Introductory Design in Freshman Engineering

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Abstract

Polytechnic University teaches a 4-credit course in Freshman Engineering that introduces students to software and hardware tools, teamwork, written and verbal communication skills, project management, as well as overview lectures on major technical and non-technical disciplines. Several laboratory experiments and two term projects emphasize engineering design. Examples of student designs are presented.

I. Introduction

Our world is becoming ever more complex. It is no longer possible to cope by relying on expertise from a single discipline. Freshmen in engineering schools must come aboard the "speeding train of runaway information overload" and be able to sort out what is and what is not relevant. They must be able to work in multi-disciplinary teams and be able to present their activities to peers as well as supervisors. To this end Polytechnic University teaches EG1004, Introduction to Engineering and Design, that provides freshman students with an overall perspective on engineering, and useful tools and work methods that will be of great utility to the students in the years to come.

II. Background to the Course

EG1004 consists of lectures (1 hr/wk), laboratory work (3 hrs/wk), and recitations (2 hrs/wk) for an academic semester. Activities and examples from a variety of engineering disciplines are presented and a selection of professional tools (MS Word, MS Excel, MS PowerPoint, MS Project, AutoCAD, LabView) are introduced. Students are exposed to team building activities and must make presentations (both written and oral), as an individual and as a member of a team. Some laboratory work involves design competitions and the students must select one of two semester-long design projects that require teamwork and develop project management skills.

The class is unique in that it primarily uses undergraduate teaching assistants (TAs) for the laboratory supervision. See ref. (1). The recitations and semester projects are run by the technical faculty and writing consultants together with the TAs. Lectures are given weekly by invited speakers who are specialists in their various fields.

The class recitations consist of presentations of lab activities (MS PowerPoint) and submission of electronic/paper lab reports. Periodically a project progress report is given. All these activities are graded and the students get immediate feedback about their performance. Technical writing specialists from the Humanities department act as writing consultants, playing a crucial role to help improve both the written and oral presentation skills of the students.

III. Overview of Course Content and Goals

Lectures are given weekly by experts in the fields and vary somewhat from semester to semester. Typical lecture topics are:

Introduction to Course / Engineering Disciplines
Robotics
Safety & Reliability
Large Software Projects
Civil Infrastructure
Aerospace, Apollo, and the Lunar Module
Design for Manufacturing
Chemical Technology & History
Signal Processing
Ethics in Engineering
Quality Management
Intellectual Property

Laboratory work covers many disciplines. The undergraduate teaching assistants help freshmen get familiar with new technical tools and concepts. The primary weekly laboratory activities cover:

Word/Excel/PowerPoint
AutoCAD/MS Project
Hardware Tests
Hardware Analysis/ Reverse Engineering
Boom Construction Competition
LabView 1
LabView 2 / Sensors and Robot Programming
Thermal Insulation Competition
Microphone
Filters
Communication
Digital Logic

IV. Semester Design Projects

Students of EG1004 must complete a semester-long design project. This is a 12-week team project done by groups of two or three students. It requires selection of one of the (currently) two projects, presentation of a preliminary design, planning the project schedule, making periodic progress reports, preparing engineering drawings, building a working model of the design utilizing required software programming, and a final "sales presentation" where the student teams compete against each other to "make the sale". Minimal design is encouraged; i.e., minimum cost, minimum time, or the fewest parts and the least amount of programming to do the task.

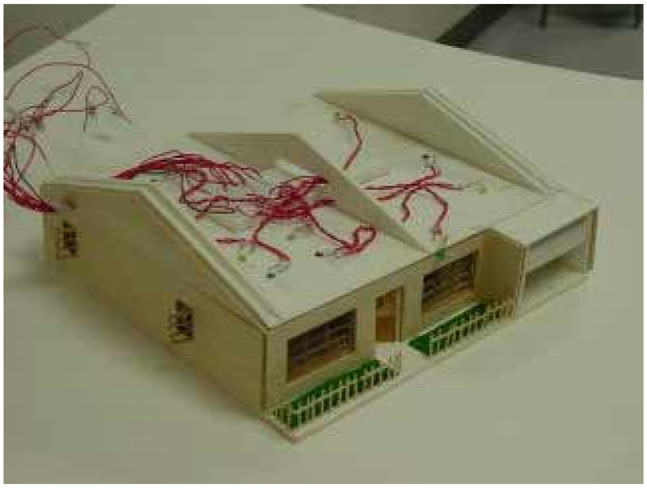
Student teams must choose one of the current semester design projects:

