Lab 01: Designing & Building a Dome

When You Barely Have One Hour

INTRODUCTION

It's official: the Oxford Dictionary added the word "MacGyver" as a verb meaning "making or repairing (an object) in an improvised or inventive way." MacGyver is, of course, the classic example of being able to make a cardiac defibrillator using only a pair of candlesticks and an electrical cord (true story; S01E15), and as an engineer you will probably never have to improvise an emergency arc welder out of a car battery, jumper cables, and an antenna (true story; S03E08).

But engineers are, at the most fundamental level, problem solvers. And you will, at some point, find yourself having to solve a problem you didn't expect, on a tight time frame and possibly without many resources. This requires flexibility and creativity. Speed and accuracy. Knowledge and imagination. You have to exercise and strengthen these skills in many contexts to be able to use them in any context. You may never have to construct a parasail from a canvas camp tent and a wind tunnel fan (true story; S06E13), but it's nice to know you can.

Also, co-workers. Working as part of a team just goes without saying, especially in engineering. Introvert or extrovert, reserved or outgoing, you are going to have to be able to deal with people. In a professional setting, you can't pick who you work with, and you can't simply walk away from a group or a project because that one guy just annoys you and won't ever shut up.

Every time you're assigned to a new project, you may find yourself having to work with people you've never met, whose skills are different from yours, and whose methods and habits are unknown to you. And suddenly you have just under an hour to take a project from concept to completion.

OBJECTIVES

The specific goals for this exercise are:

- Reliving our teenage crush on Angus MacGyver
- Team-building in two words: rapid cohesion
- Developing individual and group creativity
- Constructing, testing, and evaluating a physical structure
- Achieving awareness of, and working within, constraints
- Completing a project within strict time limitations

MATERIALS

You may use only the following materials to build your structure:

- Drinking Straws: One hundred identical plastic straws
- Masking Tape: One full roll of adhesive tape
- Chip Board: One 10cm×10cm square to be used as a platform for supporting a concentrated load

In addition, you may use measuring tools (utility knives, scissors, meter sticks, measuring tape, standard masses, etc.) to test and assess your structure. Lastly, do not forget your phone–it's a tool, not a toy.

DESIGN SPECIFICATIONS 15 MIN

You must design, build, and test a tabletop structure to meet the following criteria. Your completed structure must

- fit within the available table space;
- have an entry port large enough to admit a BOE-Bot;
- be able to house two identical BOE-Bots; and
- must support a concentrated load (applied to the apex of the structure) of at least 1 kg.

You should spend no more than about 15 minutes discussing your ideas with your team partners, but then you have to commit. Pick and stick: Choose one idea to pursue, and then make it work.

BUILD 30 MIN

Plan to spend about 30 minutes in the construction phase. It will be worth your time to take a few minutes off the top to divvy up the labor and assign tasks to all team members. Thirty. Minutes.

TEST 10 MIN

Once your bridge construction is complete, test it be sure it meets your design criteria. This should be done in about ten minutes.

1. Verify the volume. Make sure that your structure can house two robots, and that the entry port is sufficiently sized.
2. Measure the maximum load capacity. Your goal is to safely support 1kg; I would not recommend slamming the full load forcefully down on your structure with the first trial. NDT = non-destructive testing!
3. Predict the safety factor. What is the maximum load before failure? Again, you probably don't want to crush your structure, but you should be able to determine with reasonable accuracy how much load will break it. Your safety factor is the ratio of failure load to required load. For example, let's at 2kg you can see that the structure deflects, but remains solid. You might guess that failure will occur at about 2.5 kg, for a safety factor of 2.5/1 = 2.5; or you might play it safe and declare your safety factor = 2/1 = 2
4. Document! Make sure that someone is recording the data on paper. Also, use your phone camera to visually document your design, progress, and results. You'll need all that information later.

