2006-345: A DESCRIPTION OF AN INTEGRATED CAPSTONE PROJECT TEAM WITH ELECTRICAL, MECHANICAL AND COMPUTER ENGINEERING TECHNOLOGY STUDENTS

Francis Di Bella, Northeastern University

Jerome Tapper, Northeastern University

Joel Weinstein, Northeastern University

Prof. Weinstein is the Program coordinator for the Computer engineering technology unit at Northeastern University.

Len Dowd, Northeastern University

Prof.Dowd is the Electrical Engineering Technology program coordinator at Northeastern University and specializes in electrical power engineering. He has over 30 years experience with the Boston Edison company before joining Northeastern University in 1995.

Randy August, Northeastern University

Randy August is an assistant professor in the computer engineering technology unit at Northeastern University. He recently was awarded a grant from the DOE (Project I-Test) for instructing high school teaching in the engineering and technology field.

Engineering Technology Division

A Description of an Integrated Capstone Senior Design Course with Teams of Mechanical, Electrical and Computer Engineering Technology Students

Francis A. Di Bella, PE fdibella@coe.neu.edu (617-373-5240)
Director, School of Engineering Technology, Principal Course Instructor and Program Coordinator for Mechanical Engineering Technology
Randy August, Asst. Prof. Computer Engineering Technology
Joel Weinstein, Program Coordinator Computer Engineering Technology
Jerry Tapper, Acting Program Coordinator Electrical Engineering Technology
Northeastern University, Boston, MA

ABSTRACT

The capstone Senior Design course is arguably the most relevant and essential engineering course that can be offered to the engineering technology student. The Capstone course, unlike any other engineering technology course, provides pedagogical coverage of most if not all of the 'a through k' ABET student criteria. Often the Capstone Design course requires that teams of students in a single academic discipline work together to produce and an engineering analysis and design of a product or project. A more "real-world" approach to the Capstone Design course has been introduced at Northeastern University's School of Engineering Technology and has been proven successful, according to student and industrial advisor/judges assessments. The NU SET Capstone course is conducted by interdisciplinary teams of mechanical, electrical and computer engineering technology students (with an occasional integration of a team of business students), all working together as a team to complete a project. This paper will discuss the structure of this course, the successes that must be encouraged and the pit falls that must be avoided if this unique integration of engineering technology students is to be implemented in an ET curriculum.

Background and Introduction

Northeastern University is completing its third year in implementing a change from the Quarter to the Semester academic plan. The decision to change from a Quarter system to a Semester plan was driven, in a strong way, by the cooperative education division of the University who responded to their cooperative education employers who had requested that the students spend more time-at least six months-in a full time, engineering work environment. The School of Engineering Technology took full advantage of this academic change to add more technical electives, and more laboratory sessions for some courses as well as to revamp the course content of many other of its existing courses. Among the courses that were revamped was the *Introduction to Product Design and Design Laboratory* courses.

One of the major changes was to eliminate these two courses, one of which was offered only to mechanical engineering technology seniors. These courses were replaced with two courses that are offered to all seniors and that provided more content to all of the graduating students. This led to the integration of the Capstone Senior Design Project course for all of the engineering technology students in the Engineering Technology Program. Thus the senior computer, electrical and mechanical engineering students end their academic careers by teaming to conduct an engineering analysis, design, prototype fabrication, test and reporting of a "product" or engineered system. On occasion, several of the groups will also team with business (senior) students who are responsible for producing a Business Plan resulting from their objective examination of the business viability of the Capstone "project/product".

Ultimately the results of these capstone projects provide evidence to the students of their mastery of their individual disciplines as well as their ability to work in dynamic groups composed of seemingly diverse engineering individuals. From a pedagogical stand point however, Northeastern University's model of an integrated Capstone Senior Design Project provides an almost perfect implementation of ABET's "a through k, General Criteria for Students and Graduates" as summarized in Table 1.

Table. 1. ABET's GENERAL CRITERIA No.1: Students and Graduates

a. an appropriate mastery of the knowledge, tech., skills and modern tools of their disciplines,
b. an ability to apply current knowledge and adapt to emerging appl.s of math., science, engineering and technology,
c. an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes,
d. an ability to apply creativity in the design of systems, components or processes appropriate to program objectives,
e. an ability to function effectively on teams,
f. an ability to identify, analyze and solve technical problems,
g. an ability to communicate effectively,
h. a recognition of the need for, and an ability to engage in lifelong learning,
i. an ability to understand professional, ethical and social responsibilities,
j. a respect for diversity and a knowledge of contemporary professional, societal and global issues,
k. a commitment to quality, timeliness, and continuous improvement.

This paper describes how the Integrated Capstone courses effectively accomplish these criteria.

The Course Format and Structure

Before detailing how Northeastern University's Integrated Capstone Projects effectively accomplishes the ABET "a through k" criteria, a summary of the course format and structure is warranted.

The integrated Capstone course contains two sub-course components - the **Introduction to Capstone** and the actual **Capstone** course itself. These are offered as 2 and 4 semester credit-hour courses respectively and are offered to the engineering technology seniors in their last two semesters at Northeastern University[1].

The course instruction in the Introduction to Capstone focuses on the effective implementation of Design Process Methodology. Thus the student is made aware of the design process that proceeds as follows:

1. the proper construction of a Problem Statement,
2. the preparation of a (Phase 1) Quality Function Deployment House of Quality where in Customer and Engineering Specifications are determined,
3. due diligence research via literature searches and a preliminary market analysis,
4. concept generation (via brainstorming techniques),
5. selection of most viable concepts via Pugh Analysis,
6. feasibility analysis of most viable concepts,
7. budgeting and scheduling of engineering labor and materials for producing a prototype,
8. fabrication and testing of a prototype,
9. Continuous oral and written progress reporting that culminates in a final written report and an oral presentation in front of the open NU community.

