Submitted by: David Guo
Daniel Webster College
Guo_Xinyun@dwc.edu

DESIGN OF 2-STAGE TORQUE REDUCTION MECHANISM

The objective of this competition is to design and build a two-stage torque reduction mechanism that will enable an 18 volt DeWalt to lift 100 pounds a distance of one meter in the shortest possible time.

Additional details:

- The load will be lifted by a cable connected to a spool with a 6 inch diameter. Assume that losses due to friction will increase the effective load by 100%.
- In high range the DeWalt has a no-load speed of 1500 RPM and in the low range it has a no load speed of 450 RPM. The maximum torque in the low range is 400 inch-pounds. During the competition the drill will be used in the high range. Assume that the drill produces the same power in both ranges.
- In the high-load stage use ANSI 35 sprockets and chain. In the low-load stage use ANSI 25 sprockets and chain.
- Use 5/8" steel shaft on the high torque shaft. On the mid-torque shaft use either ½" or 3/8" steel depending on the torque requirement and sprocket coupling method. On the low torque shaft use 3/8" steel and tap one end for a ¼-20 hex bolt. The ¼-20 hex will be used by the DeWalt to drive the system. The end of the 5/8" shaft that drives the spool will need a keyway.
- The center of the 5/8" shaft will be 4 inches above the mounting surface for the system. A drawing showing the bolt locations for the mounting surface will follow.
- The shop will provide chain, axle and spacer material, and a reasonable amount of aluminum (Standard aluminum sizes available: 1/4"x 2", 3", 4", 6", 8", and 10") or Lexan plate. In addition, each design group can submit an order request (must be complete with part numbers and prices) to Professor Carlstrom for up to $50.
- In addition to the main objective of lifting the weight in the shortest time, other important design goals are low cost, small size, and attractive appearance.
- The low-load stage should be adjustable in such a way that you can try some ratios that are higher and lower than the optimum theoretical ratio.
- The final report should contain a clear explanation of all theory that you applied to your design. It should also include working drawings for each fabricated part and an exploded assembly drawing with a bill of materials which includes the weights and costs of the parts. It is a good idea to include digital pictures and screen shots of the software as well. A comparison should be made between the optimum theoretical ratio and the actual ratio that lifts the weight in the shortest time. Also compare the design velocity to the actual velocity achieved with the design ratio.

Submitted by: Matt Allen
University of Wisconsin
msallen@engr.wisc.edu

MODULE 1 - PROJECT GUIDELINES

DEVELOP AN ORAL PRESENTATION ADDRESSING AN ENGINEERING CHALLENGE OF SOCIETAL IMPORTANCE – SPACE TRAVEL TECHNOLOGIES

General description

Effective communication skills are critical for a successful career in engineering. Engineers must be able to effectively articulate their creative ideas and technical solutions in both written and oral formats. In this module (Module 1), you will work in a team to develop an oral presentation addressing an engineering challenge of societal importance that is related to the theme of this module. A list of possible project topics is attached.

Expectations and assessment

- Each presentation will be given in front of your instructor(s) and peers during the last two class periods of this module. The presentation should be approximately 10-12 minutes in length.
- All members of the team must contribute to the content, assembly, and delivery of the presentation.
- You may use information from any reliable source *but you must acknowledge the source* if you reproduce visuals or text, cite scientific findings, or use ideas that are not common knowledge. Plagiarism will not be tolerated and will result in a zero score for the project. Guidelines are available through the UW Writing Center web site:
  http://www.wisc.edu/writing/Handbook/QPA_plagiarism.html
- This project will account for 25% of your course grade. Your grade for the project is based on the following:
  - Instructor's evaluation of the content and delivery of the presentation (a grading rubric follows on the next page)
  - Your own self-evaluation
  - Your team's evaluation of your contribution

Elements that *must* be included in your presentation:

- Motivation (why is the engineering challenge important to solve?)
- Background and Technical Issues
  - Current status of the problem
  - Limitations of existing technologies, processes, etc.
  - Ultimate technical goal
  - Proposed engineering solutions and obstacles
- Identification of *which* engineering disciplines could contribute to the solution and *how* they can each contribute
- Discussion of relevant non-technical issues that *constrain or influence* the engineering work (social, political, ethical, economic, legal, environmental)
- References

Important dates

September 27	Project topic selection due (Module 1 Homework #1)
October 30 and November 1	Team presentations in class

Evaluation of Project Presentations

	Maximum
Oral presentation	**20%**
Delivery (e.g. volume, speed, clarity, smoothness of transitions)	
Length (within specified time – check with your instructor)	
Teamwork	
Response to questions	
Visual presentation	**20%**
Clarity of slides	
Aesthetics	
Organization	
Technical content	**55%**
Motivation	10%
Why is the engineering grand challenge important to solve?	
Background and technical issues:	20%
Current status	
Limitations of existing technologies, processes, etc.	
Ultimate technical goal	
Proposed engineering solutions and obstacles	
Non-technical issues/constraints on the engineering solutions	10%
Overview of which engineering disciplines contribute to the solution and how	8%
References and citations	7%
Overall professionalism, level of individual contribution	**5%**
Total	**100%**

List of suggested project topics:

(These are meant to be suggestions and are not inclusive. You are free to propose other topics to your instructor. You are also encouraged to focus on specific issues within each of the listed general topics below.)

How to Get to Space?

- Energy sources for propulsion
- Energy sources for steady-state spacecraft function
- Spacecraft landing systems for missions to Mars or the moon
- Traveling to space in a way that minimizes space debris

Surviving the Trip to Space

- Food sources and storage
- Water sources
- Control of atmospheric composition
- Control of temperature
- Waste removal
- Fixing equipment malfunctions
- Healthcare
  - Diagnosing illness or injury – imaging, monitoring, etc.
  - Treating illness or injury – administering long-distance care

Survival in Space/Colonization of Non-Earth Places

- Biological/health hazards
  - Radiation – natural radiation in space causes extreme health problems
  - Bone loss – microgravity conditions cause osteoporosis*
  - Muscle atrophy – microgravity conditions cause loss of muscle, heart problems
  - Pathogens – spread more easily and are more virulent in space
- Food sources/generation
- Water sources/generation
- Making a habitable atmosphere on another planet
  - Warming Mars*
- Finding resources for building, manufacturing, power
- Designing exploratory vehicles
- How to communicate with Earth
- Design of spacesuits with better mobility*
- Healthcare (see above for sub-topics)

Other Issues

- Protecting Earth from asteroids
- Managing low-earth orbit objects (i.e., space debris)
- Space-based climate or disaster prediction
- Using other planets as a source of energy resources for Earth
  - Mining the Moon
  - Space-based solar energy
- Using microgravity to investigate/solve Earth problems (i.e., food shortages)

*Indicates topics that will be covered by the instructor in class. These are not eligible for your team to choose unless you have consent of the instructor.

Submitted by: Amy Pritchett
Georgia Institute of Technology
amy.pritchett@ae.gatech.edu

Flight Readiness Review: High Dive

Georgia Tech AE1350(A/B) Introduction to Aerospace Engineering, Fall 2012

Project #1 Description

Your good friend and long time professional colleague, Sally Baker, has an opportunity to perform a publicity stunt for charity. Sally is an avid skydiver (parachutist), including: military airdrop experience, performing at air shows, and as a skydiving instructor. Now, she has been asked to perform jump from a balloon flying at the top of the tropopause (20km or 65,617feet). Sally intends to perform the dive in a pressure suit (with helmet) that has been used for other high altitude missions and is considered reliable; she does *not* plan to wear any "wings" or use clothes with webbing or other modifications. Even so, you both have concerns about the safety of the jump, and it will be necessary for both the insurance company and government regulators to be satisfied that the jump is safe. Sally has always respected your skills and integrity as an Aerospace Engineer. She recognizes this jump is beyond her experience, and she has asked for the help of you and your team.

