DESIGN 15 - Designing the Human-Made World

The First-Year Introductory Engineering Design Course

PART 3: THE GRAND DESIGN CHALLENGE

Dr. Mauro J. Caputi
Assoc Prof of Engineering
HOFSTRA UNIVERSITY
Hempstead, NY

George DeMarco
First-Year Student
Civil Engineering
HOFSTRA UNIVERSITY

Jacqueline Pierson
First-Year Student
Industrial Engineering
HOFSTRA UNIVERSITY

Brittney Schmidt
First-Year Student
Civil Engineering
HOFSTRA UNIVERSITY

Evan Sick
First-Year Student
Mechanical Engineering
HOFSTRA UNIVERSITY

INTRODUCTION

The First-Year Introductory Engineering Design course at Hofstra University is examined in detail. Because of the broad scope of components informing the course, it will be presented in a Series of three parts. Parts One and Two previously discussed the Lecture and Project Lab sections, respectively. Part Three, discussed in this paper, focuses on how the Lecture and Project Lab build towards the last half of the semester with the Grand Design Challenge project and competition.

BRIEF REVIEW

As previously discussed in Part Two, for the first five Seasons of DESIGN 15, the Project Lab was comprised of six projects and one student presentation. During Season 6, the ineffective projects and the student presentation were removed from the Project Lab structure. This now made four Lab meetings available to implement a new long-term Design Project.

The new long-term Design Project, known as the Grand Design Challenge (GDC) project and competition, is discussed in this paper, Part Three of the Series.

GRAND DESIGN CHALLENGE PROJECTS

All Lab Sections participate in the Grand Design Challenge during the second half of DESIGN 15. Each Team in a Lab Section selects a different GDC project from among the six available. With few additions, depending on the particular project, only the following set of materials is allowed for construction of the projects:

Foam core board	Mailing tube	Hot glue sticks
Poster board	Twine	Elmer's glue
Paper	Rubber bands	Masking tape
Wooden dowel		Scotch tape

Each Team must also stay within a budget credit of $15 to procure these materials, up to the maximum allowable quantity of each material. More details about materials and budget are shown in a full GDC example project discussed later in this paper.

The GDC projects have been designed with a difficulty level sufficiently high to routinely surpass the brainstorming capacity of an individual Team. This strongly motivates the Team to seek out not only the help of the Professor and Peer Teachers, but also the assistance and cooperation from the other Teams within the Lab section as well.

This expanded level of cooperation is an important factor for Teams working out their growing teamwork and communication skills previously acquired through the DESIGN 15 Lecture class content and Class Activities.

A list of the GDC projects, adapted from *The Fundamentals of Visualization, Modeling, and Graphics for Engineering Design* by Dennis Lieu and Sheryl Sorry, follows with a brief description of each:

GDC A – Escape Design and construct a mechanical system that will launch a hard-boiled egg into the air and have it land as far from the launch point as possible. The egg must land totally intact (no cracks in the shell). The egg may be surrounded with a protective covering. However, the covering cannot penetrate the shell or be bonded to it.

GDC B – Vertical Limit Design and construct a mechanical system that will deploy from a prescribed initial size to a freestanding structure that reaches as high as possible. Deployment must be automatic upon activation of a trigger mechanism. The base structure is to be fixed to the floor. For example, the system may be composed of a mechanism for extending a boom or truss structure.

GDC C – Reward Design and construct a mechanical system that will launch a York Peppermint Pattie taped to a CD so it hits an 9' W x 6' H target placed as far from the launch point as possible. The target will be placed upright such that the front faces the launcher, with the bottom edge of the target on the floor. The target distance from the launcher will be specified by the Team. The Candy/CD must hit the target before touching any other object (no bouncing off the floor, walls, etc.)

GDC D – Deploy It Design and construct a mechanical system that will deploy a structure to reach as far out from the origin point as possible. The system must remain physically connected from the origin point to the point of furthest extension. Deployment must be automatic upon activation of a trigger mechanism, and the base structure is to be fixed to the floor. For example, the system may be composed of a mechanism for extending a boom, cantilevered structure, or suspended structure from the origin point.

GDC E – Fast Food Design and construct a mechanical system that will launch a bagel over a 6' H wall and have it land and remain on a platform 3' W x 3' H totally intact and unsoiled. The bagel may be surrounded with a protective covering. However, the covering cannot pierce the bagel or be bonded to it. The goal is to get the largest number of surviving bagels on the platform.

GDC F – There 'N Back Design and construct a small-scale concept vehicle that travels in a linear trajectory as far as possible and then automatically returns along the same trajectory. A travel line will be marked on the floor. Travel distances will be measured in the direction of the line only. The travel distance to be recorded is the distance the vehicle travels backwards along the trajectory line after the vehicle stops its forward travel. The backward travel distance cannot exceed the forward travel distance.

PLANNING ASSIGNMENTS

The first three weeks of the GDC are used to progressively plan the design of the GDC project. Three Planning Assignments (PA) were developed requiring Teams to work through Design Steps Two through Five for their GDC project outside of Lab. The Planning Assignments are completed and returned with constructive feedback and comments before the Teams begin construction on the GDC projects in the Lab.

