

# Hovercraft Design Experiences in a Freshman Engineering Course at UAB

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**Abstract** – At the University of Alabama at Birmingham, freshman engineering students receive their first formal exposure to engineering in EGR 100, Introduction to Engineering. One of the main student exercises in EGR 100 is a design project. Students, in groups of four, are provided with basic theory, tools, and components and are asked to design and build a simple machine or device. In the Spring 2003 semester, students in select sections of EGR 100 were asked to build a simple hovercraft and compete in lift and speed competitions. While the projects were limited by small budgets, the students were exposed to a meaningful freshman design experience. Many of the student groups found creative solutions to the hovercraft design problems. The basic structure of the hovercraft design project, the background design information given to the students, a few examples of the creative solutions found, and selected student comments about their design experience are discussed.

*Keywords:* Freshman, design, hovercraft

## INTRODUCTION

Courses that introduce engineering concepts to freshmen students have become popular in curricula around the United States. These courses are used to explain the differences between the engineering disciplines, to expose students to design early in their program of study, to increase retention rates, to begin student to faculty contact earlier in the curriculum, to provide an early opportunity for group experience, and to impart an understanding of group dynamics [Wayne, 7][Burtner, 2][Hirsch, 5][Ohland, 6]. Whether the freshman or introductory course is taught at the departmental level or through the school or college of engineering, many institutions have found the introductory engineering courses very effective [Atashbar, 1][Eggert, 4].

At the University of Alabama at Birmingham, the introductory engineering course, EGR 100, is taught through the School of Engineering. Sections of EGR 100 contain students with a variety of engineering and engineering related majors. Students in EGR 100 must participate in a simple “design and construct” project. The design project requires the students to use basic design principles, to work in multi-disciplinary groups, to document their design and work process, and to present their results. The design projects have been very effective in achieving the objectives of EGR 100.

Every semester, the different departments are asked to participate in EGR 100 and to construct design projects for the course. Examples of design projects performed in EGR 100 are the design and construction of skateboards using sandwich composites, the design and construction of remote controlled cars, and the design and construction of balsa wood bridges. In the Spring 2003 semester, faculty from the Department of Mechanical Engineering (ME) developed the design projects for three sections of EGR 100. In the ME directed sections of EGR 100, the students

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were asked to design and construct hovercrafts to compete in lift and speed competitions. Hovercraft design projects have been used at other institutions for introductory engineering courses [Crowther, 3]. The following sections of this paper provide a background on EGR 100 and detail the instruction and direction of the hovercraft projects in EGR 100 during the Spring 2003 semester at UAB.

## **EGR 100 BACKGROUND**

The University of Alabama at Birmingham School of Engineering offers baccalaureate degrees in Biomedical, Civil, Electrical, Materials, and Mechanical Engineering, in addition to graduate degrees in these and related disciplines. All undergraduate engineering students, both admitted with a declared major and admitted to engineering without a declared major, are required to take EGR 100 early in the course of study since the course introduces the profession of engineering, ethics and safety, engineering specialties and career opportunities, educational requirements, design, teamwork, and technical communications. Some transfer students and students pursuing a technical marketing degree may take EGR 100 as juniors or seniors. A significant number of students admitted to UAB without a declared major also take EGR 100. Table 1 presents the EGR 100 enrollment statistics for the Spring 2003 semester.

EGR 100 is taught every term by faculty associated with the School of Engineering Dean's Office to freshmen students in one to four 32-seat sections. The small section size facilitates group activities. Each section is divided into eight teams to carry out the team-building exercises and three projects. The teams are assigned randomly and are maintained for the entire semester. The course uses several team projects – including a five-week long design project – to introduce students to design, teamwork, and technical communications as well as classroom exercises and guest lectures to fulfill the course goals.

The first team project involves an analysis and subsequent presentation of an engineering ethics case. The second team project is a mechanical dissection, where household appliances or other devices are disassembled to determine the operating principals. The mechanism of how the appliance or device works is then presented to the class. The final team projects vary by section and semester and are directed by faculty from the five engineering departments.

## **PROJECT DESCRIPTION**

In the spring of 2003, EGR 100 students were divided into groups of four and asked to design and build a small hovercraft with a focus on performance in lift and speed competitions. Students were encouraged to design either for overall performance in both categories or for optimum performance in one of the two categories. The groups were also asked to consider the appearance of their hovercraft for a student-evaluated style competition. The project was introduced to the students in a presentation given by mechanical engineering faculty members. A copy of this presentation is available for review at: [www.eng.uab.edu/me/faculty/amccain/Hovercraft\\_intro\\_Spring2003.pdf](http://www.eng.uab.edu/me/faculty/amccain/Hovercraft_intro_Spring2003.pdf). The freshman-level students were introduced to basic fluid concepts and hovercraft design principles. Topics introduced included: Bernoulli's equation, the Continuity Equation, Newton's Laws of Motion, and fan performance curves. Students were also introduced to MathCAD mathematical software. A MathCAD worksheet was provided for the calculation of hovercraft platform geometry. The worksheet was demonstrated in-class, and students were encouraged to use the MathCAD worksheet in the iterative design of their hovercraft platform. The initial demonstration included a paper hovercraft to demonstrate the basic principles of hovercraft operation [www.HOVERCRAFRmodels.com, 8].

### **Outcomes and Metrics**

Students were required to record group discussion and design decisions in a logbook. At the end of the project each group submitted a written report containing fundamental explanations of hovercraft operation, a record of their design process, a presentation of their final design including a detailed dimensioned drawing, a record of their competition results, and any recommendations that they would make in designing a hovercraft based on their experience. Each group was also required to present this information to an audience of their peers.