Your team needs to prepare and deliver a Flight Readiness Review (FRR), including both a report and a presentation that will be seen and read by Sally, the insurance company, key sponsors, and representatives of the Federal Aviation Administration (FAA). The questions you need to answer are the following:

1) To minimize the risk, Sally is going to take a stable body position that minimizes how fast she falls (see picture above). How fast will she fall at the different altitudes she will be at? What atmospheric conditions would impact this answer?

2) If she loses consciousness or is otherwise unable to hold the ideal body position, then how fast could she potentially end up going?

3) For what duration of time will she need to breathe the oxygen she brings with her?

4) Estimate the horizontal range she may travel from where the jump starts to where she lands.

5) What limitations do you suggest for the day of the jump regarding atmospheric conditions? You will of course need to explain your rationale.

6) What are the relevant government regulations that cover this activity?

7) How do you recommend that the altitude be measured during the jump?

8) How does this plan compare with those that have been completed or attempted in the past by others?

Any questions of fact about the planned jump or the FAA's requirements for the FRR may be directed by email to both amy.pritchett@ae.gatech.edu and eric.johnson@ae.gatech.edu.

Project presentation: September 11 (section A), September 12 (section B)

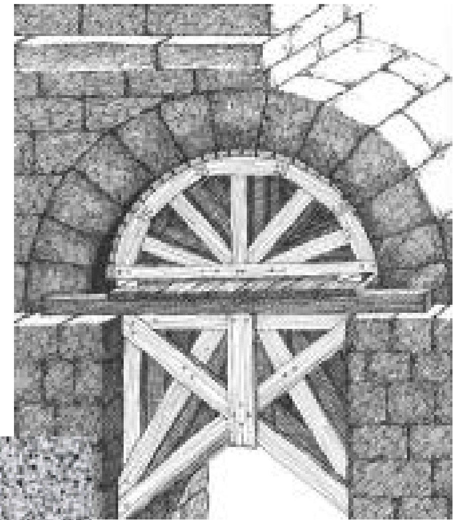
Project report: September 17 (section A), September 18 (section B)

Structural Design of an Ancient Roman Timber Bridge – Stage 1

Submitted by: Renato Perucchio
University of Rochester
renato.perucchio@rochester.edu

Structural Design of an Ancient Roman Timber Bridge – Stage 1

Submitted by: Renato Perucchio
Rochester Institute of Technology
renato.perucchio@rochester.edu



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MELIORA

TO: All structural design teams of ME104Q
FROM: Prof. R. Perucchio
http://www.courses.rochester.edu/perucchio/ME104Q/index.html
DATE: 7 November 2006
RE: STRUCTURAL Design of the new timber bridge across the danube, 104 a.D.

Introduction

We have been requested by our associated firm ARCHI-MELIORA of Roma, Italia, 104 A.D., to provide the structural design of the modular timber truss for the new imperial bridge to be erected across the river Danube near the city of Pontes. The order issued by the Emperor Trajan calls for a twenty-pier bridge 1040m long and 12m wide, see Fig. 1 below. This will be the greatest bridge ever built in the empire. According to the most modern building techniques in Roma, 104 A.D., the truss will be made with seasoned pine timber from the nearby mountains. The construction is scheduled to begin in 105 A.D. The Emperor will personally review the proposed designs.

Each bridge module spans 52m center to center of the piers and consists of six identical planar trusses equally spaced at 2.4m through the width of the bridge and laterally braced to each other. Each design team is required to provide the structural design for the typical truss according to the specifications below.

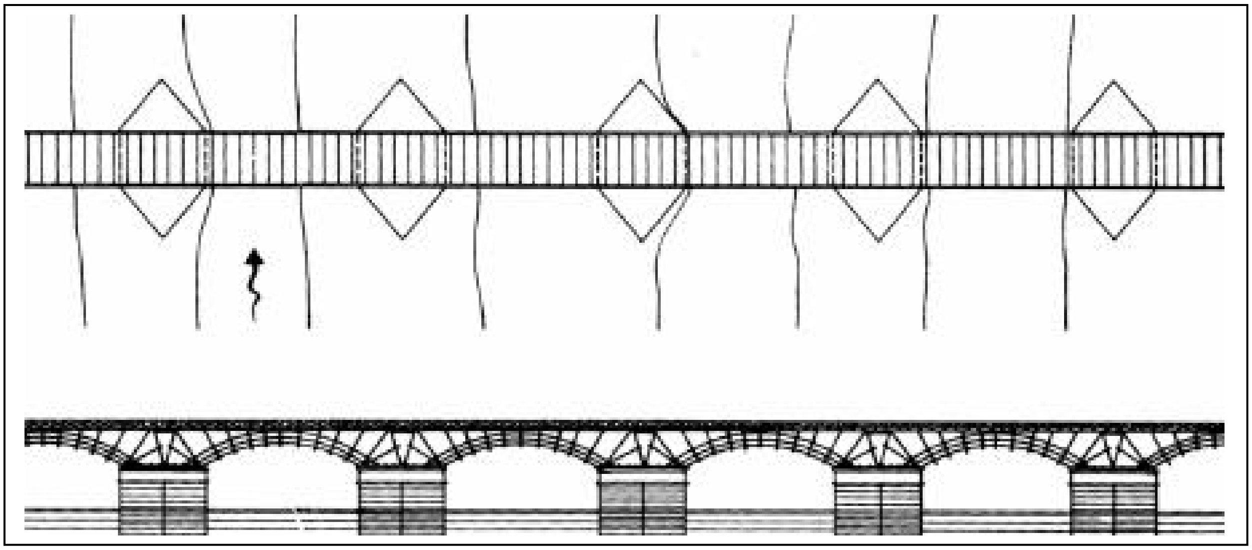


Figure 1. A section of the new bridge over the river Danube requested by the Emperor Trajan. The figure shows the modular nature of the timber structure.

Truss specifications

Figure 2 shows the spatial and mechanical constraints for each modular truss. The truss is made with straight bars of pine timber. The timber specifications are:

- Maximum length available is 10m. Any length equal or less than10m can be used.
- Cross sections available are (all dimensions are cm): 5x5, 10x10, 20x20, 30x30, 40X40: Different cross sections can be used in the same truss design.
- The mechanical properties of pine are :
  elastic modulus $E = 10\text{GPa}$,
  strength in tension $\sigma_{st} = 100\text{MPa}$, in compression $\sigma_{cr} = 27\text{MPa}$,
  density of the wood is $\rho = 0.35 \times 10^3 \text{kg/m}^3$.

The live load due to bridge superstructure and the traffic on the bridge is represented by a distributed line load $W_{live} = 4.9\text{kN/m}$. The dead load due to the mass of the truss bars must be taken into account. For timber trusses, the imperial building code requires that a factor of safety $\text{f.s.} = 5.0$ be used to design the truss bars both in tension (strength failure) and in compression (crushing or buckling failure).

In terms of the truss structural stiffness, the imperial building code requires that the differential vertical deformation between center pier and midspan of the bridge measured at the pavement level be less than 0.1% of the span.

Design objectives

We need to design a truss that (a) satisfies all the above requirements and (b) reduces the weight as much as possible.

