

**Science and Mechatronics Aided Research for
Teachers (SMART):
A Research Experience for Teachers
Site in Mechatronics**

NSF Grant # EEC 0227479

**Polytechnic University
Brooklyn, NY**

PI: Vikram Kapila

URL: <http://mechatronics.poly.edu/SMART/>

2004 SMART Workshop

Overall Mission/Objective:
Provide pre-college teachers hands-on learning opportunities to develop science projects by integrating mechanisms, sensors, actuators, electronics, and microcontrollers thereby enhancing their STEM experience and enabling them to stimulate their students' interest in STEM disciplines.

| | |
|------------|-------------------------|
| Start Date | July 12, 2004 (Monday) |
| End Date | August 6, 2004 (Friday) |
| Period | 4 weeks (Monday–Friday) |
| Time | 8:30am–5pm |
| Lunch Time | 12:30pm–1:30pm |
| Location | RH514B |

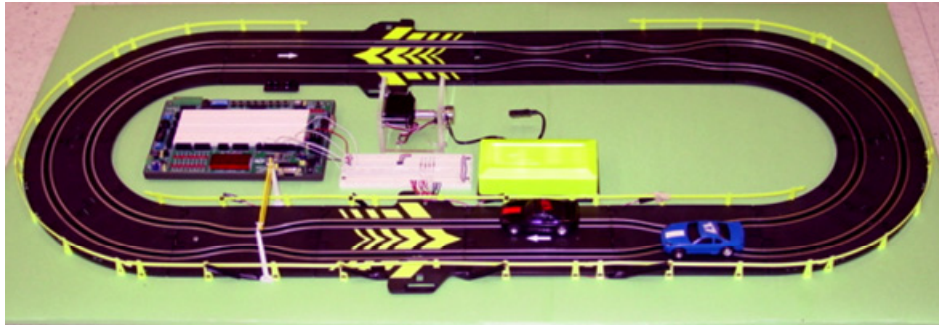
Workshop Schedule

| | Mon | Tue | Wed | Thu | Fri |
|-----------------|---|------------------------------|-----|-----|----------------------------|
| | July 12 | 13 | 14 | 15 | 16 |
| 1 st | Registration & Opening | Lecture, Lab, and discussion | | | |
| | Orientation | Lecture, Lab, and discussion | | | |
| | 19 | 20 | 21 | 22 | 23 |
| 2 nd | Lecture, Lab, and discussion | | | | |
| | Lecture, Lab, and discussion | | | | Brain storming for project |
| | 26 | 27 | 28 | 29 | 30 |
| 3 rd | Building the project, report preparation, and presentation slides | | | | |
| | August 2 | 3 | 4 | 5 | 6 |
| 4 th | Building the project, report preparation, and presentation slides | | | | Presentation |

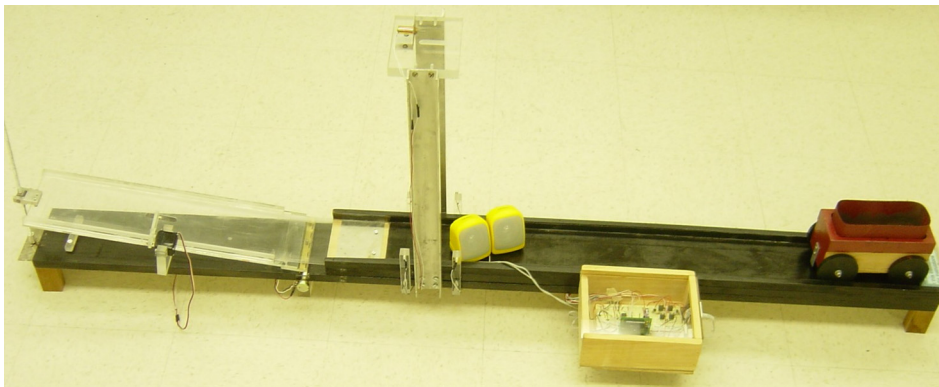
Lecture and Structured Experiment Topics

| | Topics | | Topics |
|-----------|-----------------|------------|-----------------|
| Lecture 1 | Resistor | Lecture 10 | Thermal sensors |
| Lecture 2 | Mechatronics | Lecture 11 | Robotics |
| Lecture 3 | LED | Lecture 12 | Infrared sensor |
| Lecture 4 | Button | Lecture 13 | Transistor |
| Lecture 5 | Capacitor | Lecture 14 | Relay |
| Lecture 6 | Optoelectronics | Lecture 15 | H-Bridge |
| Lecture 7 | ADC | Lecture 16 | DC motor |
| Lecture 8 | Servomotor | Lecture 17 | RC filter |
| Lecture 9 | 555 timer | Lecture 18 | Op amp |

