AC 2010-1416: UNDERGRADUATE ENGINEERING DESIGN COURSE ON PROSPECTIVE OF PHD STUDENT

Aezeden Mohamed, University of Manitoba

Aezeden Mohamed, PhD Candidate and Sessional Instructor in Department of Mechanical and Manufacturing Engineering at the University of Manitoba. He received a B.S. in Material Science and Engineering from El-Fateh University, Tripoli- Libya, and a M.Sc. in Department of Mechanical and Manufacturing Engineering. Certification in Higher Education Teaching Program 2008, a past President of Canadian Union of Public Employment (CUPE 3909) Address: University of Manitoba, EITC, Winnipeg, Canada, R3T 5V6. aezeden@cc.umanitoba.ca

Myron (Ron) Britton, University of Manitoba

Ron Britton, M.G (Ron) Britton, P.Eng. Professor and Associate Dean (Design Education), Faculty of Engineering, University of Manitoba. He received a B.E (Civil Engineering) from the University of Saskatchewan, a MSc from the University of Manitoba, and a PhD from Texas A&M University. He is a 3M Fellow, a past President of the Association of Professional Engineers and Geoscientists of Manitoba, and holds an NSERC Chair in Design Engineering. Address: E2-262 EITC, Faculty of Engineering, University of Manitoba, Winnipeg, MB, Canada, R3T 5V6.ron_britton@umanitoba.ca

Undergraduate Engineering Design Course on Prospective of PhD Student

AEZEDEN MOHAMED AND RON BRITTON
Engineering and Information Technology Complex (EITC), 75A Chancellors Circle
University of Manitoba, Winnipeg, Manitoba, Canada R3T 5V6

Abstract

ENG 1430, Design in Engineering, is a one term required course that forms part of the common first year Engineering program at the University of Manitoba. It has been structured to assist students develop team skills such as decision making, project management, communication and collaboration while experiencing the use of fundamental engineering design skills. This paper describes the components and operation of the course as observed by the senior author, a PhD student and Sessional Instructor.

Introduction

Design courses, in particular, can incorporate a significant variety of information and topics within their structure. This course targets student early in their Engineering education at University of Manitoba to introduce a creative engineering design team environment, familiarity with the engineering design process and working in teams. It exposes students to creative processes with design components and prepares students for the more advanced classes. It has been shown that keeping the interest of students early in their education has a positive effect on their subsequent educational experiences[1]. However, there is a limited amount of time that both the instructor and students can devote to any particular course and first year students do not yet have the analysis skills required for detailed component design.

The three credit course is offered to two sections of 80 students in each term, providing an annual capacity of 320 students. Both lectures (two hours per week) and studios (3 hours per week) are held in a Design Studio equipped with moveable round tables and a variety of audio and visual tools. Collapsible "work tables" are available as needed. The design studio is open daily from 8:00am to 5:00pm, apart from scheduled classes, for students to work on their projects.

Design Topics

A variety of engineering design topics are presented in the lectures and then are reinforced by exercises in the studio. Topics include; team development, idea generation, concept selection, conflict resolution, project planning techniques, task assignment and delivery, project record keeping, all illustrated with "real world" examples. Student involvement in the lectures is encouraged through the use of "I-Clickers".

At the beginning of the term students are assigned to 5-person design teams. All studio work is conducted as members of these teams. Lecture topics provide the background and required to deal with the design components in the studio sections[2,3]. Student projects are not technically complex, but they do utilize the design tools discussed in the lectures and they do require student to move from concept, through fabrication to demonstration.

System Design

Probably the most exciting aspect of ENG 1430 for first engineering students is the actual fabrication and demonstration of their design projects. The projects increase in complexity as students gain experience. The initial project is completed in one studio session. Ultimately teams will have three weeks to design, build and demonstrate their solution to the design assignment. It is important for students to gain the experience of designing systems that must be built to meet a performance standard. As projects become more complex, students gain an appreciation of the increasing interactions of components in these more involved projects[4].

During each design project the students are given a performance specification along with design constraints. They select and supply the materials required. In most cases simple hand tools are employed in the design studio to complete the fabrication.

The supervision process in the class helps to motivate the students. Instructors and Teaching Assistant involved in advanced design engineering classes have suggested that the experience with manual and electric tools gained in ENG 1430 has a positive effect on in their "follow-up" classes. Students have a better appreciation for these tools as well as the processes for which they are employed. Each year there are fewer first year engineering students with experience using tools of any sort.