WORK EXPECTED:

Students will form design teams of three students only. Members of each design team are expected to work in collaboration to perform the design tasks specified below. Each team will prepare a written report (one report per team!)

Truss design

Each team will perform three design iterations on the truss problem. In the first iteration, the team selects a truss configuration that satisfies all the requirements defined above. This implies the following steps (the modeling is done in Dr.Frame):

1) Select the truss geometry and enter the bar elements. Apply boundary conditions and material properties. Follow the geometrical, support, symmetry, and length requirements listed in Fig. 2. Only one half of the modular span needs to be modeled. See Fig.3 for an example of boundary conditions simulating structural symmetry.
2) Select the cross-sectional area of each bar.
3) Compute the joint loads due to the mass of each bar (dead load), apply loads to joints, and print out forces on each truss element and reactions at supports.
4) Compute the joint loads due to the live load, apply loads to the appropriate joints, and print out forces on each truss element and reactions at supports.
5) For the elements in tension: compute $\sigma_{applied}$ due to the sum of the loads in (3) and (4) and verify that $\sigma_{applied} \leq \sigma_{allow.} = \frac{\sigma_{st}}{\text{f.s.}}$. Tabulate the results as shown in the Appendix.
6) For the elements in compression: compute $\mathbf{P}_{applied}$ and $\sigma_{applied}$due to the sum of the loads in (3) and (4) and verify that $\sigma_{applied} \leq \sigma_{allow.} = \frac{\sigma_{cr}}{\text{f.s.}}$. Do not consider buckling. Tabulate the results as shown in the Appendix.
7) To verify the truss stiffness, compute $D = v_F - v_G$, where v_F and v_G denote the total downward displacement at points F and G, respectively (see Fig. 2). Tabulate the results as shown in the Appendix. If $D < 52\text{mm}$ the stiffness of the truss is verified.
8) If the truss passes verification, record the weight of the truss (this is equal to the sum of the vertical reactions computed in (3).) If the truss does not pass verification, make the appropriate changes in step (1) and (2) and repeat the process. The current design iteration is not completed until results are verified.

In the second and third design iterations the truss geometry and/or the element cross-sectional areas are modified in order to reduce the weight of the truss. These iterations follow exactly the same step

(1) – (8) used for the first iteration.

Project report

The written report must include

1) **Title page**
2) **Abstract (.5 page):** give a brief summary of the report including the weight of the truss for your optimized design.
3) **Introduction (1 page):** define the design problem. List all design constraints (dimensions, materials, etc.).
4) **Truss design (4-page max.):** a section on your optimized truss design. Begin with a paragraph describing the approach followed to refine your design from the first to the last iterations (the other two trusses are described in the appendix to the report, see (8) below). Add three separate figures taken from Dr.Frame showing the truss geometry (with element dimensions and joint labels), the element forces and the support reactions for the live loads, and the element forces and the support reactions for the dead loads. Include a table showing the results for each element (follow the structure of Tables A1, A2, and A3 in the Appendix) and the total weight of this truss. IMPORTANT: submit via email to Prof. Perucchio at rlp@me.rochester.edu the following files (make sure that names of all team members are indicated in the accompanying message):
   a) Two Dr.Frame files for the optimized truss (one with the live loads and the other with the dead loads) , and
   b) One Excel file with worksheets for load table, verification table – forces, and verification table – displacements for the optimized truss (follow the structure of Tables A1, A2, and A3 in the Appendix.)
5) **References**: list all the references consulted in the course of the project.
6) **Appendix (4 pages max.)**: give the results for the other two truss designs: for each provide the same material as in (4), but do not repeat the description of the design approach.

As always, make sure that you use correct English grammar and syntax. We will penalize for incorrect usage. Your reports must read easily, convincingly, and well!

The reports are due by classtime on Thursday, November 21. The Dr.Frame and Excel files must also be emailed to Prof. Perucchio by the same deadline.

Reference

The following material is on reserve at Carlson Library:

James E. Gordon, *Structures, or why things don't fall down* (DaCapo Press, New York, 1978).

Robert Mark, editor, *Architectural technology up to the scientific revolution: The art and structure of large-scale buildings* (MIT Press, Cambridge, 1993).

Robert Mark, *Light, wind, and structure: The mystery of the master builders* (MIT Press, Cambridge, 1990).

Mario Salvadori, *Why buildings stand up: The strength of architecture* (Norton, New York, 1990).

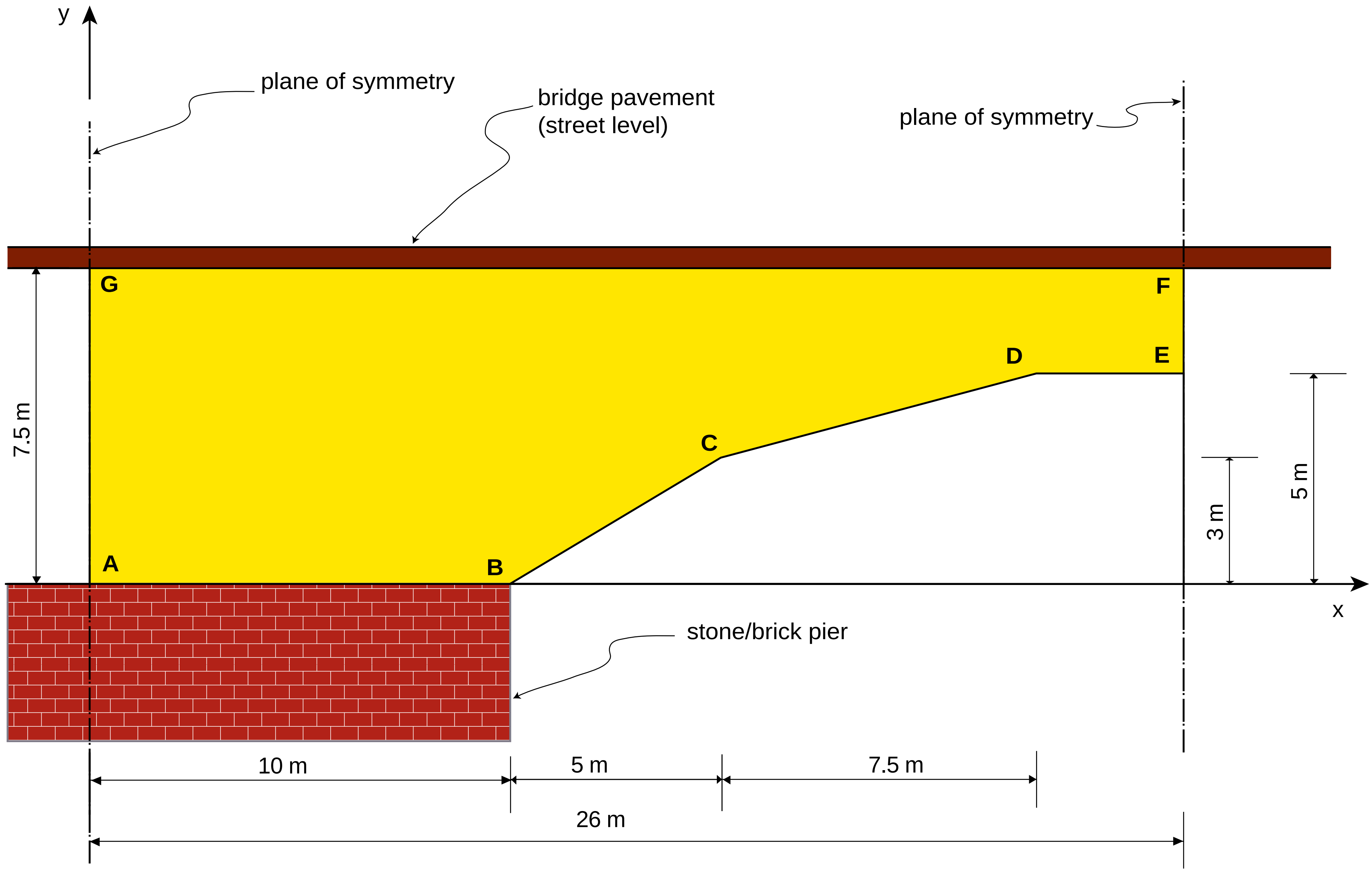


Figure 2. Design constraints

Geometrical constraints : truss must fit into yellow area and must support bridge pavement at the level indicated.