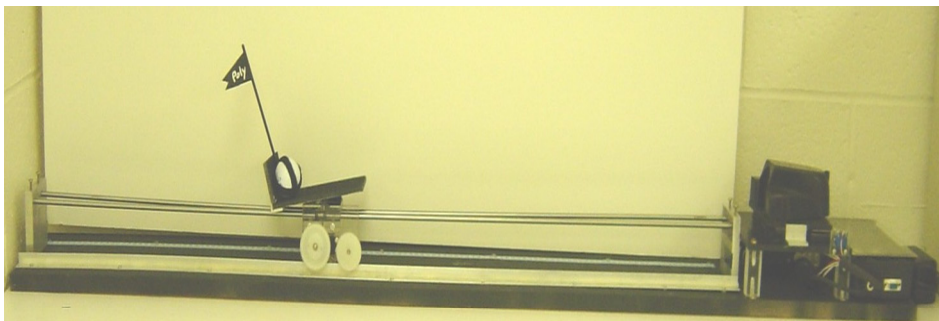
2003 SMART Projects by Teachers



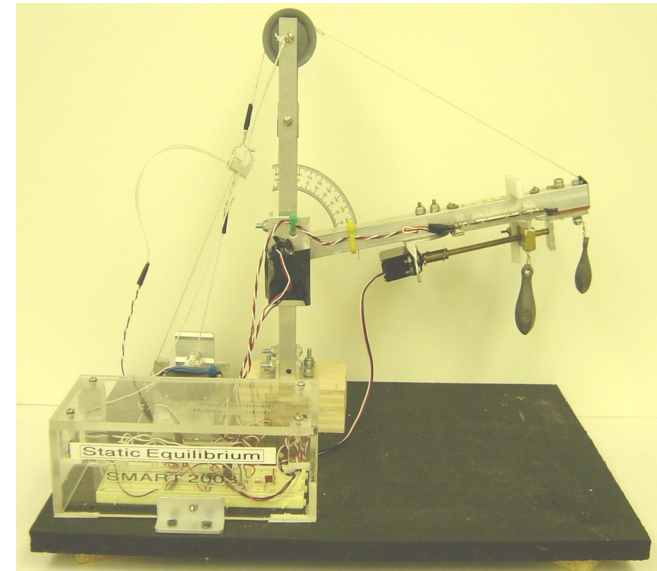
The Smart Road



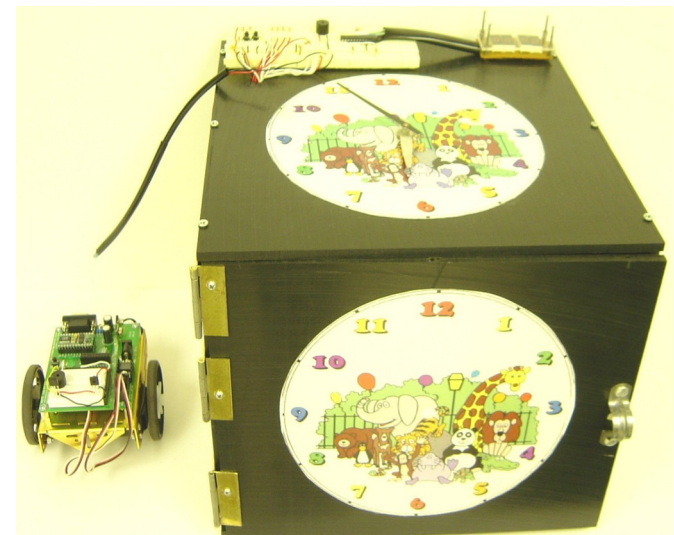
The Physics of Projectile Motion



Catch Me If You Can

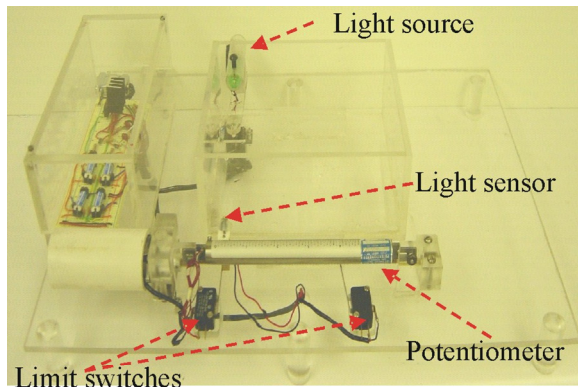


Static Equilibrium

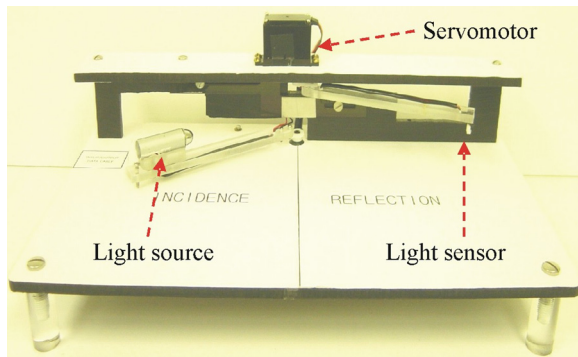


The Ro-Boe-Clock

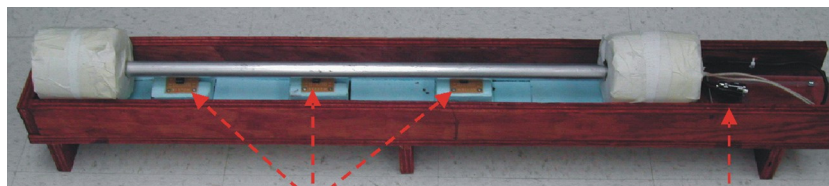
2003 SMART Projects by Mechatronics/Process Control Laboratory



