that is addressed through robotics.	On the right is a description of how robotics in general and this curriculum in particular addresses this standard.

Science Standards Addressed

From the National Science Education Standards (NSES)

Systems, Order, and Organization

The natural and designed world is complex; it is too large and complicated to investigate and comprehend all at once. A system is an organized group of related objects or components that form a whole. The goal of this standard is to think and analyze in terms of systems. Science assumes that the behavior of the universe is not capricious, that nature is the same everywhere, and that it is understandable and predictable. Prediction is the use of knowledge to identify and explain observation, or changes, in advance. The use of mathematics allows for greater or lesser certainty of predictions. Order is the behavior of units of matter, objects, organisms or events in the universe – can be described mathematically. Types and levels of organization provide useful ways of thinking about the world	Robots are excellent examples of systems, with many heterogeneous components interacting in organized, methodical ways to achieve results as a whole that they could not have achieved separately. Examples include: • Navigation systems (e.g. sensor tells the robot where it is, programmable controller tells the robot how to interpret this information, motors move in order to achieve the desired result) • Sensing systems (electrical, mechanical, and programming elements of a sensor) • Power & transmission systems (motor, axle, gear, wheel) • Manipulator systems • Lifting systems, vision systems, etc. Each system can be broken down into subsystems. Robotics technology is built upon a series of behaviors that can be measured mathematically and are understandable and predictable. There are many examples that are easy for students to manipulate and understand: • Gears and mechanical advantage • Sensors and electronic control • Wheel diameter and its effect on distance traveled • Rotation sensor readings and robot path planning

Science Standards continued

From the National Science Education Standards (NSES)

Evidence, Models and Explanation

Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems.

Models are tentative schemes or structures that correspond to real objects, events, or classes of events that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations and computer simulations.

Scientific explanations incorporate existing scientific knowledge and new evidence into logical statements. Terms like "hypothesis," "model," "law," "theory," and "paradigm" are used to describe various scientific explanations.

The investigations included in this curriculum allow students to collect evidence to investigate scientific principles. Robots physically demonstrate many scientific concepts to make them more clear and understandable.

Examples include:

- Electronics and basic circuitry, which can be demonstrated using touch sensors and the NXT power supply
- Gear trains, which demonstrate the ability to mathematically predict mechanical advantage and speed.
- Light sensors, which can detect infrared as well as visible light

Constancy, Change and Measurement

Although most things are in the process of becoming different – changing – some properties of objects and processes are characterized by constancy; the speed of light, the charge of an electron, the total mass plus energy of the universe.

Energy can be transmitted and matter can be changed. Nevertheless, when measured, the sum of energy and matter in the system, and, by extension, the universe, remains the same.

Mathematics is essential for accurately measuring change.

Different systems of measurement are used for different purposes.

Scale includes understanding that different characteristics, properties, or relationships with a system might change as its dimensions are increased or decreased.

Rate involves comparing one measured quantity with another measured quantity, for example, 60 meters per second.

Robots rely on the use of many innate constants in their basic operation. Ultrasonic sensors, for instance, calculate distance based around an assumed value for the speed of sound.

In calculating the distance a robot travels per spin of its motor, fundamental mathematical relationships govern the elements of change and constancy between the different factors involved. For example, the ratio between the diameter and circumference of the wheel is constant ($C=\pi d$). On the other hand, a robot doesn't always need to use the same wheels – they can change – yet, no matter what the size of the wheel, the distance traveled per turn of the wheel remains proportional.

Measurement is fundamental to all aspects of robotics, from matching dimensions of parts to ensure that they can connect properly, to measuring how far your robot went, to measuring how well a prediction matched a result.

Science Standards continued

From the National Science Education Standards (NSES)

Evolution and Equilibrium

Evolution is a series of changes, sometimes gradual and sporadic, that accounts for the present form and function of objects, natural systems and designed systems. The general idea of evolution is that the present arises from materials and forms of the past.

Equilibrium is a physical state in which forces and changes occur in opposite and off-setting directions. For example, opposite forces are of the same magnitude, or off-setting changes occur at equal rates.

Every robot design has a story. As they build and modify their robot designs, students can trace the evolution of their creation as they adapt it in different ways that allow it to complete different tasks, building upon lessons learned from their previous designs.