Support constraints: all joints resting on the pier (line AB) must be pin-connected (joint does not move).

Symmetry constraints: (1) line GA - one bar pin-connected at point A and with roller at point G (free to move on the plane of symmetry. (2) line FE - one bar with rollers at both ends (free to move on the plane of symmetry) and one end must be at point F.

Length constraint: bars must be 10 m long or less.

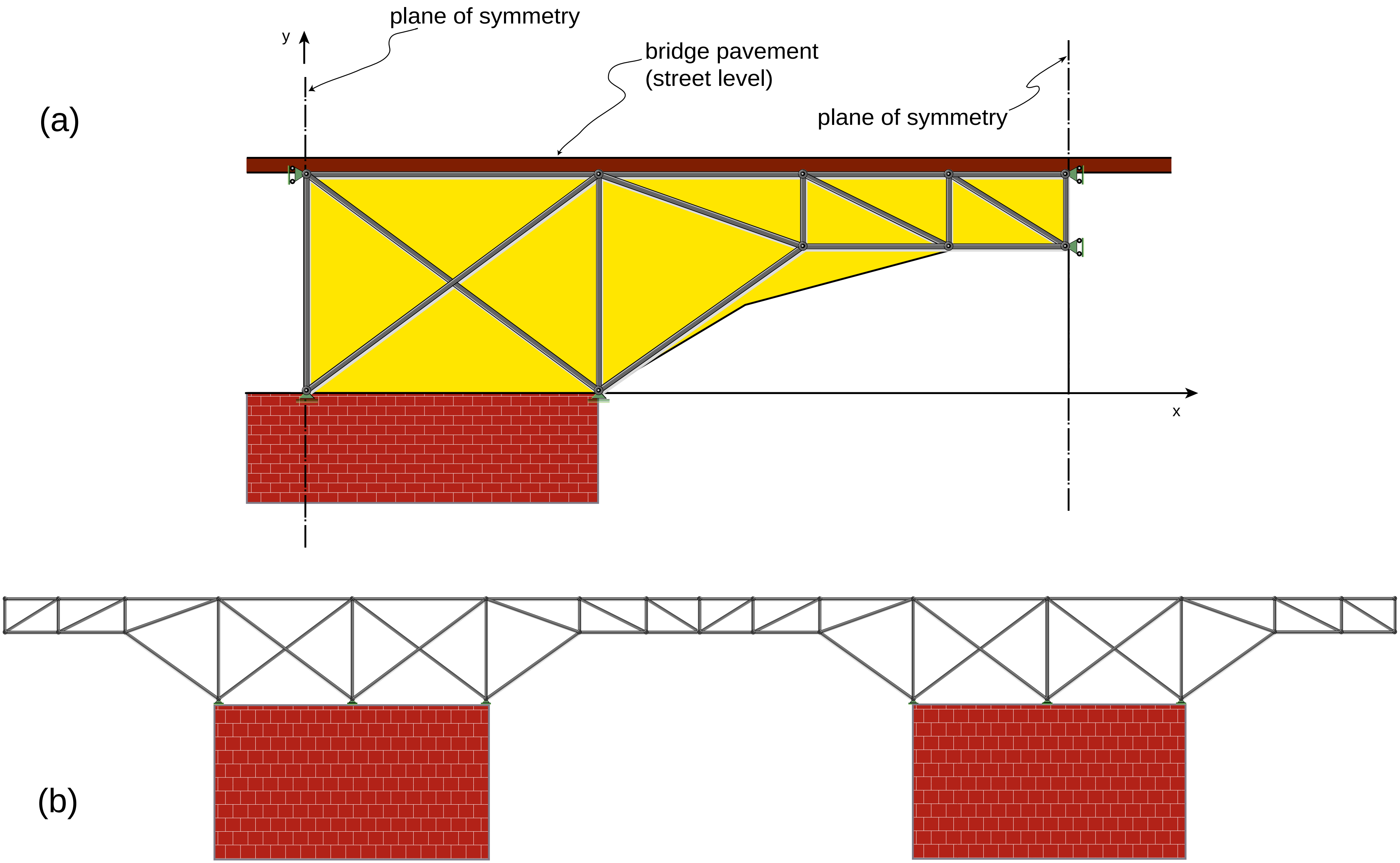


Figure 3. Structural symmetry:
(a) truss design: notice roller boundary conditions on symmetry planes. (b) Modular structure simulated by the boundary conditions applied in (a).

APPENDIX

Example of truss design

For the first design iteration, we select a simple truss geometry, see Fig. A1. Notice that, on purpose, this configuration violates the length constraint and thus cannot be used for the first design iteration. Only half of the truss is modeled. To represent the symmetry condition, joints D, I, and J are attached to rollers, which allow motion in the vertical direction only. Joints A and C are pin-connected to the surface of the pier

The element properties are listed in Table A1. For this iteration, all bars have the same 40cm x 40cm cross section. The applied dead loads and live loads are also listed in Table A1. The element forces and support reactions due to dead loads are shown in Fig. A2. Those due to live loads are in Fig. A3. The total applied stress, the allowable stress, and the critical load (for elements in compression) are given in Table A2. All applied stresses are smaller (in magnitude) then the allowable stresses (in tension or compression). The verification of the displacements is given in Table A3. Thus, the truss is verified.

Design considerations

The results suggest several approaches for modifying the truss for weight reduction:

- reduce the cross section of bars that are under-stressed in tension;
- try to remove bars that are almost unloaded;
- reduce the cross section of bars in compression that carry forces well below the critical loads.