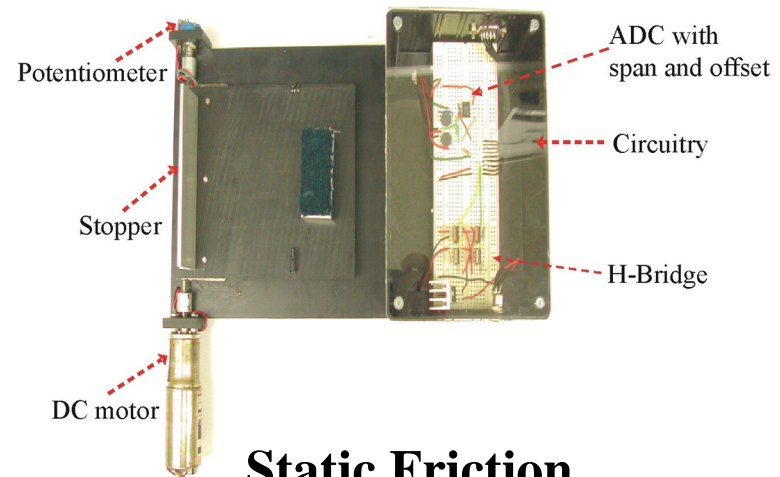
Light Refraction



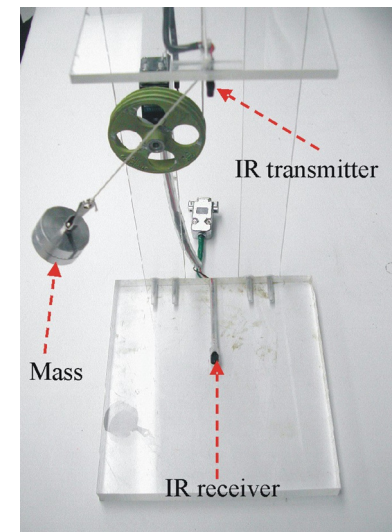
Light Reflection



Heat Conduction



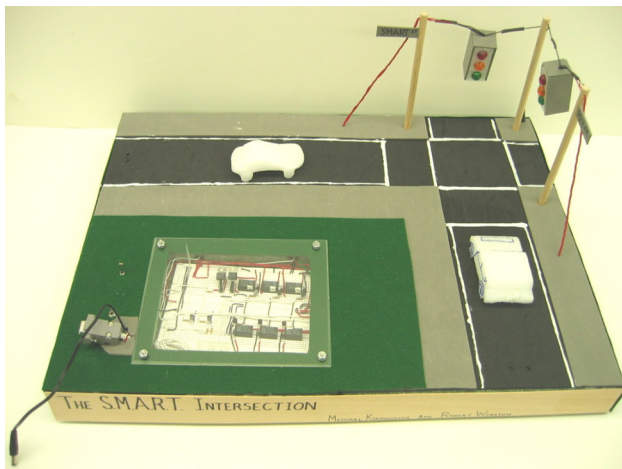
Static Friction



Periodic Motion

2004 SMART Projects—I

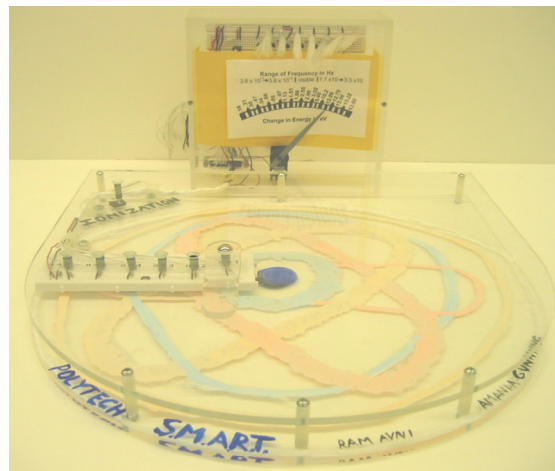
The SMART Intersection



Teachers: Michael G. Koumoullas
Robert H. Winston

Key Parts: IR LED
IR Phototransistor
Mechanical Relay
Light bulb

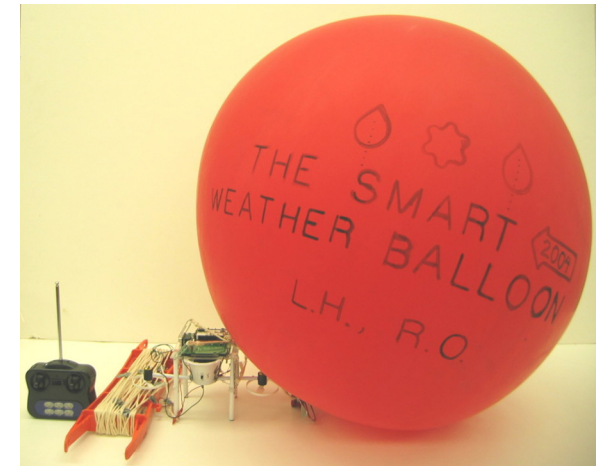
Quantum Leap



Teachers: Amanda Gunning
Ram Avni

Key Parts: Servomotor
Photoresistor
LEDs

The SMART Weather Balloon

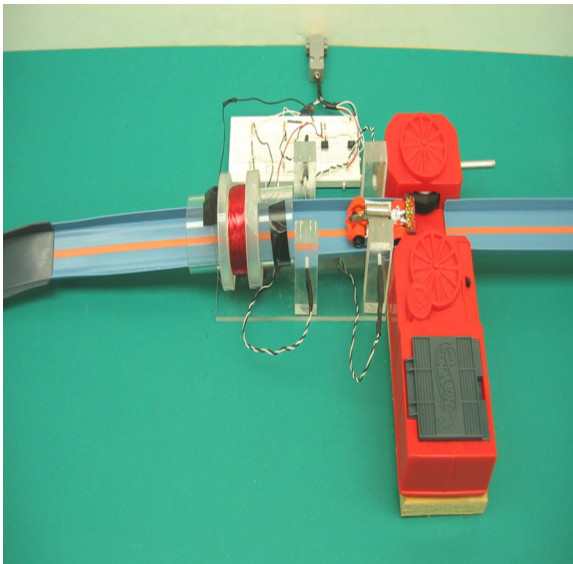


Teachers: Ronald Occhiogrosso
Lennox Henry

Key Parts: Temperature/Humidity Sensor
Parallax Homework Board
Radio Controlled Balloon

2004 SMART Projects—II

Velocity Monitoring via Magnetic Interaction



Teachers: Vincent Pereira
Steven Scharf

Key Parts: Coil
Magnet
IR LED
IR Phototransistor
Operational Amplifier
Analog Digital Converter