The course instruction in the actual Capstone Senior Design Project Course continues the study that was developed in the introduction course, taking advantage of the time spent by the students in forming effective group dynamics in the Introduction course as well as using the time between the courses[2] to "…gather the group's thoughts" regarding the projects. It is not uncommon that a few students migrate from one group to another or a team may decide on another project, having decided that after "due diligence" and the necessary amount of feasibility analysis that the project that they were studying is either no longer viable or do not have sufficient interest of the team members to continue.

During the actual Capstone Project Course, the teams work even more closely together as well as with the course instructor. The Instructor takes on a triple role of <u>*Instructor*</u>, <u>*Program Manager*</u> and <u>*Engineering Consultant*</u>. In the latter category, the instructor is aided by the entire faculty as may be required to answer a discipline-specific engineering question regarding the project. The students submit a progress report every two weeks and have an exclusive meeting with the Instructor/Program Manager/Consultant at least once every two weeks in class and more often as may be required outside of class. The teams produce a <u>Product Design Specification</u> document, a <u>Detailed Engineering Analysis</u> document, and provide a prototype or mock up of their project or a significant sub system component including test results. The capstone course culminates in a 20-minute oral presentation in addition to a written Final Report.

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[1] Northeastern University also has an Electrical and Computer Engineering and a Mechanical, Industrial Engineering curriculum that also offers a Capstone Project course. However, the students in each of these engineering disciplines work only within their own discipline as is typically done for Capstone Senior Design Projects.

[2] Northeastern University is a cooperative education school and for this reason the Introductory Course and the actual Capstone courses may be separated by a six month cooperative education work term that the students are committed to complete.

A typical team ideally consists of two students from each of the three engineering disciplines: computer, electrical and mechanical engineering technology. Certainly, this is an ideal arrangement and the actual ratio of students depends on the size of the graduating class and the numbers of students in each discipline. Appendix A identifies the projects and the students in each of these projects that composed the graduating class of 2005.

The projects that are acceptable for the integrated capstone course ideally must have an engineering technology component from each of the academic disciplines. Recognizing the limitation of the ratio of students in each discipline, several projects may not be as integrated as desired. The course topics are usually chosen by the student teams with "fall back" projects made available by the Instructor. It is also strongly suggested by the Instructor via these "fall back" projects that the team's project involve solutions to problems that involve the handicapped or projects that may contribute to the further development of third-world nations particularly in the novel use of renewable energy. An example of the Instructor's project recommendations are shown in Appendix B of this paper for reference. As an additional "fall-back" project, the Instructor can offer a Capstone project that the Instructor develops literally, in front of the class, as a way of demonstrating the principals of the Design Process Methodology. These projects have ranged from the development of an amphibian, aquatic vehicle for the handicapped and a stabilizer for a handicapped walker aid to the development of renewable alternative energy resources for skyscraper buildings. Note that the emphasis on using engineering technology for the advantage of handicapped persons and for mitigating the world's reliance on fossil fuel energy is not coincidental. Rather it is a strong espousing of the need for engineers to be involved in current and imperative human-life issues.

Projects originating from Industry have also been encouraged. However, the conditional, financial support from Industry has not been encouraged. Although unconditional grants and financial awards from Industry are welcomed, it has been found by the authors that conditional support from Industrial sources often restrict the creativity of the student teams and most certainly instills yet another significant and legitimate priority on the student. This financial obligation tends to burden the student unduly and may result in the student sacrificing the time spent on other senior courses that must be completed in this last semester to qualify for graduation.

However, this then burdens the student with the raising of funds for the construction of the project prototype. This is usually accomplished in the following ways:

1. the teams six (plus) members equally contribute to the cost of the project given that there are no textbooks assigned to either course[3] and hence a considerable expense of $600 or more for the purchase of textbooks for the course is deferred for all of the team members,

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[3] The course Instructor has prepared a concise Primer of the entire Design Process Methodology. The Primer is entitled: "The Sandman Project" and it is offered at no cost to the student. A list of published texts on the subject is also made available (see the reference section at the end of this paper)

2. the team prepares a detail design and a Bill of Materials for the prototype and formally requests (via an oral presentation) the support of the School of Engineering Technology department where limited funds are available for projects that can be used by the department for laboratories and/or other academic purposes,
3. the team prepares documentation as in item 2 but solicits contributions from the manufacturers of the various parts listed in the Bill of Materials,
4. the team prepares documentation as in item 2 and 3 but the cost is shared between the Engineering Technology department and the manufacturer,
5. a design review is made with the Instructor/Program manager/Consultant and an agreement is made to fabricate only a scaled model prototype of the entire system or of only a major sub system. The cost of the project prototype is thus reduced and the team implements items 1, 2, 3 or 4.

Starting with the Introduction to Capstone course and continuing throughout the Capstone Project, the students are required to maintain an Engineering Journal. The Journal is used to keep minutes of team meetings, to record concept developments, to provide a repository of preliminary and feasibility analysis, and in general, to be a record of the progress made during the project. The Journal can also provide formal and legal documentation of the originality of any novel concept solution to the Capstone problem that may lead to a future patent position and filing. The Journal is graded at the end of the course for technical content and continuity.

As the teams progress in the detailing of their solutions trough out the Capstone course, the Instructor also provides emphasis for the students' attention to the application of ethics in the solution to the problems at hand. For example, the Instructor requires a homework assignment that explicitly requires the teams to prepare a summary of how engineering decisions must be consistent with the established ethics of the three professions as described in their individual Code of Ethics. The Instructor also continuously monitors the ethical behavior of the students in the implementation of their projects and points out the sometimes subtle issues that involve the ethics of their decisions.

Satisfying ABET's General Criteria No.1 for Students and Graduates
The Capstone Senior Design Project is the culmination of a student's engineering academic career. It is the course where in the student can demonstrate proficiency in the courses that have been studied. The Capstone course is a revival or remembrance of how an engineering apprentice (even before engineers were trained via a formal curriculum) was trained to solve specific problems. Under the careful tutelage of a mentor, the apprentice was carefully guided in the correct manner of professionally accomplishing a given task.