Most importantly, different truss configurations should also be tested and compared to the present one, in order to provide different avenues for weight minimization

Figure A1. Bridge Truss Example : Geometry and Load Table

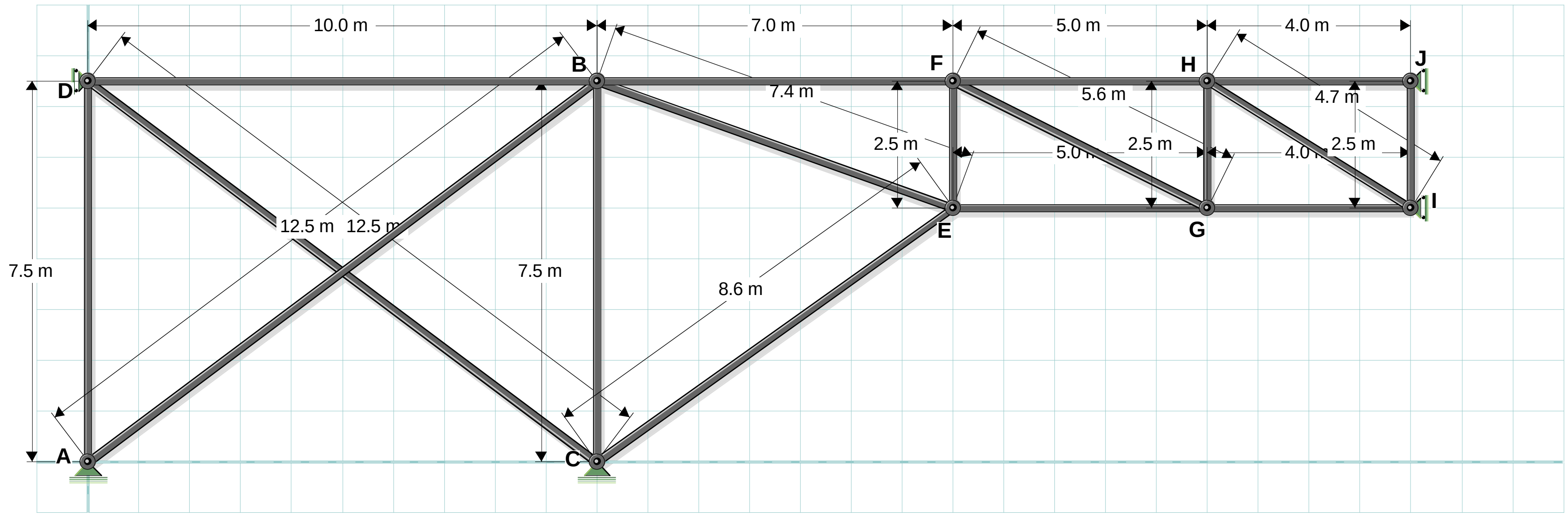


TABLE A1 - BRIDGE TRUSS EXAMPLE
LOAD TABLE

R. PERUCCHIO 11/3/03

element	side [m]]	area [m^2]	2nd Area mom. [m^4]	length [m]	dead load [kN]	live load [kN]	joint	dead load [kN]	live load [kN]
AD	0.4	0.16	0.0021	7.5	4.12		A	5.49	
AB	0.4	0.16	0.0021	12.5	6.87		B	12.20	41.65
DC	0.4	0.16	0.0021	12.5	6.87		C	7.86	
DB	0.4	0.16	0.0021	10	5.49	49.00	D	8.24	24.50
BC	0.4	0.16	0.0021	7.5	4.12		E	6.45	
CE	0.4	0.16	0.0021	8.6	4.72		F	5.52	29.40
BE	0.4	0.16	0.0021	7.4	4.07		G	4.70	
BF	0.4	0.16	0.0021	7	3.85	34.30	H	4.45	22.05
FE	0.4	0.16	0.0021	2.5	1.37		I	3.08	
FH	0.4	0.16	0.0021	5	2.75	24.50	J	1.79	9.80
FG	0.4	0.16	0.0021	5.6	3.08				
EG	0.4	0.16	0.0021	5	2.75		Total	59.77	127.40
HG	0.4	0.16	0.0021	2.5	1.37				
GI	0.4	0.16	0.0021	4	2.20				
HI	0.4	0.16	0.0021	4.7	2.58				
HJ	0.4	0.16	0.0021	4	2.20	19.60			
IJ	0.4	0.16	0.0021	2.5	1.37				
			Total	108.80	59.77	127.40			

Figure A2. Bridge Truss Example : Dead Loads

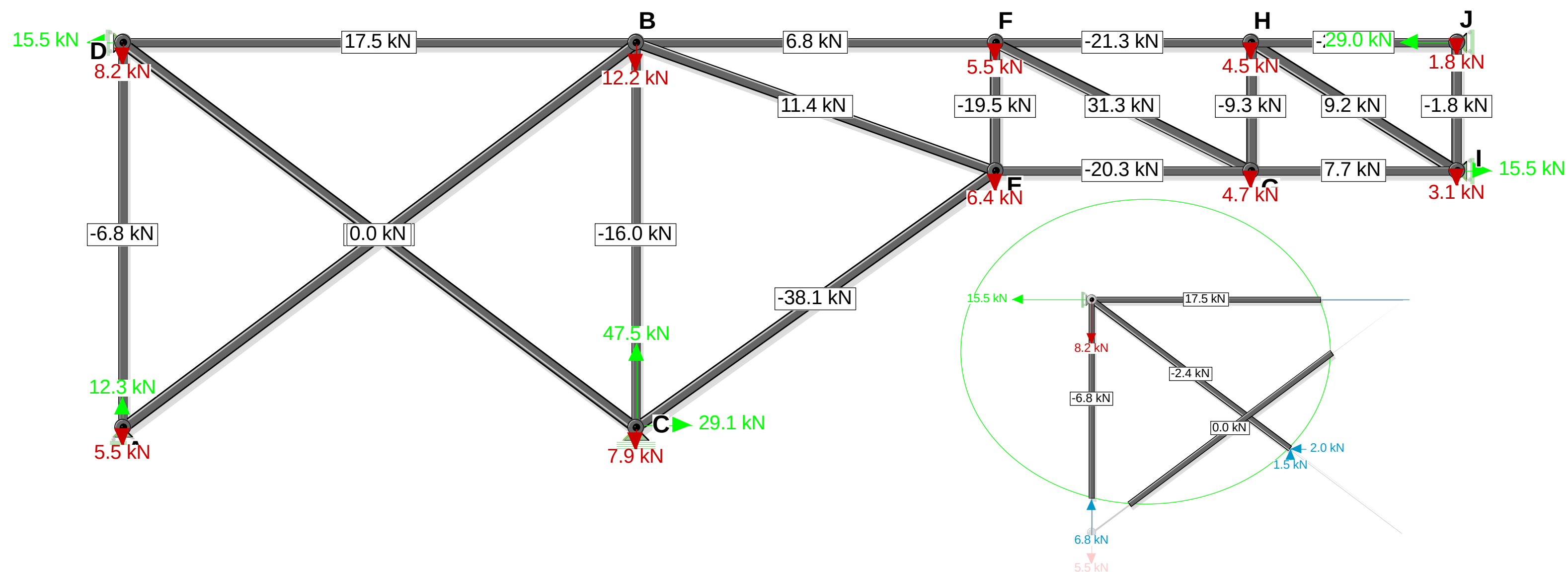
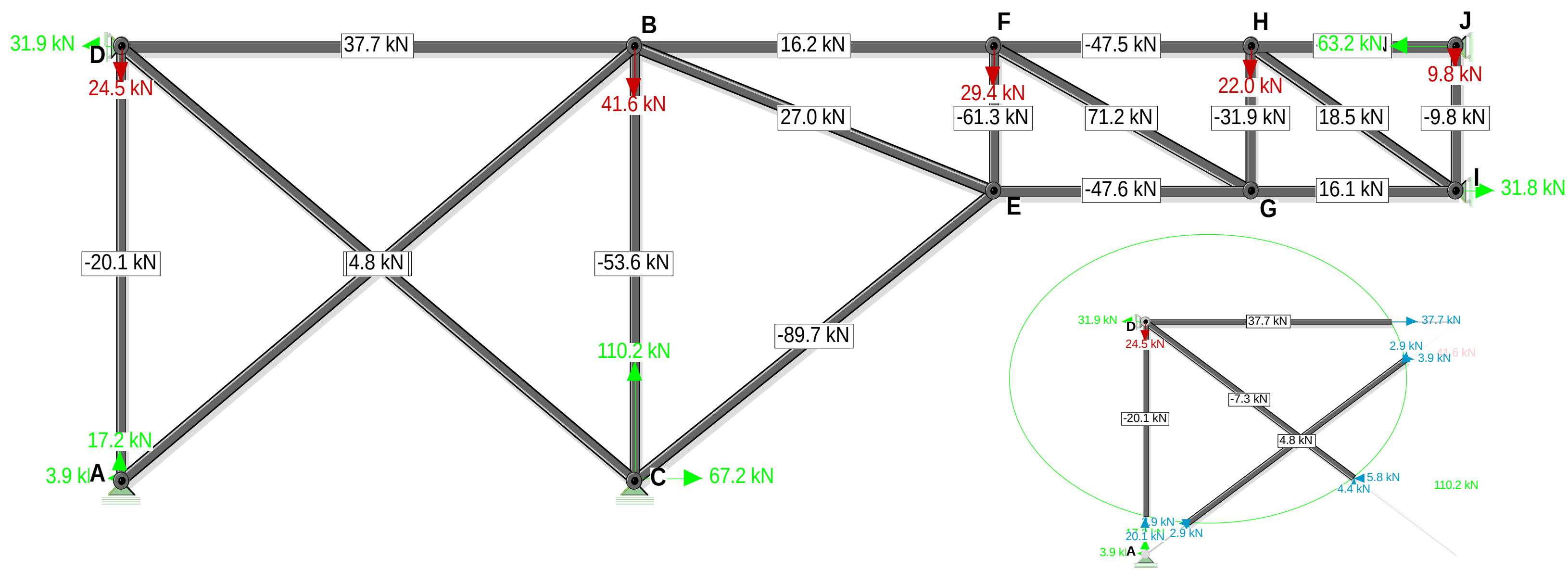