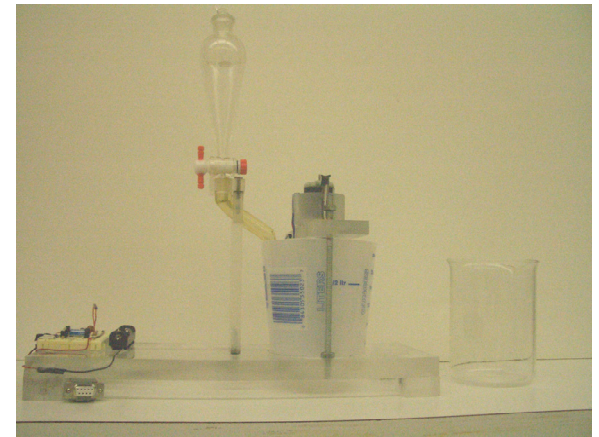
I Push! You Push Back!: Newton's 3rd Law in Action



Teachers: Ed Gruber
Dvora Geller
Denise McNamara

Key Parts: LCD
Load Cell
Punch Mitt

Conductivity Experiment



Mechatronics/Process
Control Laboratory

Key Parts: DC Motor
Agitator
Reed Relay
Lab Beaker
Electrodes
Flow Control Knob

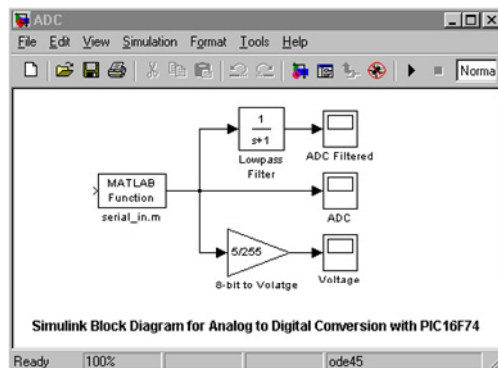
Matlab-Based Graphical User Interface Development for PIC Microcontroller Projects

Sang-Hoon Lee, Yang-Fang Li, and Vikram Kapila

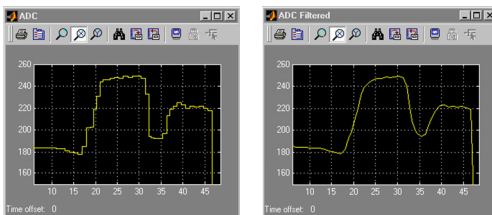
Department of Mechanical, Aerospace, and Manufacturing Engineering

Polytechnic University, Brooklyn, NY 11201

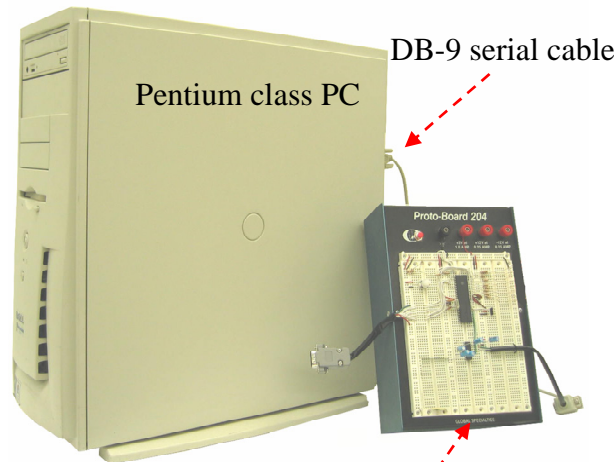
This paper presents the serial communication capability of PIC microcontrollers and the Matlab software along with graphical design tools of Matlab to create a Matlab-based graphical user interface (GUI) environment for PIC microcontroller projects. Three examples are included to illustrate that the integration of low-cost PIC microcontrollers with the Matlab-based GUI environment allows data acquisition, data processing, data visualization, and control.



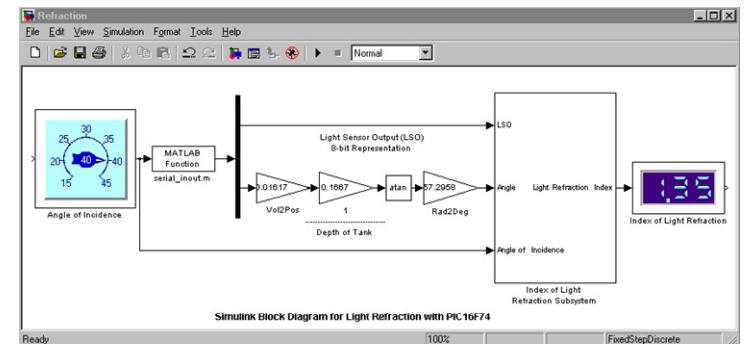
Simulink block diagram used for PIC to PC serial communication



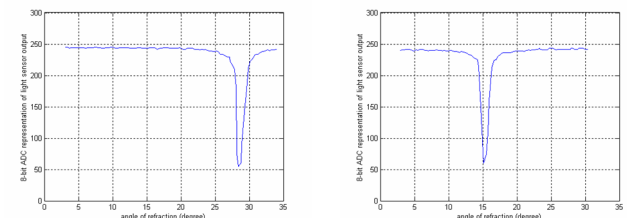
Unfiltered and Filtered plot of ADC



PIC development board



Simulink block diagram used for bi-directional serial communication between PIC and PC