The ABET criteria can be seen as a list of the actual benefits of having undertaken the Capstone project, mentored most immediately by the course instructor but also by the other faculty who have thoroughly prepared the student for the Capstone course.

A careful reading of the ABET criteria can easily be shown to be a direct pairing with the inherent attributes of the capstone pedagogy. A summary of this synergism is given here.

The "(a) through (d)" ABET criteria requires: (a). that the student gain an appropriate mastery of the knowledge, tech., skills and modern tools of their disciplines, (b). that the student gains an ability to apply current knowledge and adapt to emerging applications of math, science, engineering and technology, (c). that a student gain an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes, and (d). that a student gain an ability to apply creativity in the design of systems, components or processes appropriate to program objectives. Clearly the Capstone Project Design course compels the student to demonstrate progress in each of these areas. The capstone project does not come with answers that are "in the back of the book" and thus forces the student to gain a mastery of the subject matter in their disciplines while applying current knowledge; even if is researched only via "googled or yahoo-ed" web site. The analysis, detail design, and the fabrication of a prototype (even if its only a scaled or only one vital part of the over all system) also enables the student to design and conduct the proper tests and then analyze the data for purposes of re-designing the system as necessary.

The "(e) through (g)" ABET criteria requires: e. that the student gain an ability to function effectively on teams, (f). that the student gain an ability to identify, analyze and solve technical problems, and (g). that the student gain an ability to communicate effectively. Clearly the very team-oriented nature of the Capstone Project Design course requires the students to work effective together. The integrated Capstone Course objectives as promoted by Northeastern University's School of Engineering Technology elaborates on these goals by emphasizing that the students who are strong in one specific discipline be able to work with students of another discipline. This integration is expected to further each student's understanding of the nature of the work in the other disciplines as well as learn from the direct application of this engineering curriculum to the task at hand. The integration of the disciplines is after all exactly what will be encountered by the students after graduation. The communication between the students is never more focused than in the integrated capstone project course. Each student is forced to grapple with the need to communicate clearly in writing, orally, and/or with drawings with students who have a different frame of reference for the solution and pace for solving a problem. For example, the electrical and computer engineering technology students find it strange that the mechanical engineering student requires considerably more time to produce a working prototype of the mechanical parts of the system. The mechanical engineering technology students find it somewhat disconcerting that they must be the first discipline working on the form of the system or a component of the system before the electrical or computer engineering technology students can have an effective role in the progress of the project. This is often even more disconcerting to the electrical and computer engineering technology students who are anxious to and should contribute to the project's initial "form" in order to meet the project's "function" even if that initial task is typically considered to be the province of the MET discipline.

The “(h) through (k)” ABET criteria requires: (h). that the student gain a recognition of the need for, and an ability to engage in lifelong learning, (i). that the student gain an ability to understand professional, ethical and social responsibilities, (j). that the student gain a respect for diversity and a knowledge of contemporary professional, societal and global issues, and k. that the student gain a commitment to quality, timeliness, and continuous improvement. The capstone project requires the student to seek answers for the problems at hand from external as well as internal resources. While this effort is shared among the team members, each student grasps more fully the need to search for answers “outside their” domain, using their fellow students, the Instructor or available faculty, and/or manufacturers representatives or application engineers. The direct consequence for the successful student is an appreciation for the need for continuous learning for themselves even as they gain that learning from others. The selection of the Capstone project is often inspired by “real world” problems that must be solved that involve a wide diversity of markets. The use of the word “market” here is intended to be very generally translated as users with a variety of cultural backgrounds and needs. The culmination of the capstone course requires steadfast commitment to the project, to the team and the “customer”; even if the Instructor is the most immediate customer. This can only be accomplished by each student committing themselves to not only a timely completion of their part of the assignments but also completing a valued contribution to the project as judged by the team members even before it has been submitted to the Instructor for his/her timely comments and suggestions. In fact, the need for time management to accomplish the capstone project becomes very apparent to the student, more so than what is required of the classroom studies. The main difference is that the students must now provide sufficient time to not only complete the solution to a problem but must now reflect on what the problems are. This reflection period is not usually present in a typical classroom assignment where the Instructor has clearly indicated what end-of-the-chapter problem must be solved. The capstone student must wade through a myriad of possible questions that should be poised and reflected upon by the entire group before any one of them is selected as being important enough to the overall capstone problem solution to be solved. As these solutions often come with the need for changes to the design, the student hopefully learns quickly but certainly inevitably that time management is an integral part of the continuous improvement process for the student.

The student’s ethical consciousness is heightened by participating in the Capstone course in several ways. First, the active participation in any activity always requires the participant to be watchful for any conflict with professional, ethical principles. The Capstone Course provides a “real-world” arena where the student team is responsible for producing a prototype within a very short period of time-14 weeks. The pressures of successfully completing the academic year while beginning a job search can be a very emotionally trying experience and thus the temptation to compromise a solution to any specific capstone project problem may be too much to restrain resulting in the an ethical dilemma. The Instructor must be watchful of any such compromises during the progress of the capstone project and correct any ethical mistakes that the student or the team may make.

The second and perhaps most important ethical issue that can be addressed by the Capstone project is a consequence of having a large number of students in each team with the increased probability that the students represent a diverse range of racial, cultural, and religious backgrounds. The team dynamics can only be successful if each student respects these diverse backgrounds. Disagreements within the group that are due in part to even innocent and perceived disrespect between team members can and should be sources of careful, personal reflection on the part of each effected student. Once again the Instructor is available to serve, at the very least, as an arbiter to resolve any such conflicts that arise from issues that involve the personal backgrounds of the students.

Conclusion

The Capstone senior Design Project as practiced by most engineering schools is the perfect venue for accomplishing the “a through k” ABET General Criteria for students and graduates. The integration of three engineering disciplines into an effective Capstone team significantly increases the value of the Capstone course in meeting the “a though k” ABET General Criteria. The overall result is a graduate who is more confident in his/her creative abilities, committed to and competent in accomplishing a specific task within a larger project, able to communicate verbally or in writing the progress of a project and/or the results while increasing his/her character in the face of cultural differences.