Figure A3. Bridge Truss Example : Live Loads



BRIDGE TRUSS EXAMPLE
VERIFICATION TABLE

element	el. Force (dead load) [kN]	el. Force (live load) [kN]	el. Force total [kN]	applied stress [Mpa]		allow. stress [Mpa]	strength or crush failure
AD	-6.8	-20.1	-26.9	-0.17	COMPRES.	5.4	safe
AB	0	4.8	4.8	0.03	TENSION	20	safe
DC	-2.4	-7.3	-9.7	-0.06	COMPRES.	5.4	safe
DB	17.5	37.7	55.2	0.35	TENSION	20	safe
BC	-16	-53.6	-69.6	-0.44	COMPRES.	5.4	safe
CE	-38.1	-89.7	-127.8	-0.80	COMPRES.	5.4	safe
BE	11.4	27	38.4	0.24	TENSION	20	safe
BF	6.8	16.2	23	0.14	TENSION	20	safe
FE	-19.5	-61.2	-80.7	-0.50	COMPRES.	5.4	safe
FH	-21.3	-47.5	-68.8	-0.43	COMPRES.	5.4	safe
FG	31.3	71.2	102.5	0.64	TENSION	20	safe
EG	-20.3	-47.6	-67.9	-0.42	COMPRES.	5.4	safe
HG	-9.3	-31.8	-41.1	-0.26	COMPRES.	5.4	safe
GI	7.7	16.1	23.8	0.15	TENSION	20	safe
HI	9.2	18.5	27.7	0.17	TENSION	20	safe
HJ	-29	-63.2	-92.2	-0.58	COMPRES.	5.4	safe
IJ	-1.8	-9.8	-11.6	-0.07	COMPRES.	5.4	safe

R. PERUCCHIO 11/3/03

TABLE A3. BRIDGE TRUSS EXAMPLE
VERIFICATION TABLE - DISPLACEMENTS

joint	v. displ. -live load [mm]	v. displ. -dead load [mm]	v. displ. total [mm]	V_J - V_D [mm]			
A							
B	0.25	0.08	0.33	3.82			
C							
D	0.09	0.03	0.12				
E							
F	1.08	0.45	1.53				
G							
H	2.38	1.02	3.4				
I							
J	2.75	1.19	3.94				

total truss weight	**59.77**	**[kN]**
total vertical support	**187.17**	**[kN]**
diff. vertical deformation	**3.82**	**[mm]**
TRUSS PASSES VERIFICATION IN TENSION AND COMPRESSION		

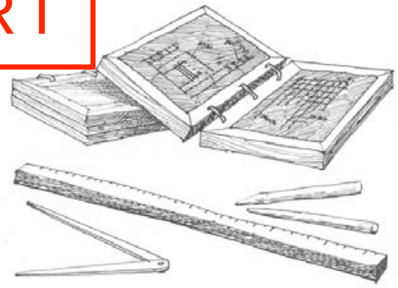
Structural Design of an Ancient Roman Timber Bridge – Stage 2

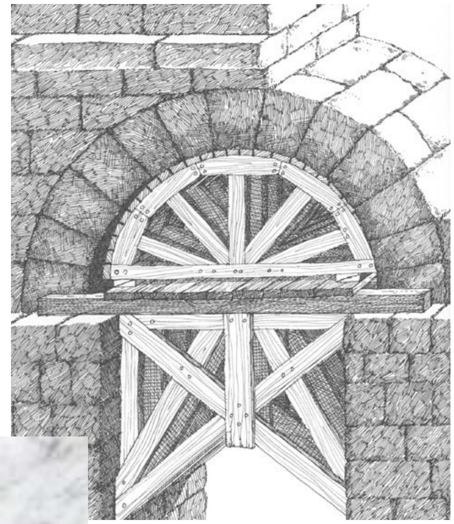
Submitted by: Renato Perucchio
University of Rochester
renato.perucchio@rochester.edu

Structural Design of an Ancient Roman Timber Bridge – Stage 2

Submitted by: Renato Perucchio
Rochester Institute of Technology
renato.perucchio@rochester.edu

FINAL REPORT





ARCHI
MELIORA

TO:	All structural design teams of ME104Q
FROM:	Prof. R. Perucchio
	http://www.courses.rochester.edu/perucchio/ME104Q/index.html
DATE:	29 November 2006
RE:	FINAL STRUCTURAL DESIGN OF A NEW TIMBER BRIDGE ACROSS THE DANUBE, 104 A.D.

Introduction

We have received and are currently reviewing the preliminary designs (Project 3). The emphasis in this second and final stage is to include the effect of buckling and wrought iron in the truss analysis and design process. For the final optimized design, between ¼ to ½ of the truss by weight must be wrought iron (see below, Truss design.)

As previously indicated, we have been requested by our associated firm ARCHI-MELIORA of Roma, Italia, 104 A.D., to provide the structural design of the modular timber truss for the new imperial bridge to be erected across the river Danube near the city of Pontes. The order issued by the Emperor Trajan calls for a twenty-pier bridge 1040m long and 12m wide, see Fig. 1 below. This will be the greatest bridge ever built in the empire. According to the most modern building techniques in Roma, 104 A.D., the truss will be made with seasoned pine timber and wrought iron bars. The construction is scheduled to begin in 105 A.D. The Emperor will personally review the proposed designs.

Each bridge module spans 52m center to center of the piers and consists of six identical planar trusses equally spaced at 2.4m through the width of the bridge and laterally braced to each other. Each design team is required to provide a final structural design for the typical truss according to the specifications below.