Plot of angle of refraction vs. light sensor output

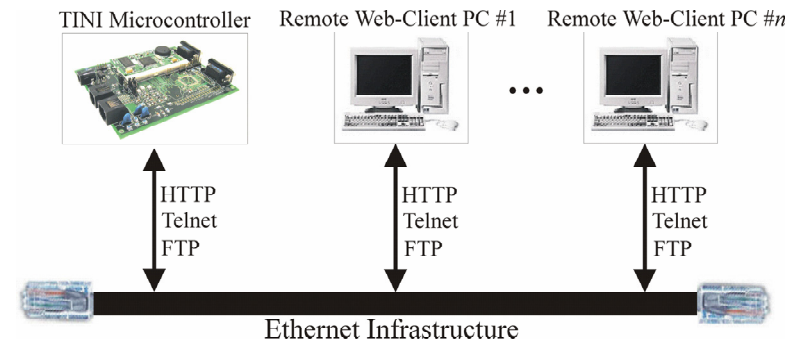
Internet-Based Remote Control of a DC Motor using an Embedded Ethernet Microcontroller

Hong Wong and Vikram Kapila

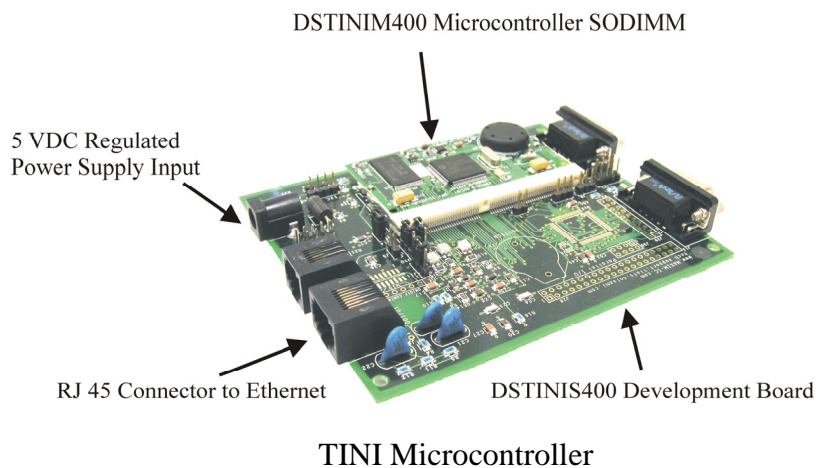
Department of Mechanical, Aerospace, and Manufacturing Engineering

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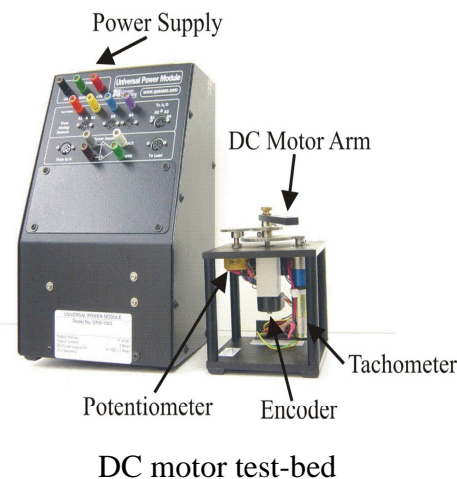
This paper presents an approach to perform position control of a DC motor experimental setup via the Internet. A main component of this setup is an *embedded server* microcontroller interfaced to the motor. A remote *client* computer communicates with the server to facilitate remote interaction with the motor. The embedded server is based on Dallas Semiconductor's Tiny Internet Interface (TINI) microcontroller platform.



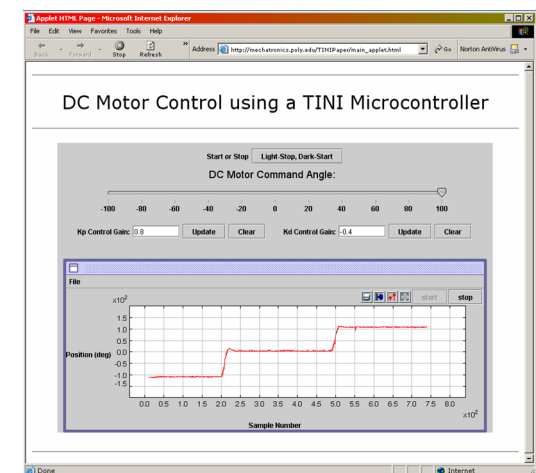
Methods of interaction between remote web-client PC and TINI microcontroller



TINI Microcontroller



DC motor test-bed



Java applet GUI screen capture

SMART Teachers' Accomplishments

Grants

| | | | | | |
|--------------------------|--|---------------------|------------------|--|--|
| Richard Balsamel | Science High School | Newark, NJ | \$4,000 | School district | Mechatronics research club |
| David Deutsch | Manhattan Center for Science and Math High School | New York, NY | \$3,000 | School and through the Children's Aid Society | After-school mechatronics club |
| Paul Friedman | Seward Park High School | New York, NY | \$1,500 | School's alumni association | After-school program |
| William Leacock | W. C. Mepham High School | Bellmore, NY | \$1,500 | School district | Hands-on activity in AP Physics class |
| Marlene McGarrity | The Christa McAuliffe School | Brooklyn, NY | \$1,500 | Online grant agency | 7th grade class |
| Michael McDonnell | Midwood High School | Brooklyn, NY | \$300,000 | VATEA | Robotics curriculum |
| Denise McNamara | High School for Health Professions and Human Services | New York, NY | \$1,600 | School | Obtaining LEGO Robotics and Parallax kits |

Articles

| | | | | | |
|--------------------------|-------------------------------------|-----------------------|--|--|--|
| Robert Gandolfo | Plainedge High School | Massapequa, NY | SMART experience in his school district newspaper | | |
| Marlene McGarrity | The Christa McAuliffe School | Brooklyn, NY | Online article, "A SMART Program for Teachers," on TechLearning | | |

SMART Project Evaluation Results—I

Pre- and Post-Project Technical Quizzes

| Year | Quizzes | Average (%) | Improvement (%) |
|------|-----------|-------------|-----------------|
| 2003 | Pre-Quiz | 57.3 | 20.9 |
| | Post-Quiz | 69.3 | |
| 2004 | Pre-Quiz | 54.2 | 29.1 |
| | Post-Quiz | 70.0 | |

For both years, the pre- and post-project quizzes contained the same 30 multiple-choice questions, ordered differently. Next, to evaluate the participants' self-perception of familiarity with topics in mechatronics, we conducted a pre- and post-project survey.