Equilibrium appears in many different forms as a design factor that students will encounter in designing their robots. For example, a robot's top speed is an equilibrium point between the physical force of friction and the force generated by the motor.

Form and Function

Form and function are complementary aspects of objects, organisms, and systems in the natural and designed world.

When designing robots, form always follows function.

Whether the design decision involves using large versus small wheels, making the motor power high versus low, or selecting the sensing device the robot will use, all decisions are based on what the robot is expected to do: its function. All of these decisions will affect the final shape of the robot: its form.

Science as Inquiry – Content Standard "A"

As a result of activities in all grades, all students should develop:

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Students should be engaged in activities that:

- Begin with a question
- Allow them to perform an investigation
- Gather evidence
- Formulate an answer to the original question
- Communicate the investigative process and results

The guided investigations in Robotics Engineering are targeted at specific relevant questions about robotics technologies and concepts that lead to rich exploratory experiences.

Some investigations focus on specific portions of the inquiry process, such as evidence-gathering or hypothesis evaluation. Others begin with a question and seek an answer using general inquiry processes.

Explanation and evaluation are primary abilities applied in answering questions, not simply calculations or summarization.

Science Standards continued

From the National Science Education Standards (NSES)

Physical Science – Content Standard "B"

As a result of activities in all grades, all students should develop an understanding of:

- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

By using simple objects, such as rolling balls and mechanical toys, students can move from qualitative to quantitative descriptions of moving objects and begin to describe the forces acting on the objects.

Understanding of energy will include light, heat, sound, electricity, magnetism, and the motion of objects.

Robotics is able to demonstrate many applied physical concepts. Here are a few examples:

- Mechanical advantage (gears)
- Basic circuitry (sensor operation)
- Digital and analog electronics (sensors)
- Light (lamp, light sensor)
- Sound (ultrasonic, sound sensors)
- Speed (motors)
- Friction (robot movement)

Quantitative measurement is a staple of all investigations.

Science and Technology – Content Standard "E"

As a result of activities in all grades, all students should develop:

- Abilities in technological design
- Understandings about science and technology

Students should begin to differentiate between science and technology.

In the middle school years, scientific investigations can be completed by activities in which the purpose is to meet a human need, solve a problem, or develop a product rather than explore ideas about the natural world.

Robotics is the premier example of the marriage of science and technology, especially as related to the solving of problems or human needs.

Every investigation students conduct with the robot is motivated by the need to advance the performance of the robot in order to meet performance criteria, connecting the "need to know" with the "ability to do".

Mathematics Standards Addressed

From the National Council of Teachers of Mathematics (NCTM)

Numbers and Operations

• Understand numbers, ways of representing number, relationships among numbers and number systems. • Understand meaning of operations and how they relate to one another. • Compute fluently and make reasonable estimates.	Robotics uses numbers and operations in nearly all lessons, for example: • Calculating distance with rotational sensors (equations, equalities) • Gears, gear ratios and speed (ratios and proportions) • Light sensors and threshold (inequalities) • Wheel circumference, radius and diameter (geometric relationships)

Algebra

• Represent and analyze mathematical situations and structures using algebraic symbols. • Use mathematical models to represent and understand qualitative relationships. • Analyze change in various contexts.	Robotics lessons that involve algebra include the following: • Conditional statements (inequalities) • Programming sensors and thresholds (inequalities) • Measuring turns (equalities, solving equations) • Gears and speed (ratios, direct and indirect proportionality) • Passing parameters in functions

Geometry

• Precisely describe, classify, and understand relationships among types of two and three-dimensional objects using their defining properties. • Specify location and describe spatial relation ships using coordinate geometry and other representational systems.	Robotics situations involving geometry include: • Wheel rotations and circumference (diameter, circumference) • Identifying locations in order to program a robot to move from point to point (connected path segments) • Interlocking gears and gear ratios (discrete combinations of radii)