A list of the Planning Assignments with a brief description of each is as follows:

PA 1 – Research and Investigate This assignment reinforces Design Step Two. Rubber band energy can be stored in some form of repeatable mechanical deformation. For example, a rubber band used in a wind-up airplane can store the energy by twisting (deforming) the material. The material releases the energy as it returns to its original shape. Rubber bands can be combined together in ways that store and release energy simultaneously. They can also be configured in ways to store and release energy sequentially (one after another).

Teams list, sketch, and describe three different methods of rubber band energy storage and release specifically applied to their particular project.

There are six types of Simple Machines: 1) the inclined plane; 2) the wedge; 3) the screw; 4) the pulley; 5) the lever; 6) the wheel & axle. Teams search the Internet to learn how these function. Teams review the list of standard materials, consider the project specifications and constraints, and list, sketch and describe two Simple Machines that can be specifically applied to their particular project.

PA 2 – Generate Alternative Designs This assignment reinforces Design Step Three. Teams brainstorm design ideas, select two of the best alternatives, and analyze their functional strengths and weaknesses. They review the list of standard materials, consider the project specifications and constraints, and supply as much detail as possible in the sketches.

PA 3 – Choose & Justify the Optimal Design This assignment reinforces Design Steps Four and Five. Teams select their optimal design, list and justify two reasons for selecting it, and work out a preliminary $15 budget credit for procuring materials in any amount up to maximum allowable limits. Teams include a detailed functional drawing of their optimal design.

LAB MEETINGS

Four Lab meetings are used to construct, test, and revise the project, make a Design Review Presentation, and write a Lab Report.

Lab Meeting 1 Teams procure materials and begin project construction and testing. This is the first time Teams come in actual contact with the materials and there are no past projects put out on display. Because of this, Teams typically get off to a slow start, despite the three weeks of planning that was completed before construction. They will change their materials, modify their budgets, and revisit their optimal design.

Lab Meeting 2 Teams are now more familiar with the project and have increased motivation to move forward with building it. Guidance is provided by the Professor, the Peer Teachers, and assistance is solicited from the other Teams in the Lab section.

Lab Meeting 3 – *Extended Time* The DESIGN 15 Lecture is cancelled and the time is used to extend the length of Lab Meeting 3. During the extended time period, Teams make a GDC Review Presentation of their projects to the other Teams in the section. Everyone is encouraged to cooperate by checking that all specifications and constraints are met, troubleshooting any project design flaws, and suggesting performance improvements. The presentations serve to increase the chances of the Lab section winning the GDC competition.

After the presentations, the full regular Lab Meeting time is available for the Teams to continue with project construction and testing.

Lab Meeting 4 Teams complete the final construction and testing of their project. They write the Lab Report and turn it in at the end of the Lab Meeting.

GRAND DESIGN CHALLENGE COMPETITION DAY

Lab Sections compete project-to-project at the end of the semester during the GDC Competition Day in a large indoor open space on the Hofstra campus. Each Team receives a Competition Score based on how well the project complies with the Competition Requirements. Individual Team scores are combined to produce the Lab Section's overall score. The Section with the highest overall score is declared the Grand Design Challenge Competition Winner.

PEER TEACHERS

During the GDC Lab meetings, Peer Teachers have the same duties as with regular Lab projects and are kept quite busy. However, since there are no sample GDC projects on display, the Peer Teachers are by default the best source of information since they have been through the GDC process before. The Peer Teachers do have to be extra careful to let the Teams make as many decisions as possible on their own, while gently steering them away from what will clearly not work well. The idea is to give the Teams enough guidance without explaining a solution in such detail that they simply give it away.

DETAIL OF GDC PROJECT F – There 'N Back

The sixth GDC project, There 'N Back, is now shown in detail as it appears in the DESIGN 15 Lab Manual. The authors (Team M-1, Season 11 – Fall 2011) will present this project during the Conference.

Grand Design Challenge - F

THERE 'N BACK

Half-Semester Project

Problem Situation

Air pollution caused by automobiles has plagued cities worldwide for decades.

Several solutions have been proposed over the years, including public mass transportation systems, electric vehicles, hybrid vehicles, low-emission fuels, human-powered vehicles, solar-powered vehicles, and wind-powered vehicles.

None of these options have been very successful to date.

Recently, someone suggested that energy in a vehicle might be stored in elastic elements. A study was commissioned to investigate the possibility of using a large number of surplus rubber bands to power a commuter vehicle.

Your Challenge

With a budget of $15, your Team will design and construct a small-scale concept vehicle that travels in a linear trajectory as far as possible and then automatically returns along the same trajectory.

A travel line will be marked on the floor. Travel distances will be measured in the direction of the line only.

The travel distance to be <u>recorded</u> is the distance the vehicle travels <u>backwards</u> along the trajectory line after the vehicle stops its forward travel. The backward travel distance <u>cannot exceed</u> the forward travel distance.