Self-Perception Survey

| Topics | 2003 | | | 2004 | | |
|-------------------------------------|---------|----------|-----------------|---------|----------|-----------------|
| | Pre (%) | Post (%) | Improvement (%) | Pre (%) | Post (%) | Improvement (%) |
| Electric/electronics | 51 | 77.3 | 51.6 | 39.9 | 75 | 88 |
| Microcontroller | 37.4 | 81.4 | 117.6 | 31.2 | 85.4 | 173.7 |
| Sensors | 64.5 | 76.5 | 18.6 | 46.3 | 82.1 | 77.3 |
| Actuators | 53.7 | 69.3 | 29.2 | 51.5 | 84.5 | 64.1 |
| Electro-mechanical systems modeling | 53 | 88 | 66 | 59.1 | 70.5 | 19.3 |
| Hands-on project | 38 | 88 | 131.6 | 34.1 | 97.7 | 186.5 |

SMART Project Evaluation Results—II

Program Effectiveness Survey

| Project Environment | Result (%) | |
|---|------------|------|
| | 2003 | 2004 |
| I gained greater understanding of the applications of science, technology, engineering, or mathematics in everyday life | 98 | 89 |
| I became familiar with new materials and equipment that I can use in my teaching | 100 | 86 |
| I learned about innovative ways to use standard materials and equipment in my field | 93 | 91 |
| I expanded my knowledge of how to use technology and computers in my teaching | 85 | 80 |
| I increased my knowledge of careers that utilize science, mathematics, engineering, or technology | 90 | 80 |
| As a professional development program for teachers, how would you rate the RET program in which you participated? | 98 | 87 |
| Will you recommend the RET program to your teacher colleagues? | 100 | 91 |

A program effectiveness survey, conducted at the end of the project, elicited teachers' reactions to the types of experiences they had during the program. As evidenced from table, results of this were highly positive, with scores ranging from 80% to 100%.

Dissemination—I

2003

| Teachers Name | | School Name |
|---------------|-----------------|---|
| Richard | Balsamel | Science High School |
| Clay | Davis | Manhattan Comprehensive Night and Day High School |
| John | Luvera | Montville Township High School |
| Michael | McDonnell | Midwood High School |
| Paul | Friedman | Seward Park High School |
| Robert | Gandolfo | Plainedge High School |
| Michelle | Carpenter-Smith | Packer Collegiate Institute |
| David | Deutsch | Manhattan Center for Science and Mathematics |
| William | Leacock | W. C. Mephram High School |
| Marlene | McGarrity | Chrita McAuliffe Intermediate School |

SMART DAY @ Poly September 13, 2003 (Saturday), 33 attendees

2004

| Teachers Name | | School Name |
|---------------|--------------|---|
| Ram | Avni | Middle College High School |
| Dvora | Geller | New York City Museum School |
| Edward | Gruber | Eastchester High School |
| Amanda | Gunning | Harry S Truman High School |
| Lennox | Henry | Washington Irving High School |
| Michael | Koumoullios | Aviation High School |
| Denise | McNamara | High School for Health Professions and Human Services |
| Ronald | Occhiogrosso | HAFTR High and Middle School |
| Vincent | Pereira | Clarkstown North High School |
| Steven | Scharf | Francis Lewis High School |
| Robert | Winston | Canarsie High School |

SMART DAY @ Poly October 23, 2004 (Saturday), 50 attendees



**Center for
Youth in
Engineering
and Science**



**David Packard
Center for
Technology
and
Educational
Alliances**



**Mechatronics
/Process
Control
Remote
Laboratory**



**For Inspiration
and
Recognition of
Science and
Technology**

Dissemination—II

COVER STORY

Brooklyn Daily Eagle

Volume 49, No. 141, MONDAY, OCTOBER 27, 2003 E-mail: ed@bdeagle.com & DAILY BULLETIN

Science-Oriented Kids from Across The U.S. Gather at Polytech Conference

Gathering Held in NYC for First Time; Students Housed at Marriott

By *Raman Gebner*
Brooklyn Daily Eagle

DOWNTOWN BROOKLYN — What are 16- and 17-year-olds interested in? Usually dating, sports, music, movies, homework, friends. The teens who were at the National Consortium of Specialized Secondary Schools in Math, Science and Technology conference at Polytechnic University this past weekend are no doubt interested in these things, but they're also interested in biotechnology, engineering, computer technology, robotics, physics and more. And they're part of a select group of about 300 that were sent from high schools around the country to the conference.

While the conference has been around for many years, this is the first time it's ever been held in New York City. The kids were housed at the New York Marriott at the Brooklyn Bridge, four to a room.

For many, it was the first time they were in New York City. "Things we take for granted, they're amazed at," said Shaed Ahmad, a Bronx High School of Science student.

"One girl from Alabama was surprised that the cars keep honking their horns. And the slang is different. One person said, 'I feel you,' and I said, 'what?'" He soon figured out, of course, that it means "I understand you."

The goal isn't necessarily to recruit the students to Polytechnic, said Dr. Noel Krifkhar, former superintendent of Brooklyn/Staten Island High Schools and one of the organizers of this year's conference. "We just want to get them to New York City and see what it has to offer."