Table 1. EGR 100, Spring 2003 Enrollment Statistics

<b>Total number of Students Enrolled</b>	114	100%
<b><u>Classification</u></b>		
Freshmen	55	48%
Sophomore	24	21%
Junior	19	17%
Senior	14	12%
<b><u>Major</u></b>		
Biomedical Engineering	11	10%
Civil and Environmental Engineering	13	11%
Electrical and Computer Engineering	13	11%
Mechanical Engineering	9	8%
Materials Science and Engineering	3	3%
Pre-Engineering	5	4%
Undecided-Engineering	14	12%
Undecided	32	28%
Other	11	10%
<b><u>Gender</u></b>		
Male	80	70%
Female	34	30%
<b><u>Ethnicity</u></b>		
White/Caucasian	68	60%
Black/African American	34	30%
Hispanic	3	3%
Other	4	4%

**Budget and Materials**

The project budgets were limited to \$100 per group. The students were presented with a variety of possible materials and were encouraged to consider other materials that may not have been presented. For each of the four class sections, half of the groups were given two small axial fans, and half of the groups were given a larger centrifugal, or squirrel-cage, fan. The axial fan groups competed in the “lightweight” division. The centrifugal fan groups competed in the “heavyweight” division. Each group was provided with a 12-volt rechargeable battery to power their fan. Suggested platform materials included: plywood and foam board. Suggested skirt materials included: plastic sheeting, bicycle inner tubes, trash bags, and a child-size inner tube pool toy. Other miscellaneous materials included: duct tape, adhesive, string, wire, and pipe fittings.

**Lift Competition**

The first design competition was to design for maximum lift. For a given fan, the area of the platform had to be selected such that the total force acting upward on the platform was greater than the weight of the platform and fan(s) to achieve lift. For the competition, additional weight was added to the platform of the hovercraft. The craft in each division that supported the most weight without losing lift won their respective lift competition. Bags of rice were used to distribute the added weight evenly across the platform. Students placed the bags on their platform,

taking care to maintain balance across the platform. In the heavyweight division, groups were required to also support the weight of the battery onboard the craft. Weight was added until the hovercraft began to touch the ground. This was judged by moving the hovercraft back and forth in the unloaded and loaded conditions. As the friction between the skirt and the smooth surface increased and the craft could no longer move easily back and forth, the maximum capacity was judged. Figure 1 shows a student loading his hovercraft with rice and attempting to balance his hovercraft.

### **Speed Competition**

The speed competition took place on an inclined ramp with a track made from a smooth, low-friction material. The material used was similar to that used for a dry-erase board. The crafts were timed from their release at the top of the ramp to the end of the ramp. All hovercrafts remained tethered for the speed competition. Groups were required to keep the tether behind the hovercraft to avoid any pulling. The lightweight division was tethered to the battery. The heavyweight division was tethered to a switch. Small time deductions were taken for any course corrections, such as a nudge to get the craft back on track. Figure 2 shows students preparing for the speed competition.

### **Student Innovation**

Several groups produced innovative designs for the two competitions. Some lightweight groups used the two axial fans in series to produce more lift. One lightweight group used a large platform and a tall skirt to achieve lift comparable to that produced by the heavyweight groups. However, this design decision did limit their performance in the speed competition, as the craft had a tendency to tip over. Other groups used innovative techniques for skirt design, including sewing 3 bicycle inner tubes together and sealing the skirt to the platform using a groove and cable. At least one group attempted to duct a portion of the airflow produced by the fan to produce a small amount of thrust. Overall, the students were innovative and enthusiastic, and they really enjoyed the competition.



Figure 1. Lift Competition



Figure 2. Speed Competition

### **Final Competition**

The final competitions took place during the UAB School of Engineering Spring Fling. This is an annual outdoor event where engineering students enjoy barbeque, live music, and a message from our dean. The speed and lift competitions were setup at the event and participants and observers enjoyed the fun. Members of winning groups were awarded prizes.

### **Faculty Commitment / Participation**

A team of four mechanical engineering faculty carried out the EGR 100 hovercraft project in the spring of 2003. One faculty member directed one of the three sections for the duration of the project. The project definition, implementation, competition, and final reports took place over six, 75-minute class periods. Two of the four faculty members organized the project, purchased materials, and coordinated the faculty in all four sections. Graduate

students from the department of mechanical engineering assisted the faculty in the classroom during the build phase. The faculty mentors also judged the final competitions and evaluated group oral presentations.

### **STUDENT COMMENTS AND PERFORMANCE**

The instructors and faculty participants were quite pleased with the students' efforts on the hovercraft projects. As discussed earlier, several groups found innovative solutions to building the hovercraft with the materials provided. No group failed to construct a functioning hovercraft and participate in at least one of the competitions. The students' performance on their oral presentations and formal reports were also very good and demonstrated their enthusiasm for the project.

Feedback from the students regarding the hovercraft projects was very positive. Many of the students made positive informal statements to the instructors and departmental faculty about their design experience in EGR 100. On the formal course evaluations at UAB, the question "What did you like most about the class/the instructor?" is asked of the students. Selected comments from the Spring 2003 are:

"I enjoyed the hands-on experience. I liked building the hovercraft."

"I got to build stuff."

"Building the hovercraft"

"Projects were interesting and provided a sense of satisfaction."

### **CONCLUSIONS**

In the Spring 2003 semester, students in EGR 100 were asked to design and build a hovercraft. Under the guidance of mechanical engineering faculty, students were provided with basic design principles, basic materials, and design specifications. The hovercrafts were required to perform in both lift and speed competitions. The students developed innovative designs, were enthusiastic, and enjoyed the project. The faculty led the design project with a reasonable commitment of time and embraced the opportunity to interact with students early in their engineering studies. While it is too early to measure student retention and degree completion rates, the remaining objectives of the EGR 100 course and the design project were achieved.

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