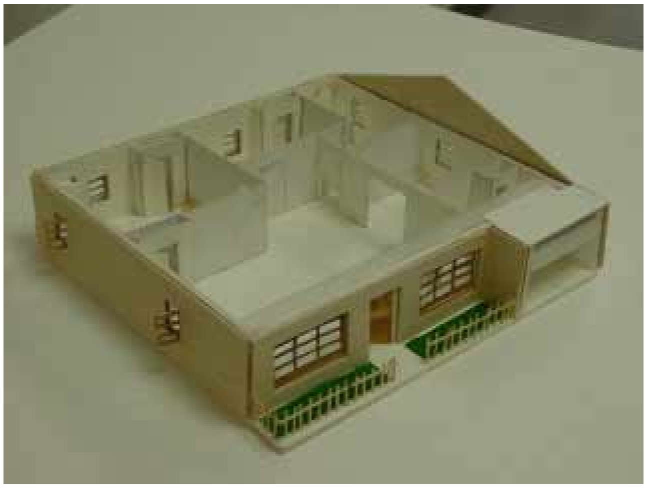
House Design Project
Robot Design Project

V. House Design Project

This project calls for the design of a single-story house using AutoCAD and MS Project. At the completion of the design period, the design team is to build a model of the design, using the materials provided, to the specified scale. The team will also implement a LabVIEW program that will control the lighting and temperature controls in the house. The project will be completed over 12 weeks. The project will include at least 6 drawings, as well as the model of the design with implementation of the LabVIEW program. The project will be a team effort, i.e. done by groups of two or three students.

The ground rules for the house design project are included as appendix A. A selection of photos of typical student house designs is shown below.