The topics of the seminars would be daunting even to most adults. Here are just a few: "The Role of Sampling Stations in Water Quality"; "The Physics of Optics"; "Lego Robotics as a Learning Strategy"; "Redevelopment of the Manhattan Waterfront Using Recycled Plastic Pylon"; and even "Prepare for Mars Travel."

This reporter sat in on two seminars. In the first, "The Internet and Recorded Music," a Polytechnic student demonstrated how he recorded a CD onto his computer hard drive, using Windows Media Player. He played it at its normal size, about 20 MB.

He then played it at different levels of compression until he reached the smallest, 8 K.B. By this point, it sounded like music recorded underwater.

In another seminar, Sang-Hoon Lee, PhD mechanical engineering student at Polytechnic, showed the teens some robots he constructed. One of these was the six-legged, radio-controlled "Hexapod." Another ran on a track, similar to the slot cars of yesterday.

For student Kristin Beck, of High Tech High School, Lincoln, N.J., this was her second year at the conference. "Last year, at school, I did a project that was based in part on one of the seminars I saw here."

"This year, I'm sure I'll also be able to work on a project inspired by

Science-Oriented Kids From Across the U.S. Gather At Polytech Conference

Continued from page 1

some of the seminars here," said Ms. Beck, who hopes to study computer science and electrical engineering in college.

Polytechnic students acted as greeters and tour-guide leaders for the teens. Two who were interviewed, Jeffrey Chia and Nancy Escoboy, said they enjoyed working with the high schoolers and giving them a taste of what college life is about.

When not in seminars, they kids were taken on tours of the city — with a science-oriented twist. Some of them were "Brooklyn's Waterfront: Architecture and Engineering"; "Field Study in Prospect Park"; and "Rehabilitation of the Williamsburg Bridge."

Teams from five New York City schools were represented — Stuyvesant, Brooklyn Tech (a co-sponsor of the event), Brooklyn Tech, Staten Island Tech, and the High School of Math, Technology and Science at CCNY.

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NY1 and WABC

Michelle Carpenter-Smith
Packer Collegiate Institute

Clay Davis
MANHATTAN COMPREHENSIVE NIGHT ACADEMY

Prof. Vikram Kapila
POLYTECHNIC UNIVERSITY

Rich Balsamel
SCIENCE HIGH SCHOOL

November 2003

Plainedge Union Free School District
Volume XXXIX, Number 2

Plaintalk

Plainedge Public Schools Community Newsletter

Engineering Teacher Constructs Mechatronics Device

Introduction to Engineering teacher Robert Gaudolfo demonstrates a mechatronics device operated by computer commands, that he and another teacher built as part of a summer research program.

Plainedge teacher Robert Gaudolfo demonstrated a mechanism that combines concepts of mechanical, electrical and computer science engineering to his students in the Introduction to Engineering class. The device was designed, built and programmed by Mr. Gaudolfo and Mr. Paul Fridman of Seward Park HS as part of a summer research program at Polytechnic University.

The device is a visual demonstration that simulates the motion of a crane or a human elbow and has applications to the engineering problem solving activities that the Introduction to Engineering students will be doing over the school year.

The mechanism, a cantilever beam supported by a cable (string) at one end, is operated by a programmable micro-processing chip. Servomotors driven by the chip set the angle of the beam to the desired value. All of the measured and calculated data is displayed on the computer screen allowing the student to make changes and instantly see the effect.

During the summer Mr. Gaudolfo and nine other teachers from Long Island, New York City and New Jersey spent four weeks participating in a National Science Foundation funded research program at Polytechnic University in Brooklyn under the direction of Professor Vikram Kapila. The goals of the program are to train teachers in the area of engineering called mechatronics enhancing high school instruction and thereby attracting more students to the engineering profession.

Board of Education

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Christine P. Simer, 9952466; Section 504 Coordinator (handicap discrimination) Mona Moran 9952480

Dissemination—III

BROOKLYN HeightsPress & COBBLE HILL NEWS

BROOKLYN HEIGHTS PRESS & COBBLE HILL NEWS

THURSDAY, JULY 22, 2004, PAGE 18

Robots Are Part of New Instruction at Polytechnic

By Rosam Caplan

Teachers, novices, even Doctors of Philosophy, are surrounded by a host of robots, CD and DVD players, and

But when they go to school and attend science classes, the says, they frequently are taught the same way they would have been taught 100 years ago. Clearly, a new type of technology is needed to make

That's why Polytechnic University is now testing, with funding from the National Science Foundation, the Science and Mathematics Assisted Research for Teachers (SMART) Program, to train teachers from public high schools from

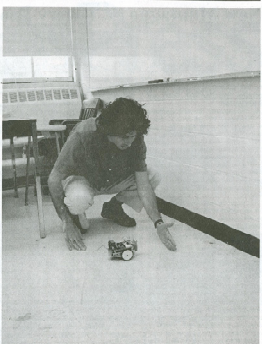
One teacher, Lennox Henry, who teaches earth science, says he was here to learn more about using microprocessors, programming languages and robotics. He found the information process was slow, but the school is now a new device making use of a solar panel, but with a great limit programmed in and speed sensors on the track. If the car exceeds the speed limit, the sensor picks it up and the controller slows them down.

Teachers who are taking part in the SMART sessions come not only from the five boroughs, but also from nearby locations on Rockland and Westchester Counties.

Yet another device makes use of a solar panel, but with a great limit programmed in and speed sensors on the track. If the car exceeds the speed limit, the sensor picks it up and the controller slows them down.