References

1. "The Art of Inventing-How to Invent and Solve technical Problems", by: H. Altov (as translated by Lev Shulyak,
2. "Jump Start Your Brain", by: Doug Hall, Warner Books
3. "Professional Creativity", by: Eugene Von Fange, Prentice Hall (NOTE: may be out-of-print; see Instructor to borrow a copy)
4. "The Engineering Design Process", by: Ertas, Atila and Jones, John Wiley and Sons,
5. “Engineering Design”, by: Rudolph J. Eggert; Prentice Hall
6. “Engineering Design”, by George Dieter, Prentice hall
7. “The Mechanical Design Process”, by David Ullman; Mc Graw-Hill
8. “Product Design and Development”, by Karl Ulrich and Steve Eppinger, Mc Graw-Hill

Appendix A. Suggested Joint Capstone Projects

1. ROAD RAGE INSTRUMENT (intentionally not disclosed for future patent considerations)

2. PAINT BALL LAUNCHER FOR MOUNTAIN BIKE

BACKGROUND:

Paint ball sports have become a very large business in the United States. Many different devices have been designed that can launch a paint ball at a competitor. All of these devices are usually carried on the user. A paint ball launching system for a pedaled mountain bike could provide an entirely new dimension to the sport.

PROBLEM STATEMENT:

Design a paint ball launching system that can be manually powered and attached to a mountain bike. The aiming mechanism must be controlled via the rider using only controls on the bike handlebars. An aiming guidance system is also preferred.

In a more general statement: Many sports require unique devices for practice and honing skills. Thus identify such systems and propose a Project related to sports.

3. HEDGE CLIPPER BAGGING SYSTEM

BACKGROUND:

Despite the grievances of some communities who are displeased with the noisy administration of common yard duties (see Item No. 3), other communities, who have a truer artistic regard for the stature of handsomely groomed privet hedges, do not take exception to electric hedge cutters. These same individuals are, however, fastidious about the effectiveness of the clean-up after the necessary cutting has been completed. Privet hedge cutting is now performed very quickly with the advent of the electric hedge cutter (no mention is made here of the inversely proportional lack of artistry that seems to accompany the speedier removal of the hedge) but the time saved does not seem to be spent cleaning up after the hedges have been reduced. Bits and pieces of hedge may be found everywhere until the next rainstorm

PROJECT STATEMENT:

It is necessary to design a hedge-clipping recovery system for an electric hedge clipper of typical construction and design. The system must be able to successfully capture and bag the errant clippings without adding any imposing weight on the clipper. The system must also be retrofittable to all standard brands of hedge clippers that are on the market. The system must not be burdensome for the user despite the size (breadth and width) of the hedge that may need trimmed.

4. **STAIR CLIMBING ROLLATOR (ELDERLY WALKER-On-WHEELS)**

BACKGROUND:

The slightly mobile impaired patient or even healthy but elderly adult may often take advantage of a sturdy and stable walker with wheels, sometimes called: a rollator. In her recent “Letters to the Editor” (9/24/2000, New York Times), Ms. Caroline Birenbaum writes that the elderly are certainly benefited by having a walker with wheels but that these walkers are difficult for the elderly to use on stairs. She was advised that “…the rollator was designed for flat surfaces…” She concludes her letter by suggesting that “If this limitation is overcome, such devices will be godsend for more people.”

PROBLEM STATEMENT:

The student is requested to design a retrofit device that enables the rollator to be transported upstairs without burdening the user. It must propel itself up the stairs while providing adequate stability for the user. The power source for this device may not be derived from an electrical source. The weight and installed space of the system must not interfere with the rollator’s primary function: to assist the patient’s mobility on flat surfaces.

5. **CHAIN-LINK FENCE PAINTING SYSTEM**

BACKGROUND:

If Tom Sawyer thought white-washing a wooden fence was difficult, he would probably have run away sooner if he had to paint a chain link fence. The painting chore is one of the most time consuming exercises in patience and endurance, particularly if the painting is to be done on a sweltering summer’s day. The difficulty of the job is compounded by the fact that the painter must be sitting in a cramped position for hours while trying to get to the lowest spots on the fence. It is also necessary to drag along adequate ground covering in order to avoid dripping silver paint on the City's sidewalk or, even worse, dripping paint on the recently planted marigolds; which actually have the sole purpose of trying to make the chain-link fence look hospitable. The painter must not miss one spot of the fence wire or the first signs of rust reveal itself after only a few months of rainy or even humid weather. An all-around thankless job that must be done whenever a few of the best summer days are available.

PROJECT STATEMENT:

Develop a paint delivery system that can automatically paint a chain link fence without the painter actually needing to touch the paint. The system should be readily installed around the conventional chain link fence design regardless of the fence's height or curvature. The system can be powered and controlled via electrical energy.

6. VARIABLE HEAT CONTROL FOR ELECTRIC RESISTANCE STOVE TOP HEATING ELEMENTS (Researcher: F. Di Bella)

BACKGROUND:

An electric range resistance-heating element is known to be very difficult to accurately and quickly control. Experienced chefs dislike using an electric oven and range top because the elements do not heat up or cool down quickly and allow only three settings. Most chefs prefer to use natural gas (or propane) fueled range tops (or oven) heaters because they allow almost infinite control and the heating is almost instantaneous. Unfortunately these gas-fired heaters can be inefficient and can release toxic (in the worst scenario) or combustion gases that displace a kitchen's oxygen supply (in the best scenario). What is needed is an improved electric resistance-heating element that can quickly heat and/or cool in response to a simple but variable control administered by the operator.

PROBLEM STATEMENT:

Design an electric resistance heating element that can be as quick to respond to controls by the operator as a gas fueled range top heating element is now but without jeopardizing the electric heater's efficiency or non-toxic environmental pollution attributes.