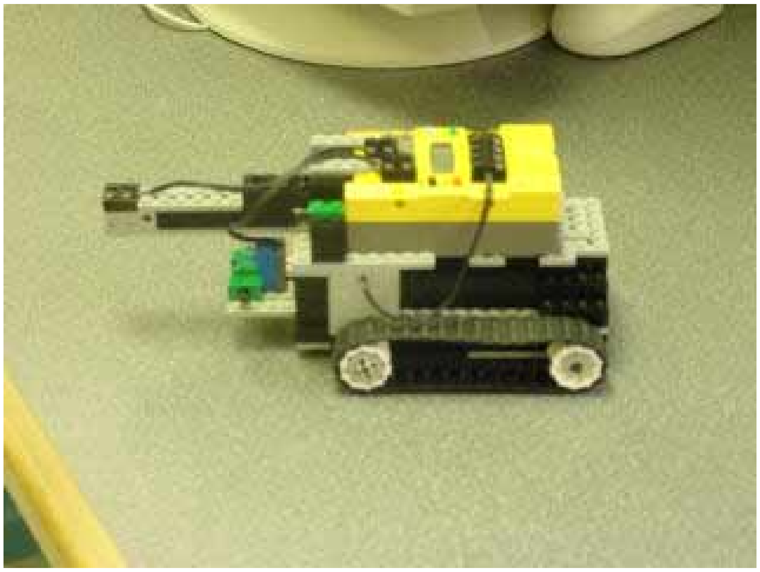
Photos of two house designs

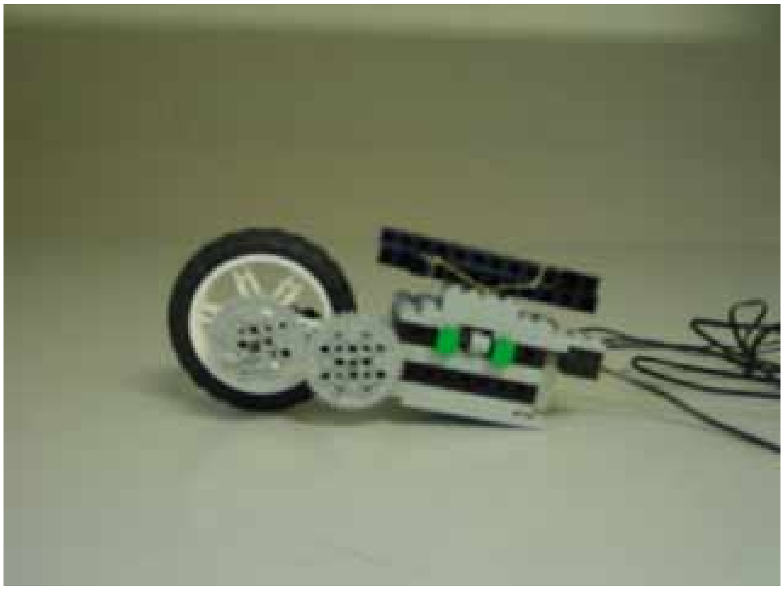
VI. Robot Design Project

For this project, the team will bid on a contract for the Unites States Federal Bureau of Investigation. This contract calls for the design of a robot or vehicle that is able to navigate an obstacle course. The robot will be made from parts sourced from the Robolab kits and be built according to a project plan. Upon completion of this project the group will have designed a robot according to the specifications given below, presented the robot with a budget estimate, project plan, and full two-dimensional drawings to the customer. The group will also have built a model of the robot and competed against the other groups for the production contract.

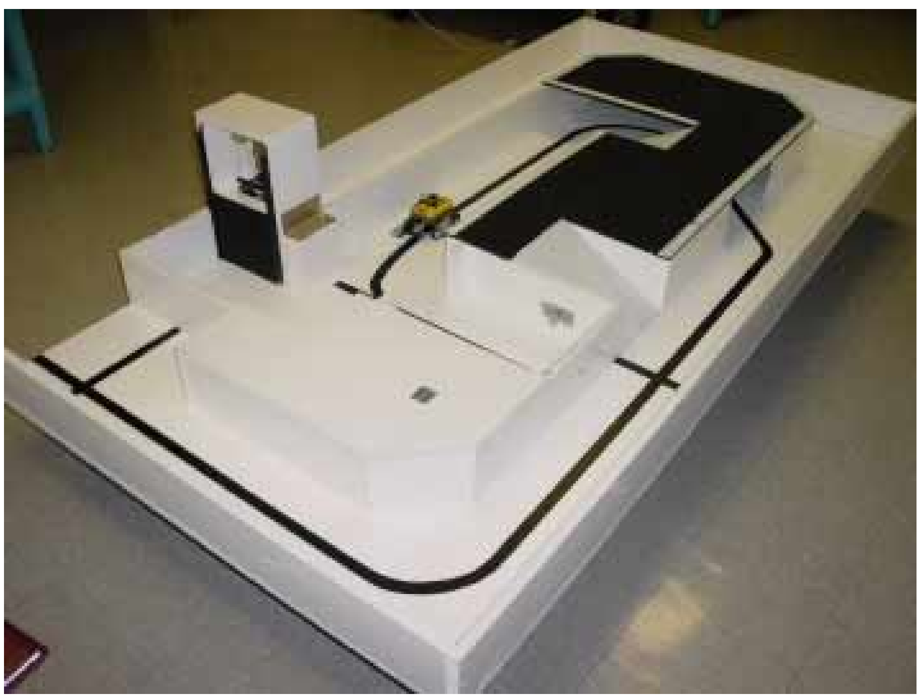
Students learn about uncertainties in design: variation in battery power, traction, motor speeds, sensors, pressure connections (fitted assemblies allow faster construction but increase tolerances and are not as solid as other fastening methods). Software logic had to include frequent reassessments as to where the robot is and had to compensate for the mechanical tolerances.

The ground rules for the robot design project are included as appendix B. Photos of two robot designs and photos of the obstacle course are shown below.





Photos of two robots



Photos of obstacle course to be traversed by robot

Videos of robot solutions can be found at   http://eg.poly.edu/Robotvideos/

VII. Student Feedback & Comments

Student feedback is solicited: both optional and mandatory surveys are conducted during the semester. A majority of students preferred the robot project. They were allowed to take the Robolab kit home, with all components and were able to do testing and programming using their university mandated laptop computers. Thus they only had to come to the lab when they tested their design in the maze. One problem with the robot designs is that it could become addictive. Some students became totally enthralled with the mechanical/sensor/software aspects of the designs and spent significant amounts of time on the project.