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Teacher Ramani Arav of Middle College High School demonstrates a "pet" robot that has sensors on its "whiskers". Photo by Nathanael Santos



Brooklyn Daily Eagle & DAILY BULLETIN

Volume 61, No. 77, TUESDAY, JULY 20, 2004 E-mail: edit@brooklyn.eagle.net

www.brooklyn.eagle.com • Founded in 1841 by Isaac Van Anden

Polytechnic Program Helps Teachers Integrate High Tech into the Classroom

They Build Robots to Demonstrate Scientific Concepts and Laws

By Rosam Caplan
Brooklyn Daily Eagle

BROOKLYN — Tamara novak, 30, says she learned to use a laser pointer, a CD and DVD player, and more. But when they go to school and attend science classes, the says, they frequently are taught the same way they

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Polytechnic Program Helps Teachers Integrate High Tech into the Classroom

They Build Robots to Demonstrate Scientific Concepts and Laws

By Rosam Caplan
Brooklyn Daily Eagle

BROOKLYN — Tamara novak, 30, says she learned to use a laser pointer, a CD and DVD player, and more. But when they go to school and attend science classes, the says, they frequently are taught the same way they

would have been taught 100 years ago. Clearly, a new type of technology is needed to make

That's why Polytechnic University is now testing, with funding from the National Science Foundation, the Science and Mathematics Assisted Research for Teachers (SMART) Program, to train teachers from public high schools from

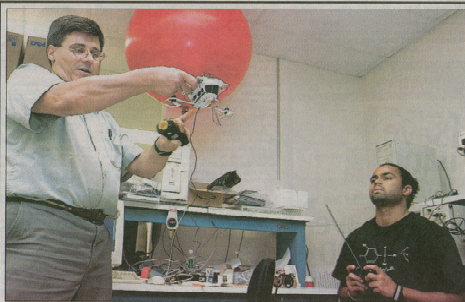
One teacher, Lennox Henry, who teaches earth science, says he was here to learn more about using microprocessors, programming languages and robotics. He found the information process was slow, but the school is now a new device making use of a solar panel, but with a great limit programmed in and speed sensors on the track. If the car exceeds the speed limit, the sensor picks it up and the controller slows them down.

Teachers who are taking part in the SMART sessions come not only from the five boroughs, but also from nearby locations on Rockland and Westchester Counties.

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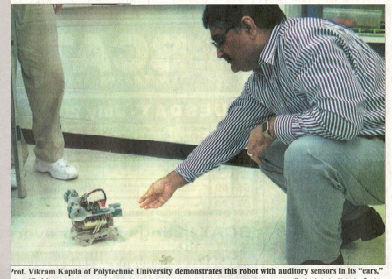
Science teacher Ron Ochingsross (l) and Lennox Henry, a biology and Earth science teacher at Washington Irving High School in Manhattan, build a remote-controlled weather balloon in Polytechnic University science program.

Teachers go hi-tech

Taking Poly U science know-how back to HS

SCIENCE TEACHERS from across the city are headed back to the classroom this summer to learn innovative ways to teach up-to-the-minute technology. The newly created teachers — from high schools such as Canarsie in Brooklyn and Astoria in Queens — learned how to build "SMART" robots that do everything from wiping up spills to planning their flight paths in the sky. The program is funded by a \$100,000 grant from the National Science Foundation, the three-year program aims to expose teachers to cutting-edge technology so they can take the skills back to their classrooms. "It's great," said Robert Winick, biology and physics teacher at Canarsie who has been teaching for 28 years.

PHOTO BY NATHANAEL SANTOS



Prof. Vladimir Kapitsa of Polytechnic University demonstrates this robot with auditory sensors in its "ears" amplified by paper cups.



Teacher Ramani Arav of Middle College High School demonstrates this "pet" robot, with sensors in its "whiskers". Photo by Nathanael Santos

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Dissemination—IV



FEATURE

Science and Mechatronics-Aided Research for Teachers

The “SMART” program provides teachers with training and workshops

“Smart” Teachers

Mr. Richard Balsamel of Science High School, Newark, NJ, raised over US\$4,000 from his school district for mechatronics kits and supplies and began a mechatronics research club. In addition, he is introducing mechatronics in his physics classes by integrating four sample activities for students. Mr. David Deutsch of Manhattan Center for Science and Math High School, New York, NY, has raised over US\$3,000 from his school and the Children’s Aid Society for mechatronics and robotics kits. He is training students in an after-school mechatronics club. Mr. Paul Friedman of Seward Park High School, New York, NY, has raised over US\$1,500 from his school’s alumni association for robotics kits. He has partnered with a colleague to train students in an after-school program. Mr. Robert Gandolfo of Plainedge High School, North Massapequa, NY, reported on his SMART experience in his school district newspaper [12]. Mr. William Leacock of W. C. Mephram High School, Bellmore, NY, received a US\$1,500 minigrant from his school district for mechatronics kits. Every other day, during a single class period of AP physics, he teaches a short lesson introducing his students to a hands-on activity planned for a double class period

the following day. Mr. Leacock wrote the following to us: “The students are enjoying it so much that, even though I allow them a break in between the double periods, almost all of them stay and work right through the break. It is wonderful to see them learn and enjoy themselves so much.” Mr. Michael McDonnell of Midwood High School, Brooklyn, NY, used over US\$5,000 funding from his school to obtain robotics kits and taught robotics to over 200 students in the Fall of 2003 and Spring of 2004 through robotics and advanced robotics courses. Furthermore, with colleagues, he applied for and received a three-year US\$300,000 grant from his school district under the Vocational and Technical Education Act (VATEA). The VATEA grant will enable him to develop and implement a four-year robotics curriculum in his school. Finally, Ms. Marlene McGarrity of the Christa McAuliffe School, Brooklyn, NY, raised over US\$1,500 for a project titled “Young Engineers are Made in Brooklyn Through Robotics and Mechatronics,” through an online grant agency. From this grant, she obtained wheeled robots and Mars rover kits, and is using these in her seventh-grade classroom. She also wrote an article [13] on her SMART experience.