7. MATTRESS DESIGN FOR MASSAGING SEDENTARY PATIENTS

BACKGROUND:

A serious health concern for a patient who is bedridden is the proclivity for his/her body to develop bedsores if periodic body motion is not maintained. The need for the immobile patient to be moved and/or massaged, in even the slightest manner, often is injurious or at the very least very uncomfortable. Perhaps a significant part of this discomfiture is fear that the well-intentioned actions of the care caretakers, causes local pain and even embarrassment. The patient needs more control over the exercising of the body so as to avoid the development of painful and unhealthy bedsores.

PROJECT STATEMENT:

A system for delivering a periodic massage to the patient in order to avoid bedsores is required. The system must be able to deploy the massage under the control of the patient, if possible, and/or via an automatic control system that sequences and varies the massage that must be administered. The system must be versatile enough to not require trained doctors or nurses to be present and must be retrofitable to the patient's private bed (i.e. the one used at home) as well as retrofitable to a hospital bed. A more deluxe system must also enable the patient to control the bed temperature (hot or cold) for an additional level of comfort.

8. VARIABLE SPEED, BELT DRIVE SYSTEM FOR A BIKE

BACKGOUND:

A chain drive system tends to be noisy and require constant lubrication. The derailer system also is complex and offers only discrete steps in speed control. A variable speed, transmission using an elastomeric belt may eliminate both of these problems.

PROBLEM STATEMENT:

Design a bike transmission system that uses a variable speed pulley and belt drive.

9. **PORTABLE DYNAMOTER (POWER MEASURING) DEVICE FOR A FIRST ROBOTICS DRIVE CHASSIS**

BACKGRUND:

The FIRST Robotics event often requires that the motored robotic vehicle pushes and pulls against a competitor. The design of the power drive system thus needs to be tested to determine the power delivery of the vehicle's powered wheels. The device also needs to be portable in order to enable it to be transported easily to the FIRST events that are outside the city.

PROBLEM STATEMENT:

Design and prototype an inexpensive method for accurately measuring force, speed and torque and record the measurements so that it may be analyzed via computer or hardcopy.

10. **INTERACTIVE CATAPULT EXHIBIT FOR OPEN-HOUSE ENGINEERING TOURS**

BACKGROUND:

S.E.T. is starting "Technology Friday" tours of its facilities at Northeastern University. An inter-active exhibit is thought to be useful to have the students use while also seeing what the S.E.T. students in electrical, computer and mechanical engineering technology can build. A catapult (Trebuchet) that can be instrumented with an electric "range-finder" carpet and a data acquisition system would be an interesting exhibit that can also be used by the S.E.T. staff for several other courses.

Similar inter-active exhibits are also likely to draw the attention of students and help them discern the benefits of a Northeastern University education.

PROBLEM STATEMENT:

Design an integrated catapult and data acquisition system that can be operated safely by a high school student and that will record and save the measured and predicted distances that an object has been thrown. The object must be less than ½ pound.

A similar interactive exhibits can also be proposed by the student and a prototype or model designed, built and tested

11. PET CARRIER/STORAGE COMPARTMENT SYSTEM FOR S.U.V.

BACKGROUND:

The market for SUV.'s is still growing despite the increase in fuel costs. One of the attractive features of an SUV is the large storage capacity. However, this storage area must be versatile enough to enable any large and/or heavy object to be easily installed and/or removed from the storage compartment area. In particular, some companies have suggested that a pet storage system is a very attractive option for a young family, particularly a family that travels with their pets for overnight stays at a " not-so, pet friendly" motel or hotel.

PROBLEM STATEMENT:

Design one or more different storage systems that can be used in a specific application (i.e. pet habitat) or for a variety of applications (i.e. sports equipment, food shopping bags, baby seat, and play area, etc.)

12. ADJUSTABLE MECHANICAL DISPLAY SYSTEM FOR FOOD PRODUCTS.

BACKGROUND:

There is an "art and a science" to the marketing of food products for the food industry. The placement of a packaged food item in a store could mean the difference between the acceptance or a rejection of a product by a customer. The ease with which the product can be displayed and the ease with which the product can be taken by the customer as well as the appearance of the dispenser is essential to the successful "launching" of a new product.

PROBLEM STATEMENT:

Design an attractive and functional mechanical display system for dispensing a packaged food product. The dispenser must be flexile to accommodate a variety of product sizes.

13. WEB-BASED DATA ACQUISITION SYSTEM AND COGENERATION SYSTEM PERFORMANCE MODEL

BACKGROUND:

Cogeneration of electric power and heat is becoming more attractive as the power needs and the cost of power increases in the United States. In order to evaluate the cost effectiveness of a cogeneration system for the perspective customer, a cogeneration system model needs to be developed (it is in progress) that will predict the effectiveness of the cogeneration system in a user's facility. The user need only type in the electric and gas or oil bills from previous years and the cogeneration system will determine the cost effectiveness of the system for that user. However, the data input from these users is very vital to the determination of the energy use of various industries in the United States. Thus, the data must be saved and sorted by industrial user type and, if necessary, used by the computer model when sufficient data is not available from the customer.

14. **REFRIGERATOR FOR USE BY HANDICAPPED (WHEELCHAIR BOUND) USERS**.

BACKGROUND:

A wheelchair bound person is often impeded by very simple things in their homes. For example, opening a refrigerator door and reaching into the refrigerator to retrieve an item that is on the shelf can be frustrating. Many other home appliances and household articles can be similarly frustrating to use by a handicapped (wheel chair bound or otherwise less mobile person).

PROBLEM STATEMENT:

Identify a household appliance or device that is difficult to operate and or use effectively due to the nature of the handicap that a user may be encumbered with. Design a new system that eliminates this problem. The solution must be easy to retrofit and/or cost effective and certainly safe to use.