List of Standard Materials

Material	Dimensions	Maximum Limit	Cost Each
Foam core board	3/16" thick 40" x 32"	1 board	$ 3 / board
Poster board	22" x 28"	3 boards	$ 2 / board
Paper	27" x 34"	4 sheets	$ 1 / sheet
Wooden dowel	3/8" diameter 36" long	2 dowels	$ 1 / dowel
Mailing tube	2" diameter 37" long	2 tubes	$ 2 / tube
Twine	5 foot strand	2 strands	$ 1 / strand
Hot glue sticks	6" length	4 sticks	$ 1 / pair
Elmer's glue	1.25 oz	1 bottle	no charge
Masking tape	1" x 60 yd roll	1 roll	no charge
Scotch tape	3/4" x 650" roll	1 roll	no charge
Rubber bands	#62 or #64	10 bands	no charge

1F. *THERE 'N BACK* - Design Specifications & Constraints

Your design shall comply with the following specifications and constraints:

1. The vehicle shall initially fit within a 3.0 ft x 3.0 ft x 3.0 ft volume without external support, excluding triggering means. Once triggered, the vehicle may expand to any size.
2. No external systems (e.g., ramps, lever arms, slingshots, catapults) may be used for launching the vehicle at any time.
3. The vehicle shall be set up and armed within 2 minutes.
4. Rubber bands are the sole source of energy that imparts motion to the vehicle.
5. Tape and glue may be used only as bonding or adhesive agents, not as construction materials.
6. Human power may be used to store energy in the rubber bands as required, but may not impart motion to the vehicle.
7. The vehicle shall be remotely triggered (e.g., by a string or rod).
8. Once the trigger is armed, it shall remain armed without any human effort or energy.
9. The trigger may be used to release energy from the vehicle, but may not impart motion to the vehicle.
10. Team members (all parts of the body) shall remain a minimum of 2.5 feet away from the vehicle when the vehicle is deployed.
11. The vehicle may be launched up to three times.
12. Travel distance is measured in the direction parallel to the length of the path. If the vehicle hits something and stops, all vehicle motion is considered finished.
13. Distance is measured <u>FROM</u> the starting point of the *backward motion* <u>TO</u> the ending point of the *backward motion*.
14. The backward travel distance shall not exceed the forward travel distance.
15. No objects shall be expelled from the vehicle while in motion.
16. Some part of the vehicle shall remain in contact with the ground at all times.
17. No external structures (e.g., walls, ceiling, pipes, people) may be used for guidance or support at any time.
18. The Maximum Backward Distance shall be recorded from among the three trials.
19. Rubber bands may be exchanged for new ones at any time (ask your Lab Professor).

Competition F: *THERE 'N BACK* *(Car)*

Team Day-Number: _______________ Date: ____________________

- The Competition is worth 20% of your Grand Design Challenge grade.

Competition Requirements **Score:**

1. The vehicle initially fits within a 3.0 ft x 3.0 ft x 3.0 ft volume without external support, excluding triggering means.	OK -50
2. No external systems (e.g., ramps, lever arms, slingshots, catapults) may be used for launching the vehicle at any time.	OK -50
3. The vehicle is set up and armed within 2 minutes.	OK -10
4. Rubber bands are the sole source of energy that imparts motion.	OK -50
5. Tape and glue may be used only as bonding or adhesive agents, not as construction materials.	OK -50
6. Human power may be used to store energy as required, but may not impart motion to the vehicle.	OK -10
7. The vehicle is remotely triggered.	OK -10
8. Once the trigger is armed, it shall remain armed without any human effort or energy.	OK -10
9. The trigger may be used to release energy from the vehicle, but may not impart motion to the vehicle.	OK -10
10. Team members (all parts of the body) remain a minimum of 2.5 feet away from the vehicle when the vehicle is launched.	OK -10
11. The vehicle may be launched up to three times.	
12. Travel distance is measured parallel to the length of the path. If vehicle hits something and stops, all vehicle motion is finished.	
13. Measure Distance <u>FROM</u>: the starting point of the *backward motion* <u>TO</u>: the ending point of the *backward motion*.	1 ____________ 2 ____________ 3 ____________
14. Backward travel distance may not exceed forward travel distance.	
15. No objects shall be expelled from the vehicle while in motion.	OK -10
16. Some part of the vehicle shall remain in contact with the ground at all times.	OK -10
17. No external structures (e.g., wall, ceiling, pipes, people) may be used for guidance or support at any time.	OK -10
18. The Maximum Backward Distance of the three trials is recorded.	Max Backward Distance: _________

Max Backward Dist	0' ≤ D < 5'	5' ≤ D < 10'	10' ≤ D < 15'	15' ≤ D < 20'	20' ≤ D < 25'	D ≥ 25'
Score	50	60	70	80	90	100

BIBLIOGRAPHY

[1] Caputi, M. J., *DESIGN 15 Class Workbook & Lab Manual, Season 12 - Spring 2012.* Hofstra Engineering Dept., 2012.

[2] Lieu, D. K., Sorby, S., *The Fundamentals of Visualization, Modeling, and Graphics for Engineering Design.* Delmar, Cengage Learning, 2009.