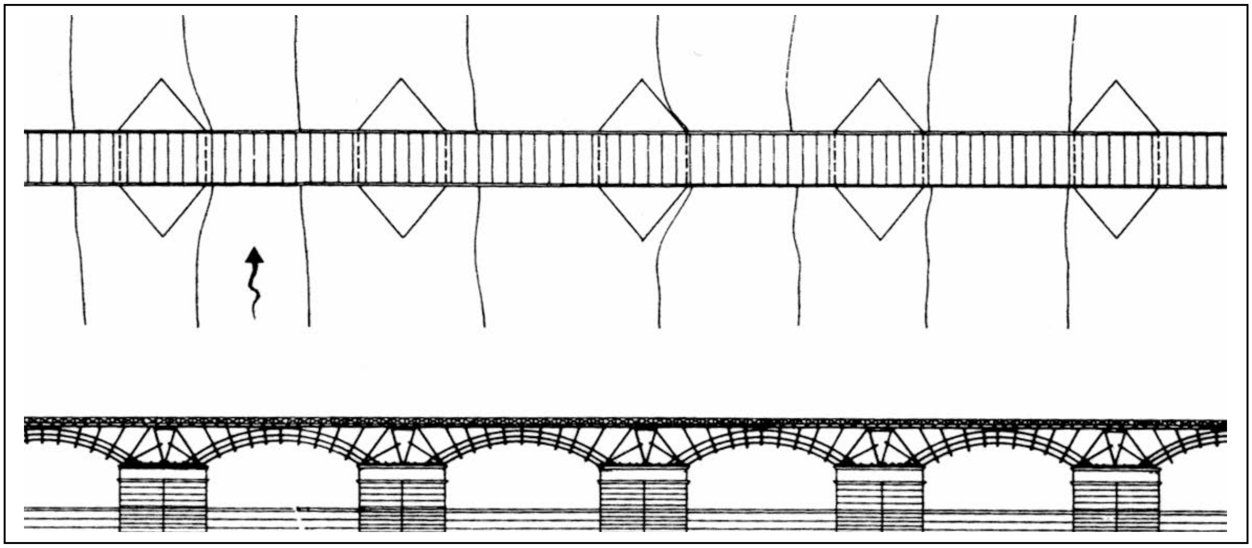


Figure 1. A section of the new bridge over the river Danube requested by the Emperor Trajan. The figure shows the modular nature of the timber and wrought iron structure.

Truss specifications

Figure 2 shows the spatial and mechanical constraints for each modular truss. The truss is made with straight bars of pine timber and wrought iron. The timber specifications are:

- Maximum length available is 10m. Any length equal or less than10m can be used.
- Cross sections available are (all dimensions are cm): 5x5, 10x10, 20x20, 30x30, and 40x40. Different cross sections can be used in the same truss design.
- The mechanical properties of pine are :
  Elastic modulus $E = 10\text{GPa}$,
  Strength in tension $\sigma_{st} = 100\text{MPa}$, in compression $\sigma_{cr} = 27\text{MPa}$,
  Density of the wood is $\rho = 0.35 \times 10^3 \text{kg/m}^3$.

The wrought iron specifications are:

- Maximum length available is 8m. Any length equal or less than 6m can be used.
- Cross sections available are (all dimensions are cm): 2x2, 4x4, and 5x5. Different cross sections can be used in the same truss design.
- The mechanical properties of wrought iron are :
  Elastic Modulus $E = 190GPa$
  Strength in tension $\sigma_{st} = 210MPa$, in compression $\sigma_{cr} = 340MPa$
  Density of wrought iron is $\rho = 7.4 \times 10^3 kg/m^3$

The live load due to bridge superstructure and the traffic on the bridge is represented by a distributed line load $W_{live} = 4.9\text{kN/m}$. The dead load due to the mass of the truss bars must be taken into account. For trusses, the imperial building code requires that a factor of safety $\text{f.s.} = 5.0$ be used to design the truss bars both in tension (strength failure) and in compression (crushing or buckling failure).

In terms of the truss structural stiffness, the imperial building code requires that the differential vertical deformation between center pier and midspan of the bridge measured at the pavement level be less than 0.1% of the span.

Design objectives

We need to design an optimized truss that (a) satisfies all the above requirements, including <u>buckling failure</u> and <u>usage of wrought iron bars</u> and (b) reduces the weight as much as possible.

WORK EXPECTED:

Students will continue to work as design teams of three students only. Members of each design team are expected to work in collaboration to perform the design tasks specified below. Each team will prepare a written report (one report per team!)

Truss design

Each team will perform <u>three</u> design iterations on the truss problem using Dr.Frame. In the <u>first</u> iteration, the team will design a truss consisting of timber bars only. Wrought iron bars will be used for the second and third iterations.

For the first iteration:

1) Select the truss geometry and enter the bar elements. <u>You may want to use the optimized design developed in Project 3 as your first design iteration</u>. Apply boundary conditions and material properties. Follow the geometrical, support, symmetry, and length requirements listed in Fig. 2. Only one half of the modular span needs to be modeled. See Fig.3 for an example of boundary conditions simulating structural symmetry.
2) Select the cross-sectional area and material of each bar (all pine for first iteration).
3) Compute the joint loads due to the mass of each bar (dead load), apply loads to joints, and print out forces on each truss element and reactions at supports.
4) Compute the joint loads due to the live load, apply loads to the appropriate joints, and print out forces on each truss element and reactions at supports.
5) For the elements in tension: compute $\sigma_{applied}$ due to the sum of the loads in (4) and (5) and verify that $\sigma_{applied} \leq \sigma_{allow.} = \dfrac{\sigma_{st}}{\text{f.s.}}$. Tabulate the results as shown in the Appendix.

6) For the elements in compression: compute $\mathbf{P}_{applied}$ and $\sigma_{applied}$ due to the sum of the loads in (3) and (4) and verify that $\mathbf{P}_{applied} \le \frac{\mathbf{P}_{critical}}{\text{f.s.}}$ and $\sigma_{applied} \le \sigma_{allow.} = \frac{\sigma_{cr}}{\text{f.s.}}$. Tabulate the results as shown in the Appendix.
7) To verify the truss stiffness, compute $D = v_F - v_G$, where v_F and v_G denote the total downward displacement at points F and G, respectively (see Fig. 2). Tabulate the results as shown in the Appendix. If $D < 52\text{mm}$ the stiffness of the truss is verified.
8) If the truss passes verification, record the weight of the truss (this is equal to the sum of the vertical reactions computed in (3).) If the truss does not pass verification, make the appropriate changes in step (1) and (2) and repeat the process. The current design iteration is not completed until results are verified.

In the second and third design iterations you must replace some of the timber bars with iron ones, such that ¼ to ½ of the weight of the truss is iron. Iron bars should be inserted where they will make the greatest contribute to structural efficiency. Thus, at each iteration, the truss geometry, the element cross-sectional areas, and/or element material are modified in order to reduce the weight of the truss. These iterations follow exactly the same step (1) – (8) used for the first iteration.

Project report

The written report must include:

1) **Title page**
2) **Abstract (.5 page):** give a brief summary of the report including the weight of the truss for your optimized design.
3) **Introduction (1 page):** define the design problem. List all design constraints (dimensions, materials, etc.).
4) **Truss design (4-page max.):** a section on your optimized truss design. Begin with a paragraph describing the approach followed to refine your design from the first to the last iterations (the other two trusses are described in the appendix to the report, see (8) below). In particular, you must explain your rationale in using iron bars. Add three separate figures taken from Dr.Frame showing the truss geometry (with element dimensions and joint labels), the element forces and the support reactions for the live loads, and the element forces and the support reactions for the dead loads. Include a table showing the results for each element (following the structure of Tables A1, A2, and A3 in the Appendix; in Table A1 add a column specifying the material of each element) and the total weight of this truss.
IMPORTANT: submit via email to Prof. Perucchio at rlp@me.rochester.edu the following files (make sure that names of all team members are indicated in the accompanying message):
   a) Two Dr.Frame files for the optimized truss (one with the live loads and the other with the

dead loads) , and

b) One Excel file with worksheets for load table, verification table – forces, cost, and verification table – displacements for the optimized truss (follow the structure of Tables A1, A2, and A3 in the Appendix.)