Simple Electronic

Apart from those who have prior interest in electronics, very few first year engineering students are comfortable with basic digital systems. ENG 1430 provides an introduction to the practical end of electronics for all students. This results in an awareness for those who will subsequently study outside of the Electrical/Computer Engineering area. This exposure seems to enhance first year engineering student's comprehension of the material being taught[5,6]. The problem with employing computers and digital electronics in an early engineering design course is the temptation to transform the course into an analysis or programming course. Students are familiar with using computers and they equate their use with "advanced" design. Thus, care is taken in designing the projects to ensure that they are firmly grounded in engineering system design. In this course they learn to build their circuit on a basic breadboard, shown in Figure 1.

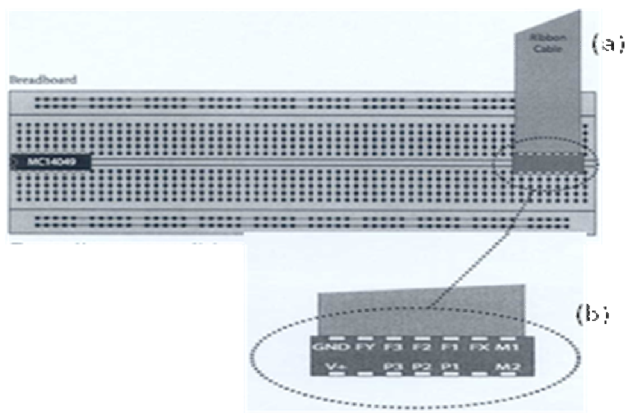

Figure 1 Basic controller (a) Breadboard with a sample IC chip (b) Ribbon Cable

A typical electronics project is the design of a controller for a model 3-story elevator. Unlike the other projects, all materials are provided for the circuit building project. A typical breadboard assembly is shown in Figure 2. This is usually connected to either the top or bottom two rows on the board to supply GND+6V through the student's breadboard to the elevator main power bus. Students wire their IC pins to the ribbon cable that connects the controller circuit to the model elevator. The ribbon cable is connected a cross the middle of the breadboard as shown in Figure 3. Students at this moment have to be careful not to bend the pins when inserting or extracting the ribbon cable. The connector supplies signals from the elevator floor location sensors (F1, F2, F3), and bottom/top limit sensor outputs from elevator (FX, FY) and push-buttons (P1, P2, P3) to student's controller. The student's controller will then provide the motor control signals (M1, M2) to the elevator by student's controller via student's battery pack 6V through the +V/GND pins as shown in Table 1. The design for the board is completely electronic (using a standard CAD system) and is readily replicated via a variety of PC board manufacturing techniques[7].

Table 1 Data M1, M2 motor control inputs to elevator from student's controller

M2	M1	Action
0	0	stop
0	+V	up
+V	+V	down
+V	+V	stop

Some precaution for students should be carefully considered, students must be careful not short circuit must not connect two IC outputs together as a potential short circuit might occur must not connect an IC output to a sensor signal.

Basic digital electron component students in this course learn how to use digital electronic components in electromechanical projects such as in the case of elevator controller engineering project. The components perform specified binary logic operations. Examples of some of the components or the gates are provided in the studio handout with their function defined in the accompanying input/output "truth" tables. Students of this course are highly exposed to use designing a circuit using logical operations. Then, when students want to construct students design, students would choose a technology (logic family) to implement students design. This would often be in the form of discrete integrated circuits (ICs). Some examples of these are given in the studio handout, and the ICs may contain several logic gates. The input/output signals representing the logic levels are voltages; students in this studio are using ~6V to represent logic "I" and ~0V to represent logic "0" in studio. Students also in this course learn become educated with various logic components that may used in the studio and then solve the problems as shown in Figure 2.