Measurement

• Understand measurable attributes of objects and the units, systems, and processes of measurement. • Apply appropriate techniques, tools and formulas to determine measurements.	Understanding the significance and meaning of measurements are central to the understanding of robotics: • Distance the robot travels (linear measurement, meter stick) • Amount a motor turns (angular measurement) • Directional change of the robot (angular measurement, protractor) • Speed of the robot (rate measurement, meter stick, built-in timer) • Physical quantities measured by sensors (touch, sound, light, distance) • Detectable region of a sensor (ultrasonic sensor, meter stick, 2D graph paper)

Mathematics Standards continued

From the National Council of Teachers of Mathematics (NCTM)

Problem Solving

• Build new mathematical knowledge through problem solving. • Solve problems that arise in mathematics and other contexts. • Apply and adapt a variety of appropriate strategies to solve problems. • Monitor and reflect on the process of problem solving.	In the lessons, there are both guided and open-ended design problems that involve designing, building, and programming needed to create autonomous robots. • How do I get a robot to move a certain distance? (solved through measurement and the verification and use of a proportionality relationship) • What does the sound sensor measure? (solved by graphing the sensor readings with tones of varying volume and pitch, then seeing which one indicated an orderly relationship)

Reasoning and Proof

• Recognize reasoning and proof as fundamental aspects of mathematics. • Make and investigate mathematical conjectures. • Develop and evaluate mathematical arguments and proofs. • Select and use various types of reasoning and methods of proof.	Reasoning in robotics comes in many different forms, including the following: • Experimental reasoning, proof using measurements and physical evidence (Wheels and Distance) • Reasoning using equations, proof by solving (Measured Turns) • Reasoning about graphs, proof by observing trends (Frequency and Amplitude)

Communications

• Organize and consolidate their mathematical thinking through communications. • Communicate their mathematical thinking coherently and clearly to peers, teachers, and others. • Use the language of mathematics to express mathematical ideas precisely.	Activities and Engineering Labs requires documentation that allows student to reflect on what they have accomplished or experienced, and describe it or some aspect of it in their own words to someone else. Emphasis is placed upon explaining reasoning in addition to showing calculations. The Engineering Design Challenge includes opportunities for students to communicate with their peers and teachers what they have learned and accomplished.

Connections

• Recognize and use connections among mathematical ideas. • Understand how mathematical ideas interconnect and build on one another to produce a coherent whole. • Recognize and apply mathematics in contexts outside of mathematics.	One of the strongest features of using robotics to teach math, science, engineering, technology and communications is its ability to make links between multiple disciplines. Students are able to take what they know and connect it to what they are learning, synthesizing new knowledge as they continue.

Technology Standards Addressed

From the International Technology Education Association (ITEA)

The Nature of Technology

1. Students will develop an understanding of the characteristics and scope of technology. 2. Students will develop an understanding of the core concepts of technology. 3. Students will develop and understanding of the relationships among technologies and the connections between technology and other fields of study.	All robotics activities provide excellent hands-on exposure to technology in use and development. • Robotics activities feature linkages to advanced technologies that allow students to connect their designs to real-world needs and solutions • Successful robot operation revolves around the application of systems concepts to make sensors, actuators, and other components work together • Design processes take into account goals, resources, and trade-off factors to achieve optimal results • Technology exists in proper context alongside applications in science, math, and engineering • Several different technologies (e.g. desktop computer, USB/Bluetooth peripheral interface, mobile robotics controller, electromechanical sensors and actuators) are routinely used together in the operation of the MINDSTORMS robot system, and all are necessary for it to work

Technology and Society

6. Students will develop an understanding of the role of society in the development and use of technology.	Robotics Engineering Design Challenges are linked to real world problems that use similar technologies to accomplish tasks that fulfill a social and/or economic need in the real world. For example: • For instance the robot mining project that is part of this curriculum addresses a real problem that mining industries face daily. Some robot activities focus specifically on Human-Robot Interaction (HRI), an emerging field dealing specifically with psychological and design issues relating to the use of robots in human environments.