VIII. Summary

This paper provides an outline of EG1004, Polytechnic University's Introduction to Engineering and Design course. This course is a required course for all Polytechnic freshmen. Emphasis is given to two semester-long design projects done by teams of two or three students: the house and the robot projects. Student feedback is used to enhance future versions of this class.

Acknowledgments:

The authors would like to acknowledge the many people who have helped make this class a success: instructors, teaching assistants, and dedicated students --- both current and from previous years.

Bibliography

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2. "EG1004 - Introduction to Engineering and Design," Laboratory Manual, Polytechnic University, January 2001.

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Appendix A

INDEPENDENT HOUSE DESIGN PROJECT

A.1 Project Description

This project calls for the design of a one-story house using AutoCAD and MS Project. At the completion of the design period the design team is to build a model of the design, using the materials provided, according to the specified scale. The team will also implement a LabVIEW program that will control the lighting and temperature controls in the house. The project will be completed over 12 weeks. The project will include at least 6 drawings, as well as the model of the design with implementation of the LabVIEW program. The project will be a team project, i.e. done by groups of two or three.

A.2 Project Specifications

The following are the specifications for this project. They are to be strictly followed.

1. The maximum area of the design shall not exceed 2,500 sq. ft.
2. The design shall include at least one secondary egress.
3. The outer walls shall be 6" thick and the inner walls shall be 4" thick.
4. The ratio of the floor area to the external opening area should be at least 10% in each room.
5. The cost of the design shall not exceed the budget of $60,000.00.
6. An extra 200 sq. ft. and $2,000.00 are allotted if the design includes a garage.
7. The model shall be built to a scale of 1:4, i.e. 1 foot on the drawing is represented by 4 in. on the model.
8. The LabVIEW program must control the lights and temperature controls in the model house. The team must demonstrate the LabVIEW program using the model it has built.

A.3 Drawings Required

The best way to finish all the drawings necessary is by using layers, as explained in Lab #2 of ref. (2). The base layer should be the basic floor plan and then layers can be added for the dimension layout, electrical layout and plumbing layout. In this way all of the drawings can be in one file rather than 3 or 4 separate files. Also line-type is very important when it comes to drawings. The requirements for each layout are as follows:

A.3.1 Floor plan
The basic floor plan shall show the basic layout of all the rooms in the house. These rooms should be clearly labeled.

A.3.2 Dimension Layout
This drawing must show in detail the dimensions of the design. It is intended that the design can be constructed from this layout. The dimensions are to be in engineering

format (1.50’) and not in architectural format (1” 6 ¾”). As much as possible, try to keep dimensions on the outside of the house for visual clarity.

A.3.3 Electrical Layout
This drawing must show the electrical fixtures in the design, i.e. all the lights, switches and electrical outlets (110V and 220V). Please note that all lights must be connected to the switches that control them (using the correct line-type). The distance between outlets should be no more than 12 ft.

A.3.4 Plumbing Layout
This drawing must show all the piping in the house. It is assumed that the city water and sewer lines are at the front of the house, so the cold water and sewage pipe should start at the front of the house. All water pipes should be 4” in diameter while all sewage pipes should be 6” in diameter. The sewage pipes should be kept outside of the house as much as possible to prevent damage should a leak occur.
N.B. All pipes turn at right angles.

A.3.5 Front Elevation
This drawing shows the front of the house from the perspective of someone standing directly in front of the house looking at it straight on. The front elevation should show the height of the house (10 to 12 ft), the pitch of the roof, and the window and doors at the front of the house. N.B. It is expected that the measurements of the doors and windows, on the elevation layout correspond with those on the dimension layout.
The roof shall have an overhang of at least one foot so that rainwater will not run down the walls of the house.

A.3.6 Side Elevation
This drawing is similar to that of the front elevation. The side chosen must be the most detailed side of your house design, i.e. the side with the most windows, doors or other features.