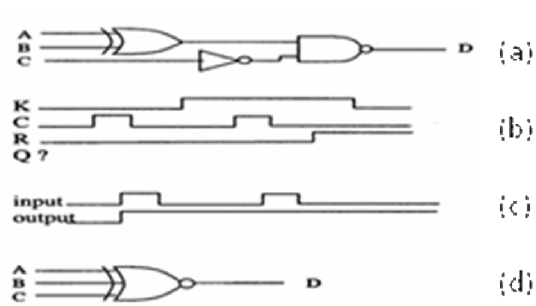

Figure 2 Various problems of digital logic components

The Final Test Event

In addition to the midterm and final exam, students are required design systems that perform specific tasks. The course is designed to be fun and to permit a wide spectrum of learning experiences associated with different sectors of the engineering profession. A team's project grade is dependent on how well their system performs at the final show test. Although the final tests of each project are the major events in the course, the course grade criteria are designed such that even a student whose systems perform poorly in the final show does not irreversibly harm their over all course grade. The only severe penalty from a grading perspective is not participating. The final test show is actually a combination of six design projects in this course however in this paper we will discuss only three of them; the car hill climb, the controller elevator and the egg mover. Teams have an opportunity to perform individual trials anytime prior to the final show. On each of the final test days all demonstrations are executed in the studio. Project performance is judged by a panel of "external judges" as well as the other 15 teams in the section. The committee consists of Instructor from different class, student's evaluation and the course Instructor. Three specific design engineering tasks are described below.

Car Hill Climb

This is dubbed the “great rubber band vehicle” design. The rubber band powered vehicle starts 15 ft from the front of the 3 ft wide ramp. The vehicle moves forward and moves up the slope to level 1. After moving across the flat section, it continues up the slope to level 2. This process is shown in Figure 3.

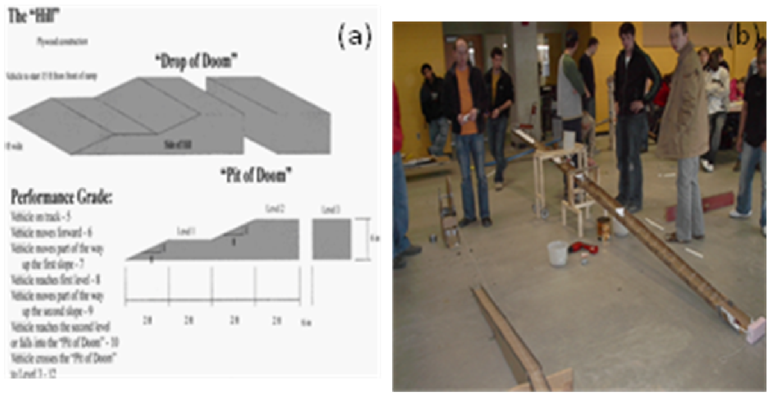

Figure 3 Car hill climb project show hill with ramp levels and drop doom (a) paper design (not to scale) (b) actual design

The vehicle motor must be contained within the vehicle and move with the vehicle, the car must be made of recycled or used materials or materials as may be approved by the instructor (no Lego TM or similar products, or chassis parts from a toy car can be employed). The motor cannot catapult the vehicle to the hill. It must remain in contact with the ramp. Each vehicle will have a maximum of three test hill climbs. Grading the vehicle performance is described in Table 2. Test results are be the average of the top two runs as described in Table 3. Each design team will have two minutes (per test run) during which to demonstrate the performance of their vehicle. There can be no interaction with any vehicle once it has left the start line. A run is discontinued when the vehicle reaches maximum forward progress. If the vehicle front wheels touch the start of the one of the slopes on the hill, it is considered that the vehicle is “on the slope”. The students may use a small battery to operate vehicle accessories (lights, radio, etc) and to steer the car (steering by remote control will not be considered as interacting with the vehicle) but it can not be used to power the car.

Table 2 Grading vehicle when climb hill

No.	Vehicle Status	Points
1	Vehicle placed on track	5
2	Vehicle moves forward	6
3	Vehicle touches first slope	7
4	Vehicle touches first level slope	7
5	Vehicle touches second slope	9
6	Vehicle touches top of the hill	10
7	Vehicle goes into “Pit of Doom”	12
8	if vehicle drops off side of the hill	-1