15. BATTLE-BOTS ROBOTICS VEHICLE

BACKGROUND:

Northeastern University is coordinating a team of engineering students to design, build and operate a Battle-Bots robotic vehicle. The vehicle will be entered into competition with M.I.T. The robot will require a variety of mechanical, electrical and computer (autonomous operation) sub-systems in order to be competitive. For example, it has been proposed to design and integrate a collision avoidance system, an audible signal to assist a blind operator to guide the robot, autonomous operation to provide escape maneuvers.

PROBLEM STATEMENT:

Assist the Battle-Bots team by designing, building and testing a prototype subsystem that can be used effectively on the Battle-Bots robotic vehicle.

16. **MOTORIZED ICE SCRAPPER DEVICE**

BACKGROUND: A New England winter can be very harsh for the driver. Not only is traffic bad, but on most wintry mornings the driver must scrape off a layer of ice from the windshield. To make this chore easier and quicker there needs to be a motorized ice scraper that can be used by hand or affixed to the windshield wipers.

PROBLEM STATEMENT:

Design a hand held and/or windshield mounted ice scraper for auto windshields.

17. **A TRIPLE DECKER WHITE/BLACKBOARD WITH CLEANING SYSTEM FOR CLASSROOM USE**

BACKGROUND:

A whiteboard or blackboard is an essential tool in classroom instruction. One of the disadvantages of the solid (2 dimensional) blackboard is the need to constantly erase the board to make room for more written information. Also, there never seems to be enough board space for that "last equation that makes the point" The lecturer is forced to erased parts of the board only to later in the lecture need to refer to the erased information. What is needed is an easier way to erase the blackboard but also a way of increasing the writing area without increasing the wall space devoted to the white/black/board.

PROBLEM STATEMENT:

Develop a new white/blackboard system that increases the useable writing surface area without needing an increase in wall area and a means of cleaning the surface more quickly and automatically.

18. CASINO CARD SHUFFLING MACHINE
BACKGROUND:
Casino card shuffles are essential for any well run, efficient casino. The automatic card shuffles and dispensers can handle up to six decks. However, there are some techniques of "card counting" that can still be applied to the game of blackjack with even this large number of decks in play. A casino card shuffle is needed that can store up to 20 decks of cards and guarantee a maximum degree of randomness in the stack of cards.
PROBLEM STATEMENT:
Design a card shuffler that can provide the dealer with a maximum degree of random shuffled cards.

19. A "SMART" BLACKBOARD SYSTEM
BACKGROUND:
Many professors try to solve problems that are directed to them by the students in the class. This provides a high degree of originality to the problems that are presented as well as encouraging the students to participate in the class and not simply listen and take notes. Unfortunately, as the problems are being solved, the instructor often needs to calculate the answer to some mathematical equation which can be a very difficult and time consuming effort. In an effort to not waste the class time while the instructor performs these mathematical operations, it would be very useful to have a blackboard or whiteboard that can be "coupled" to a local PC and have the instructor's equations solved and the answers displayed on the blackboard or PC.
PROBLEM STATEMENT:
Design a blackboard or whiteboard that is integrated with a PC and math software that can "read" the hand written equation in script and then solve the equations and present the result in real-time.

20. **EMERGENCY REPAIR SYSTEM FOR NATURAL GASLINE PIPE RUPTURE**
BACKGROUND:
Natural gas Utilities are in desperate need for a means of quickly securing a pipeline that has been accidentally ruptured by excavating equipment. The story is as common as it is tragic. An excavation is being conducted near a residential area in order to repair water pipes and/or to lay new TV cable lines. Tragically the crew has either not checked with the local gas Utility as to the routing of their natural gas lines or has misread the sometimes very old engineering site drawings and has accidentally punctured a gas line. The resultant release of natural gas has not caused an explosion but is immanently in danger of doing so. The local Utility and/or the excavation crew must quickly shut off the gas line and, at least temporarily repair the ruptured gas line so as to stop the release of the combustible gas.
PROJECT STATEMENT:
A system must be developed to be able to quickly seal a ruptured gas pipeline in order to, at least temporarily, stop the release of the gas and thus avoid a very dangerous explosive hazard. It is also beneficial to the customers downstream of the pipeline that their service remain uninterrupted-after all the gas Utility is trying to be as "Safe and Dependable" as their nearest competitor. The Emergency Repair system must be safely deployable with a minimum of field tools by trained personnel. The system must be deployable in less than 20 minutes and from a working distance that will not jeopardize the field engineers/technicians who deploy the system in the event of an explosion.

21. AN AUTOMATIC WIRE CORD DISPENSING AND WINDING SYSTEM
BACKGROUND:
Electric-powered tools are becoming very popular, particularly in those geographical areas where CO_2 emissions are strictly enforced. Electric lawn mowers, weed whackers, and hedge clippers are generally lighter than gas powered devices, less noisy and do not require that gasoline be stored on the property during non-use. The one disadvantage cited by most users is the need to constantly be on the guard for where the wire cord is with respect to the cutting blades. Many electric cords have been cut when the user is briefly distracted and the electrically powered blades accidentally cut the wire cord. This is a very constant danger and is most likely to occur with lawn mowers.

Another disadvantage of electrically powered devices is the need to carefully wind the electrical cord into a neat coil after its use without twisting the cord.

PROJECT STATEMENT:
Design a device that will allow the user of an electric lawn mower user not to need to constantly watch for the electric cord and thus to be able to not only dispense the electric cord safely but also to wind the electric cord without twisting it. Proximity sensors should be considered that monitor the position of the user and constantly reel-in or out the necessary amount of power cord without the user tugging at the cord or trying to avoid the slack cord.