ASSESS 15 MIN

During the last fifteen minutes of class, your bridge will be assessed based on your presented test results. If you are prepared to be evaluated before that time, you may be assessed upon request.

1. Sufficient storage. Demonstrate that your structure can safely stow both BOE-Bots.
2. Required load. Demonstrate the capacity of your structure to support the 1 kg concentrated load at or near the center or apex. Your structure must sustain the load for a minimum of 20 seconds without failing.
3. Maximum load. Your structure will be loaded to what you have predicted will be its maximum capacity. If it sustains your predicted load, it will be incrementally loaded until it fails. *No one's structure survives!*

REPORT

To receive credit for the exercise, your team must submit a brief report which addresses each of the following points:

- Information: Did your team do any research or gather any additional information? What kind of information did you seek out? How was it helpful?
- Design: Discuss your design, and the process by which your team arrived at it. Did your team use sketches to communicate? Did you arrive at the design by consensus, or by another means? Did your team plan the design, or did the design just happen as time passed? How did the time limit impact your design strategy?
- Resources: How well did you use your resources? Your obvious resources were straws, tape, tools, time, and manpower, and each had clear limits. Did you maximize the use of each of your resources? Which, if any, resources would you have liked to have more of? Did you have too much of anything?
- Results: Present your test procedures and results. Make sure that you present any numerical data in a clear, logical, and concise fashion. Did your predictions match the final testing? If not, comment on how you formulated your predictions and why you think those predictions failed.
- Reflection: What will you do differently when asked to repeat the exercise? What constraints would you approach or resources would you use differently? Are there any loopholes (seriously, *look for the loopholes*–this is important for multiple reasons)?

SUBMIT

For this project, the format of your report is left open. You must address the points above, but you do not have to discuss them in the same order as they are presented. Please be concise; you should need no more than two pages to address the issues adequately.

Please take a bit of time to consider what you have done and how you have done it. Let this guide the structure of your report, and keep in mind that your intended audience is a professional peer who is aware of the design specifications and knowledgeable of the constraints (as opposed to a general reader without an engineering background).

Make sure that you present professionally; please do not submit handwritten pages. Handwritten submissions will incur an automatic 20% deduction. Hand-drawn sketches or figures are always acceptable, and you may also always include photographs in your report.

All report submissions must be received no later than 6:00 PM on Friday, 30 Jan 2024. Late reports will not be accepted, and you will receive a score of 0 for the exercise if you do not submit a written report.

GRADING RUBRIC

Your bridge and your report will be graded using the assessment rubric below. There are 30 points possible points for this assignment, and because there are competitive elements to your design performance, not every team will earn a perfect score.

ASSESSMENT	CRITERIA	POINT VALUE
SIZE, PORTS, AESTHETICS: Structure is carefully and neatly constructed; volume and port(s) are sufficient; overall design is aesthetically pleasing	Meticulous construction	3 points
	Sufficient size/volume/ports	3 points
	Aesthetically pleasing	2 points
REQUIRED LOAD: Measure length of time (up to 20sec) dome can support 1 kg load at or near center on the designated loading square	Dome supports 1 kg load for 20 seconds	5 points
	Dome supports 1 kg load for 10-20 sec	4 points
	Dome supports 1 kg load for 5-10 sec	2 points
	Dome supports 1 kg load for < 5 seconds	1 point
SAFETY FACTOR: Measure the maximum load dome can support; calculate the factor of safety = (max load)/(required load)	Maximum safety factor	5 points
	Second-highest safety factor	4 points
	Lowest safety factor	3 points
	Dome fails before maximum load applied	1 point
REPORT CONTENT: Does the submitted report contain the content required according to the assignment specifications?	Reports will be carefully and individually assessed for completeness of content and for grammar, spelling, and usage.	15 points
REPORT FORMAT: Is the submitted report prepared and submitted according to the assignment specifications?	Points may be deducted from your overall score for failing to follow instructions or for unprofessional presentation. Late reports will not be accepted.	