Design

8. Students will develop an understanding of the attributes of design 9. Students will develop and understanding of engineering design 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem-solving.	Students gain first-hand experience with developing a functional robotic system in many activities, including: • The Warehouse Programming Challenge • The Robot Mining Challenge • Teacher assigned robot problems

Technology Standards continued

From the International Technology Education Association (ITEA)

Abilities for a Technological World

11. Students will develop the ability to apply the design process 12. Students will develop the ability to use and maintain technological products and systems	Students will apply design processes continually while working with and developing the robot. Here are some basic examples: • Solving engineering design problems • Robotics Competitions In the course of working with the robot, students will be responsible for the maintenance of their robots: • Mechanical soundness (the robot needs to be kept in good enough condition to perform its tasks daily) • Organizing information (students must keep good records to know how to use systems they initially designed days or weeks earlier) • Troubleshooting (robots have problems–often–and students must be able to identify and solve these issues as they arise) Students will work with many important technologies as part of the operation of the NXT system: • Electronic microcontrollers (NXT) • Desktop/laptop computer and software (NXT Programming Software, word processor for write ups, spreadsheets for data graphs) • Peripheral interfaces (USB or Bluetooth wireless) • Electromechanical systems (touch, light, rotation, sound, ultrasonic sensors) • Electromechanical actuators (Interactive Servo Motors)

The Designed World

16. Students will develop an understanding of and be able to select and use energy and power technologies 17. Students will develop an understanding of and be able to select and use information and communications technologies 18. Students will develop an understanding of and be able to select and use transportation technologies 19. Students will develop an understanding of and be able to select and use manufacturing technologies	The TETRIX robot is an excellent example and integrator of many different designed technologies working together as a coordinated system. • Power sources (battery technologies – rechargeable Lithium-Ion vs. disposable alkaline) • Vehicle systems (all the robot's systems must work together in order to make it mobile, a viable platform for transportation of goods or as a platform to perform other work) • Manufacturing and prototyping (robot must be built and modified using appropriate materials, plans and tools) • Structural soundness and stability concepts are integral to the design of the robot's physical form. • Communication between system components (desktop to VEX, sensors to VEX, VEX to motors) • Communication technologies (USB vs. Bluetooth)

Reading, Writing, Listening, and Presenting

Communications skills developed through robotics

Engineering does not exist in a vacuum; it is highly interdisciplinary and highly social. Teamwork is a central foundation of Engineering, and communication is essential to smooth functioning of any engineering team. Students will find that highly developed communication skills are an absolute necessity for success.

Communications skills applied when working with Robots

Situation or Activity	Communications Concepts Applied
Maintain Engineering Design Notebook	Organization of information
Reach consensus on which of several student-proposed designs the team will build	Teamwork and group communication skills • Running and participating in meetings • Building consensus
Compose a compelling proposal to convince a (virtual) sponsor that their robot's development is worth funding	Formal persuasive composition Integrate self-conducted research into a piece that is not purely expository Technical writing • Explaining technical decisions and implementations to an audience that is not necessarily technically inclined
Document the team's progress and accomplishments daily	Documentation and accounting for time, resources, and progress
Undergo review and integrate feedback from experts	Review and feedback processes Learning to accept and respond to criticism
Choose from a variety of representations to best illustrate and communicate a point	Use many different formats of both technical and non-technical information, across different media: • Graphs • Charts • Tables/Matrices • Photographs • Sketches • Timelines • PERT and Gantt Charts • Multimedia presentation • Text
Use Bluetooth to communicate between two NXTs	Electronic communication paradigms (as opposed to human) Networking and connected devices
Establish a standard "language" for communicating between two NXTs	Electronic communication Basic principles of communication • Necessity of shared language • Encoding and interpretation
Programming the robot	Communicate instructions explicitly to a robot using a "foreign" language

Reading, Writing, Listening, and Presenting continued

Communications skills developed through robotics

Communications skills applied when working with Robots

Situation or Activity	Communications Concepts Applied
Various interim deliverables intended for either internal or external use	Examples • Descriptive/Explanatory Composition: Describe behaviors, verbalize the functionality of parts of the program • Expository writing: How the machine works • Persuasive/Explanatory Composition: Justify a design choice • Record data in a table, evaluation of methods, predictions, describing robot behavior, describing a proportional relationship • Verbalize troubleshooting processes, analyzing and describing an unexpected situation or observation • Describe a design concept • Compare/contrast design choices, document and record steps, explain why the group took a certain approach • Research, examine and evaluate real-world robot applications • Describe a complex programming concept • Develop a marketing plan for a robot technology