Table 3 Test results show the average of the two best runs, rank and evaluation

Team	Run One	Run Two	Run Three	Top Two	Performance Rank	Students Evaluation	Total
1	9	8	8	8.5	8.3	8.3	16.5
2	10	7	9	9.5	8.8	9.5	18.5
3	12	12	12	12	10.0	9.4	19.4
4	12	10	12	12	10.0	9.4	19.4
5	6	7	7	7	7.5	7.9	15.4
6	12	12	8	12	10.0	9.5	19.5
7	6	8	10	9	8.5	8.8	17.3
8	12	12	12	12	10.0	10.0	20.0
9	9	6	9	9	8.5	9.6	18.1
10	7	9	7	8	8.0	9.5	17.5
11	9	12	6	10.5	9.3	9.0	18.3
12	6	7	12	9.5	8.8	7.1	15.8
13	8	8	10	9	8.5	9.3	17.8
14	6	6	6	6	7.0	9.2	16.2
15	9	10	9	9.5	8.8	8.5	17.2
16	6	6	6	6	7.0	7.0	14.0
17	6	6	8	7	7.5	7.9	15.4
18	10	7	12	11	9.5	8.5	18.0
19	12	12	12	12	10.0	9.5	19.5
20	12	10	12	12	10.0	8.3	18.3

Elevator Controller

In this project, students design a controller for a model elevator as shown (see Figure 5) that is capable of operating between three floors. The elevator consists of three floor position sensor outputs (F1, F2, F3), two limit sensor outputs (FX, FY), three push-button command outputs (P1, P2, P3) and two motor control inputs (M1, M2). The controller should sense a push-button command, requesting the elevator at that floor, and then send control signals to the elevator motor to move the car to the appropriate floor and stop there. A push-button command will consist of momentarily pushing one of three floor request buttons, will activate signal P1, P2 or P3. The team may not continuously hold these buttons and no interventions are permitted once the elevator car is in motion. The presence of the elevator car at any of the three floor locations is indicated by one of the three signals (F1, F2, or F3) being active. When the elevator car is not positioned at one of the three floors sensors, these signals will be inactive. In addition to the three floor sensors, there are two additional limit sensors to indicate that the car is either past the top floor (FY) or below the button floor (FX). Students may or may not wish to use of these two limit signals in their design. The elevator car moves up and down by applying control signals to the motor control lines (M1, M2). Their function is defined as (SOP when M1=0; M2=0; DOWN when M1= 0, M2=1).

Power is supplied by a 6V battery to power the controller and their logic Ics. An active sensor will be ~ 6V (including logic “1”) and an inactive sensor will be ~0V (indicating “0”). The controller circuit is constructed on a breadboard and connected to the elevator using a ribbon cable with a specified writing pin configuration.

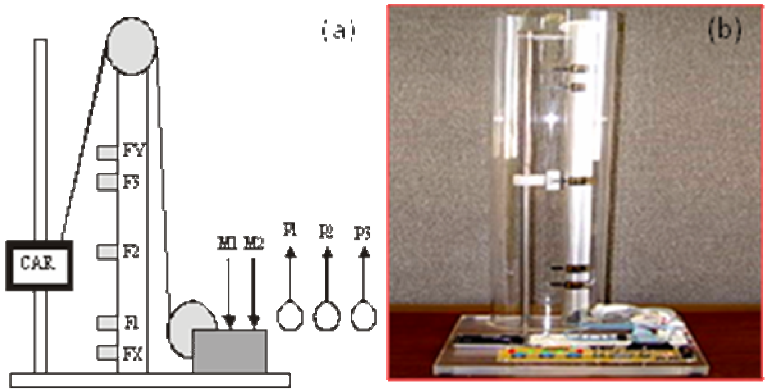

Figure 4 Design of a model elevator controller project (a) paper design (not to scale) (b) actual design

Egg Mover Project

The requirement of this project to design build, and demonstrate a device that will pick up, move and place a raw grade "A" large egg. To start the test, the egg is placed on a spot 2.4 m from a 2 x 6 (38mm x 140mm) that is on edge. The engineering object is to pick up the egg, move it over the 2 x 6 and place it (unbroken) on a spot 2.4m on the other side of the 2 x 6 (see Figure 5).

Grading is based on the performance of the device and peer evaluation. The instructor places the unbroken egg on the start point. The engineering device can not be within 10 mm of the egg at the beginning or the end of the test. Students interact with their device only once to start the device and only one person can interact. The device cannot employ any form of electricity, AC or DC, any type of internal of external combustion engine or a device that will produce smoke or gas of any kind. The egg must pass over the 2 x 6 (not around it). Upon the completion of the demonstration, the egg must be left on the floor, free of any constraint that might prevent it from moving (nothing can be touching the egg). If the egg is cracked (content of the egg still within the shell) there is a penalty on the performance grade. If the egg is broken (contents of egg no longer confined to the shell) there is a greater penalty and on the performance grade and the students must clean up the mess. Further grading details are shown in Table 2.