A.4 MS Project

As mentioned in the project description, each team will create a project plan using MS Project. This plan should detail all tasks related to the project including task name, duration and relation to other tasks. The project plan should be completed before any other work on the project commences, and followed your project plan throughout the duration of the project. If, for any reason, the team is behind schedule, explain the reasons for the delays and what steps are being taken to get the project back on track. Any changes in the project plan should be mentioned and explained in the Progress Reports.

Appendix B

INDEPENDENT ROBOLAB PROJECT

B.1 Objectives

For this project, the team will bid on a contract for the Unites States Federal Bureau of Investigation. This contract calls for the design of a robot or vehicle that is able to navigate an obstacle course. The robot will be made from parts sourced from Robolab kits and be built according to a project plan. Upon completion of this project the group will have designed a robot according to the specifications given below, presented a budget estimate, project plan, and full two-dimensional drawings to the customer. The group will also have built a model of the robot and competed against the other groups for the production contract.

B.2 Project Specifications

B.2.1 Design

The following are the specifications for this project. They are to be strictly followed:

1. The contract is for the production of a bomb retrieval/disarming robot.
2. The robot should be totally autonomous.
3. The robot your group designs must be able to fit through a 28” door and turn around in a confined area.
4. The height of the robot must not exceed 6’.
5. The maximum weight of the robot is 600 pounds.

B.2.2 Model

1. Design the robot to handle as many different types of terrain as possible (don’t forget the robot might have to climb stairs). The working model of the robot should be similar (not in size) to your design.
2. The working model’s only constraint is that it must navigate the course, disarm the “bomb” and exit the course.
3. The robot should be able to cross semi-rough terrain, and navigate normal building layouts (i.e. doorways and narrow hallways).
4. Video and audio feedback are a must (the working model does NOT have to include video or audio feedback).

B.3 Drawings Required

At least two drawings of the robot design are required

1. A front view of the design *(fully dimensioned).*
2. A back view of the design *(fully dimensioned).*
3. A drawing showing the most detailed side of the robot *(fully dimensioned).*

N.B. All drawings must have a *“Title Block”* see ref. (2) pg. 127.

B.4 MS PROJECT

As mentioned in the project description, create a project plan using MS PROJECT. This plan should detail all tasks related to the project including task name, duration and relation to other tasks. The project plan should be completed before anything on the project commences. Follow your project plan throughout the duration of the project. If, for any reason, the team is behind schedule, be prepared to explain the reasons for any delays and what steps are being taken to get the project back on track. Any changes in the project plan should be mentioned and explained in the Progress Reports. A sample project plan can be seen on ref. (2) pg. 128.

B.5 Extra Credit

There will be extra credit given to the team with the best working model.

B.6 Final Report Requirements

The guidelines for the Robot Final Proposal can be found in ref. (2) Appendix B on page 156

B.7 Design Presentations

The bidding process involves four presentations to the project leader and technical advisor. The subjects of these presentations will be as follows:

1. Presentation 1-Rough sketches, project plan, and initial design proposal
2. Presentation 2-Two-dimensional drawings
3. Presentation 3-Physical Model
4. Presentation 4- Full product presentation including project plan, drawings, physical model, demonstration of model, cost analysis, and design proposal.

B.8 Final Report Breakdown

Proposal…………………………………………………………………..30%
Front view……………………….……………………………………..15%
Back view………………………………………………………………15%
Side view……………………………………………………………….20%
MS Project plan………………………………………………………...10%
Cost Estimate …………………….…………………………………….10%
Total……………………………………………………………………**100%**

B.9 Project Breakdown

Progress Presentations	15%
Final Report – Technical	12.5%
- Writing	12.5%
Working Model	20%
Model Program	20%
Final Presentation	20%
Total	**100%**

Supplemental

Each group will have available to them one RoboLab robotics invention kit to design and build a working model. The kit comes with a LabVIEW based programming language that can be used to program the robot (this program may ONLY be loaded on Polytechnic University owned computers). There will be an addendum distributed with the program to explain the use of the programming language. If any additional RoboLab parts are needed by the group to complete the project, these parts may be requested during the design presentations. Also the group may request a specialty add on kit; please speak with the technical advisor to find out what kits and extra parts are available. Each group may request material that is readily available. Parts from the RoboLab kit may not be modified in any way.