22. TRADE-MARK EMBOSSING- STAPLER SYSTEM
BACKGROUND:
The common paper stapler is a necessity for every well-equipped office. It may be seen in a variety of shapes and sizes. However, the basic design for all of these staplers is basically the same. Whether powered electrically or manually the stapler head is designed to bend a U-shaped, very small diameter metal wire after it has successfully punctured through a layer of papers. If performed successfully the fastening of the papers is usually very secure but very non descript. A stapling of papers performed in the ACME company is the same as a stapling of papers done by Amalgamated Products Co.
PROBLEM STATEMENT:
It is desirable to have a customized stapler-type fastening system for papers that can identify the users unique Trade-mark or company LOGO. The stapler system must be easy for the manufacturer to be able to give their user-customers, The Company the same basic stapler head design while enabling the user to deploy their unique Trade-mark or emblem. Thus, the fastening material must not be formed or shaped prior to the purchasing of the fasteners from the manufacturer. The fasteners take the shape of the Trade-mark only with a customized fixture or fittings that The Customer has purchased from the manufacturer. Certainly, the fastening must be as good as or better than the present, common stapler system.

23. AUTOMATIC CAR WASH SYSTEM
BACKGROUND:
A brand new automobile invokes interesting and sometimes diverse emotions in their new owners. Anxiety over the payments is weighed against the feel of a new car on the road and the absence of fear that the automobile will break down at the least inopportune moment. But a new car requires constant diligence to keep the external appearance sparkling and new. A new car driver in New England also fights the inevitable enemy: road salt during the winter not to mention road dirt administered by passing vehicles and trucks. Summer time driving is no less troublesome. Who wants to drive a new automobile that isn't as clean as it could be? Unfortunately, new car owners are a little leery about using "...just any..." car wash with hard bristles and strange moving mechanical arms and rollers that seem to all but attack the new car from all angles.
PROBLEM STATEMENT:
The Excelsior Automobile Co. wants to provide their new automobile customers "...who have everything..." with one more luxury: An Automatic Car Wash System. The system must be able to completely wash the car with hot water and dry the car. The system must be deployable by the user with only water and drain connections to the vehicle. The system must be deployed from and stored on the vehicle- how else can the car always be in a presentable and pristine appearance despite what ever the trip to work may have wrought?

24. NO NOISE, LOW ENERGY LEAF BLOWER DEVICE
BACKGROUND:
Many communities are waging war over neighbors who not only deploy dirty, energy inefficient gas fired, leaf blower systems but who also want the world to know that they are working diligently on their yards by making the most noise at the earliest possible hours in the morning. Some communities in Los Angeles and New York have been so enraged that they have started petition drives to have the gasoline powered blowers outlawed due to concerns about "...global warming" and polluted air. Can the electric powered blowers be far from suffering the same fate? There appears a need therefore for a new energy source that can power the leaf blower while not disturbing the local or global eco-system.

PROBLEM STATEMENT:
Develop a manually operated, leaf blower device that can be deployed without the need for electric and/or fuel (natural gas, propane, butane, etc.) energy source. The system must not weigh more than what can be wielded by the average man or woman while performing the typical chore of cleaning the yard (grass or solid cement or tar) surface.

Appendix B. Past Actual Capstone Projects, the Student Teams and Instructor/Consultants

AUTOMATIC DRINK DISPENSING SYSTEM
An Automatic Drink Dispensing system has been designed and prototyped. This system is intended to be used in high-traffic, entertainment areas such as casinos, sports events and intermissions where the speed of service is paramount to the customer. An automatic drink dispenser will mix liquor and soft drinks according to a programmed recipe and also keep inventory of the drinks that has been dispensed.
MECHANICAL TEAM: KARRAS, LEUNG, LEE
ELECTRICAL TEAM: KOLLMAN, STROB, MONTALBANO, SLOWIK
COMPUTER TEAM: CHAN, CHAN, CHAN, GEE

Faculty Advisors: Asst. Prof. Randall August, Ronald Scott and Frank Di Bella

TREBUCHET AND DATA ACQUISITION SYSTEM FOR SNELL ENGINEERING DISPLAY AND/OR ADMISSIONS TOURS
An interactive display has been designed and prototyped to be installed in Northeastern University's Snell Engineering Center. A two-foot tall, trebuchet (catapult) mechanical launcher has been designed to launch a small (250 gram, stuffed animal) projectile approximately 20 ft. The trebuchet has been integrated with an automatic range finder, data logger and trebuchet computer model that predicts the distance that the trebuchet will toss the object. The integrated system will be installed in the engineering center at Northeastern University to enable visitors and prospective freshmen to operate the system. The system is also used for instruction purposes in Dynamics classes to demonstrate the principles of Conservation of Energy and Newton's laws.

MECHANICAL TEAM: SWEENEY, JACKSON, GOULART (jgoulart@coe.neu.edu), KHAYYAT (barhoomjadh@aol.com), LUKEY (nlukey9@aol.com)
ELECTRICAL TEAM:
COMPUTER TEAM: WANG, TREYES, YEM, CHIOU

Faculty Advisors: Asst. Prof. Randall August, Ronald Scott and Frank Di Bella

MOTORIZED AUTOMOBILE SERVICE CREEPER FOR ALL-TERRAIN APPLICATIONS
A motorized vehicle service creeper has been designed and prototyped. The creeper is designed to be mobile on a variety of hard or soft surfaces that may be encountered when servicing vehicles that have broken down at a distance from service facilities. The creeper is designed with service lamps and an automatic, electronic inventory database to maintain service, inventory and billing records.
MECH. TEAM: MEYERS, WEST, BEGIN, MURPHY
ELECTRICAL TEAM: YILDEZ, KRIKORIAN
COMPUTER TEAM: MOKHTAR, MANSEAU, PAN, BRIGGS

Faculty Advisors: Asst. Prof. Randall August, Ronald Scott and Frank Di Bella

AUTOMOBILE OBSTACLE AVOIDANCE SYSTEM
An automobile obstacle avoidance system has been designed and prototyped. The system determines the relative speed of an approaching obstacle and the distance and determines the degree of collision danger. The danger level is announced to the vehicle operator via an on-board display that indicates the location of

the obstacle and the danger level by means of a color code (green for safe, orange for caution and red for danger, etc.).