In addition to device performance, grades are influenced by a series of oral and written reports detailing the design phases of each device. The composite grade includes reports on the initial events, a qualifying round, a design review as well as a final performance score. These scores are designed to force the students to begin work on their project making the final result substantially more robust and effective.

Figure 5 Egg mover project (a) design on paper (not to scale) (b) set up and picks up eggs(c) move and a place grade A large egg

Results

This course addresses not only engineering design process and technique but also exposes students to a reasonable simulation of the design workplace. Because the course involves a continuing interaction of team members, issues arise that stimulate discussions and reactions to a wide range of interactions, from communications to ethics. The design courses sequence in the Faculty of Engineering has been developed to brings these issues into the curriculum. Students learn the importance of the "soft skills" early in their careers. The discussions that arise from in-class situations provide an excellent foundation for the follow-on philosophy class on ethics that the students are required to take. Communication, both oral and written, is critical to the success of any engineer and any design. Because these designs are the result of group effort, most students see, first-hand, the effects of communication, both good and bad. Even the best designs have a difficult time being supported and implemented if the design engineers cannot justify their designs in a clear and concise manner. During this course, students are provided with a strict set of guidelines for their written and oral reports. These guidelines are a set of rules that the students use for the remainder of their time at the Faculty of Engineering and hopefully beyond.

Conclusions

Most engineering students with a less than positive view of team projects. One of the most difficult yet critical lessons for students to learn how to be an effective team member. This is also a difficult skill to assess. However, when the instructors of the required Technical Communications course requested that ENG 1430 be made a prerequisite for their course, which also uses a team approach, we felt that we were having some positive effect.

Students tend to spend a great deal of time working on the hands-on design projects, often to the detriment of more traditional theory. However, feedback from graduate student TAs and Instructors involved in advanced engineering courses indicates that students perform better in teams and are more able to communicate their concepts after taking ENG 1430.

Bibliography

1. Ambrose, S. A. (1997). Systematic design of a first-year mechanical engineering course at Carnegie Mellon. Eng. Education , 2 (86).
2. Brassard, M. (1996). The Memory Jogger Plus, GOAL/QPC.
3. Brent, R. M. (2001). New faculty an orientation to the profession. Proceedings of the 31st ASEE/IEEE Conference, 31, pp. S3B/1-S3B/3. New York.
4. Byrd, J. (1995). Teaming in the design laboratory. ASEE , 84, 225±341.
5. Catalano, G. D. (1996). Adding hands-on design to an engineering curriculum. Engineering Education , 3 (85).
6. Gorman, M. E. (1995). Teaching invention and design: multi-disciplinary learning modules. Engineering Education , 2 (84).
7. Kurfess, T. R. (2001). Challenges and directions for integrating mechatronics into early design. Engineering Education , 4 (17).

Authors Biography

Aezeden Mohamed, PhD Candidate and Sessional Instructor in Department of Mechanical and Manufacturing Engineering at the University of Manitoba. He received a B.S. in Material Science and Engineering from El-Fateh University, Tripoli- Libya, and a M.Sc. in Department of Mechanical and Manufacturing Engineering. Certification in Higher Education Teaching Program 2008, a past President of Canadian Union of Public Employment (CUPE 3909) Address: University of Manitoba, EITC, Winnipeg, Canada, R3T 5V6. (204) 995-3775. aezeden@cc.umanitoba.ca

Ron Britton, M.G (Ron) Britton, P.Eng. Professor and Associate Dean (Design Education), Faculty of Engineering, University of Manitoba. He received a B.E (Civil Engineering) from the University of Saskatchewan, a MSc from the University of Manitoba, and a PhD from Texas A&M University. He is a 3M Fellow, a past President of the Association of Professional Engineers and Geoscientists of Manitoba, and holds an NSERC Chair in Design Engineering. Address: E2-262 EITC, Faculty of Engineering, University of Manitoba, Winnipeg, MB, Canada, R3T 5V6. (204) 474-6059. ron_britton@umanitoba.ca