COMPUTER TEAM: AGOUCHA, AMEDEE, BORGESON, COSTANZO, MELIN

Faculty Advisors: Asst. Prof. Randall August, Ronald Scott and Frank Di Bella

STANDARDIZED DRIVE CHASIS FOR FIRST COMPETITION ROBOT-I

Northeastern University has a very active FIRST Robotics team. FIRST (For Inspiration and recognition of Science and Technology) is a national event that was founded by Mr. Dan Kamen (Deka Engineering) in order to inspire high school students toward careers in engineering and science. NU's team traditional builds a robot drive system from "scratch" wit a NEW mechanical design each year and this inevitably takes more than the six weeks allowed by the contest rules. This team has designed a standardized drive system that can be reproduced (with some modifications) once the new contest rules have been established for the new contest. Although the chassis cannot be built BEFORE the new contest is announced each year, the FIRST rules does allow a standardized design to be prepared and tested and READY for building BY THE HIGH SCHOOL STUDENTS. This team is presenting one such standardized design that enables the robot to move horizontally, vertically and diagonally with control form the operator.

MECH. TEAM: DOUGHTY, ARMATO, COVINO
ELECTRICAL TEAM:
COMPUTER TEAM: CUNNINGHAM, HERNANDEZ, IRUKULLA, CHAMBERS

Faculty Advisors: Asst. Prof. Randall August, Ronald Scott and Frank Di Bella

WIRELESS, GPS CONTROLLED ROBOT FOR HOMELAND SECURITY DEFENSE APPLICATIONS

This vehicle has been designed to provide security for a variety of close-quarter inspection applications. The rover is wirelessly controlled and is outfitted with cameras on extension arms to enable versatile inspection of its environment. The robot is designed to move around and over obstacles using its tank-tread drive system.

MECHANICAL TEAM: ALEXI RYBALNIK (arybalink@yahoo.com)
ELECTRICAL TEAM:
COMPUTER TEAM: BOUTHIETTE(zjb@raytheon.com), EVERARD, GARSIDE (shawn_J_Garside@ratheon.com), WORTHINGTON,ALEXANDER

Faculty Advisors: Asst. Prof. Randall August, Ronald Scott and Frank Di Bella

AUTOMATIC CARWASH SYSTEM FOR RESIDENTIAL USE (danadeny@hotmail.com)

A single car wash system has been designed for personal use by residents or apartment dwellers. The system can be folded for storage and unfolded into an archway made of PVC tubing that can provide a timed sequence of water spray(s) to the sides and top of the vehicle. The cleaning solution can be water-based, cleaning solution water with or without a wax constituent. The wash water is collected by a floor covering that can safely and cleanly direct the water to a local drain system. The system is controlled by a microprocessor based (PLC-like) controller.

MECHANICAL TEAM: DE MARCE, JOHNSON, ABRAHAM, CAVANAGH
COMPUTER TEAM: CHIN, ENG, DESAMOURS

APPENDIX C. Class of 2006 CAPSTONE TEAMS

1. **Fluidic Mattress for Sedentary Patients**
   Rodriguez, Fage (vfage@coe.neu.edu), Mantia (Comp)
   Corneau, Hill (Mech.)
   O'Neil, Fraser (Elec.)

2. **Bed Assist System for Handicapped Persons**
   Krenning (krenning.a@neu.edu), Giampa (Mech.)
   Bonda, Szarmach (Comp.)

3. **Network-Web Based Data Acquisition System for Renewable Energy System Monitoring**
   Healey, Manor Almansour (Elec.)

4. **Automatic Home Powered Window (safety) System**
   Ragozzino, Wood (Elec.)
   Santos (msantos1@coe.neu.edu), Ablondi (Mech.)

5. **Highway Lane Monitoring and Vehicle Steering Correction System for Passenger Vehicles**
   DeCorral, Silva & Leonard (Comp.)
   Minassian (hminassi@coe.neu.edu), Siemaszko (Mech.)

7. **Coal Mine Rescue Robotic System**
   Brochu, Phan, Koudanis, Colon (Comp)
   Mamakos , Lizaur (Mech.)

8. **Renewable Energy Power Generation Pod for Residential Applications**
   Gandler (tgandler@verizon.net), E.Nguyen (Elec.)
   Cerza, Andrisani (Comp.)
   Pomeranz , Bates (Mech.)

9. **Food Storage Monitoring and Refrigerator Design for Handicapped Persons**
   Wade, Keane, Galvis (Comp.)
   Blasé (blasé.j@neu.edu), Forti (Mech.)

10. **Mobile Walking (Cane) Device for Visually or Mobility Impaired Users**
   Chiang, Cheung (ccheung@coe.neu.edu), Ng & Castillo (Comp.)

11. **Nano-Search Engine Development for Laptop/PC Presentations Station**
   Arroyo (l.arroyo@coe.neu.edu), Palatty, Yue, Kitagawa (Comp.)

12. **Automatic Compactor for City Street Trash Receptacles**
   Chan, Chin (chin.ri@neu.edu) (Mech.)
   K. Nguyen, Wong , Duong, Te (Comp.)

13. **Electro-Mechanical, Shock Absorber System for Automobiles**
Dulay (dulay.md@neu.edu), Petruzzello, Paquet (Comp.)
Swanson (Elec.)
Rosswag, Tully (Mech.)

14. Motor Bike Driving System for Handicapped Users
Neff (rneffii@coe.neu.edu), Duly, Garcia, F.Scott Lian (Mech.)
Constantino, Kaunalis (Comp.)

16. Computerized Therapeutic Muscle and Joint Treatment System
Marchiesiello, Greenwood, Maceachern , Coppola, Gitlin (Mech.)

17. Wireless, Mobile Personal Transport (Back pack) Device
Scotland, Hinds (hinds.t@neu.edu), Norton, Ventura,
Andre (andre.y@neu.edu), (Comp.)

18. Electro-Mechanical Emergency Combination Safe Decoding Device
Hoffman, Khouri (Mech)
Grauds (Elec.)