5) **Evaluation and comparison with your previous design (1-page max):** compare the present optimized design with that developed in Project 3. Discuss how the consideration of buckling failure and the introduction of wrought iron affects force distribution, weight, cost, and geometry of your truss.

6) **References**: list all the references consulted in the course of the project.

7) **Appendix (4 pages max.)**: give the results for the other two truss designs: for each provide the same material as in (4), but do not repeat the description of the design approach.

As always, make sure that you use correct English grammar and syntax. We will penalize for incorrect usage. Your reports must read easily, convincingly, and well!

The reports are due by noon on Friday, December 15, in the Mechanical Engineering office (235 Hopeman). The Dr.Frame and Excel files must also be emailed to Prof. Perucchio by the same deadline.

Poster presentation

A public poster session will also be held on Thursday, December 14, 2006, from 12:00 noon to 4:30 p.m. in the Bridge Lounge of Wilson Commons. This is a joint project presentation for all Fall 2006 Introduction to Engineering courses. The President of the University may attend the presentation. Prof. Perucchio and the TAs will review and evaluate the posters at this time. In addition, the instructors for the various Introduction to Engineering courses will evaluate the posters made by students of the other courses and vote on a "BEST POSTER" award to be given for each class. **Everyone is expected to attend and to dress properly!** The absence of design team members during evaluation will count heavily against the team in the presentation grade and the BEST POSTER evaluation.

Posters are a very common and effective way of presenting technical or scientific information to the public at professional conferences or public meetings in general. At the University, posters are also used frequently to present results of course projects. Instructions on how to prepare an effective presentation can be found on several web sites (see, for example, this site from the University of Kansas:
http://www.kumc.edu/SAH/OTEd/jradel/Poster_Presentations/PstrStart.html)

Folding poster boards (approximately 4’ wide by 3’ tall) are available to the design teams from the undergraduate secretary in the Mechanical Engineering office (235 Hopeman).

Reference

The following material is on reserve at Carlson Library (two-hour reserve for either ME104Q or ME105):

Adam, Jean-Pierre. *Roman Building: Materials and Techniques*. Indiana University Press, 1994.
Colin O'Connor. *Roman Bridges*. Cambridge University Press, 1993.
James E. Gordon, *Structures, or why things don't fall down* (DaCapo Press, New York, 1978).
Robert Mark, editor, *Architectural technology up to the scientific revolution: The art and structure of large-scale buildings* (MIT Press, Cambridge, 1993).
Robert Mark, *Light, wind, and structure: The mystery of the master builders* (MIT Press, Cambridge, 1990).
Mario Salvadori, *Why buildings stand up: The strength of architecture* (Norton, New York, 1990).

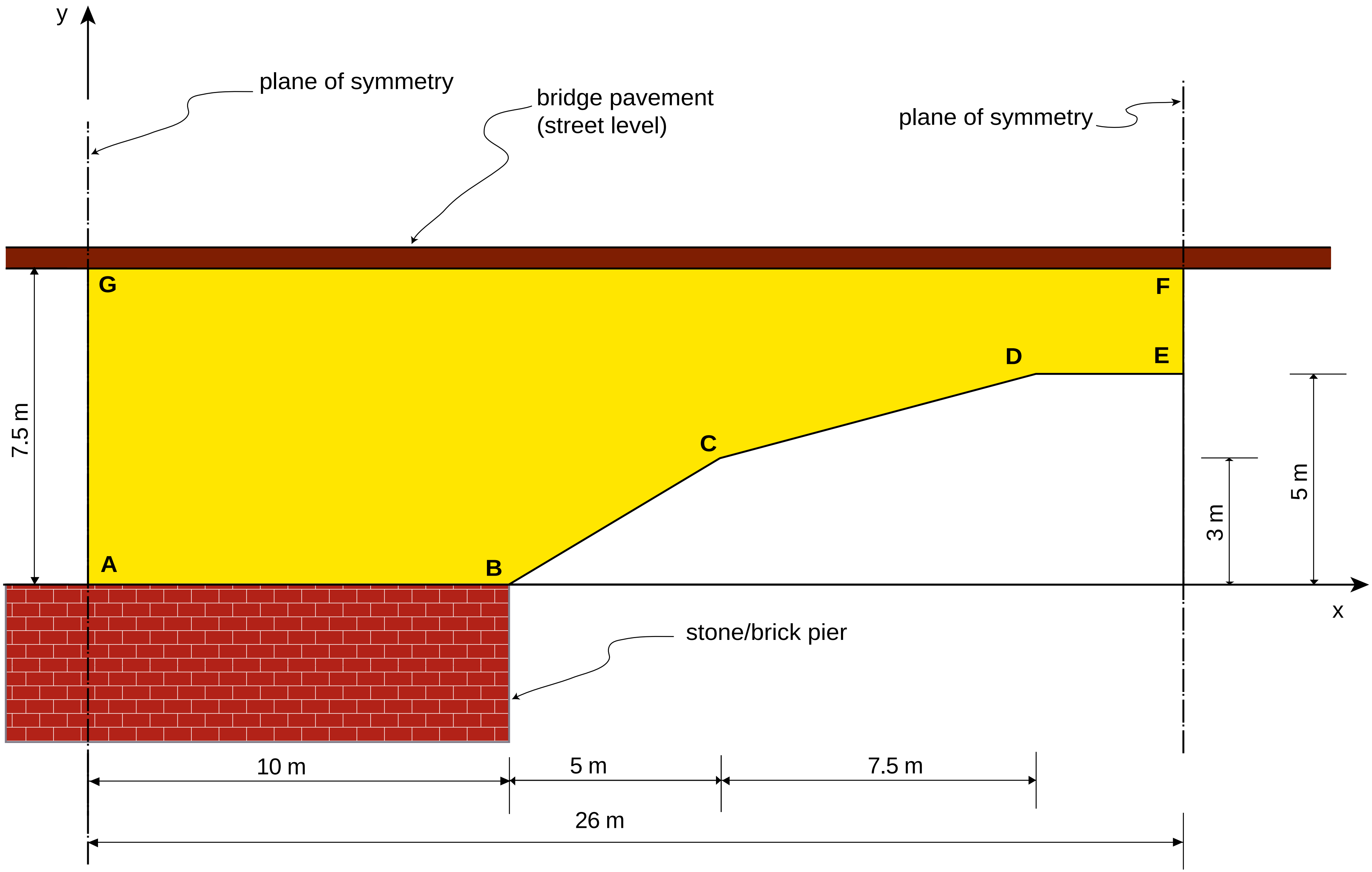


Figure 2. Design constraints
Geometrical constraints : truss must fit into yellow area and must support bridge pavement at the level indicated.
Support constraints: all joints resting on the pier (line AB) must be pin-connected (joint does not move).
Symmetry constraints: (1) line GA - one bar pin-connected at point A and with roller at point G (free to move on the plane of symmetry. (2) line FE - one bar with rollers at both ends (free to move on the plane of symmetry) and one end must be at point F.
Length constraint: bars must be 10 m long or less.

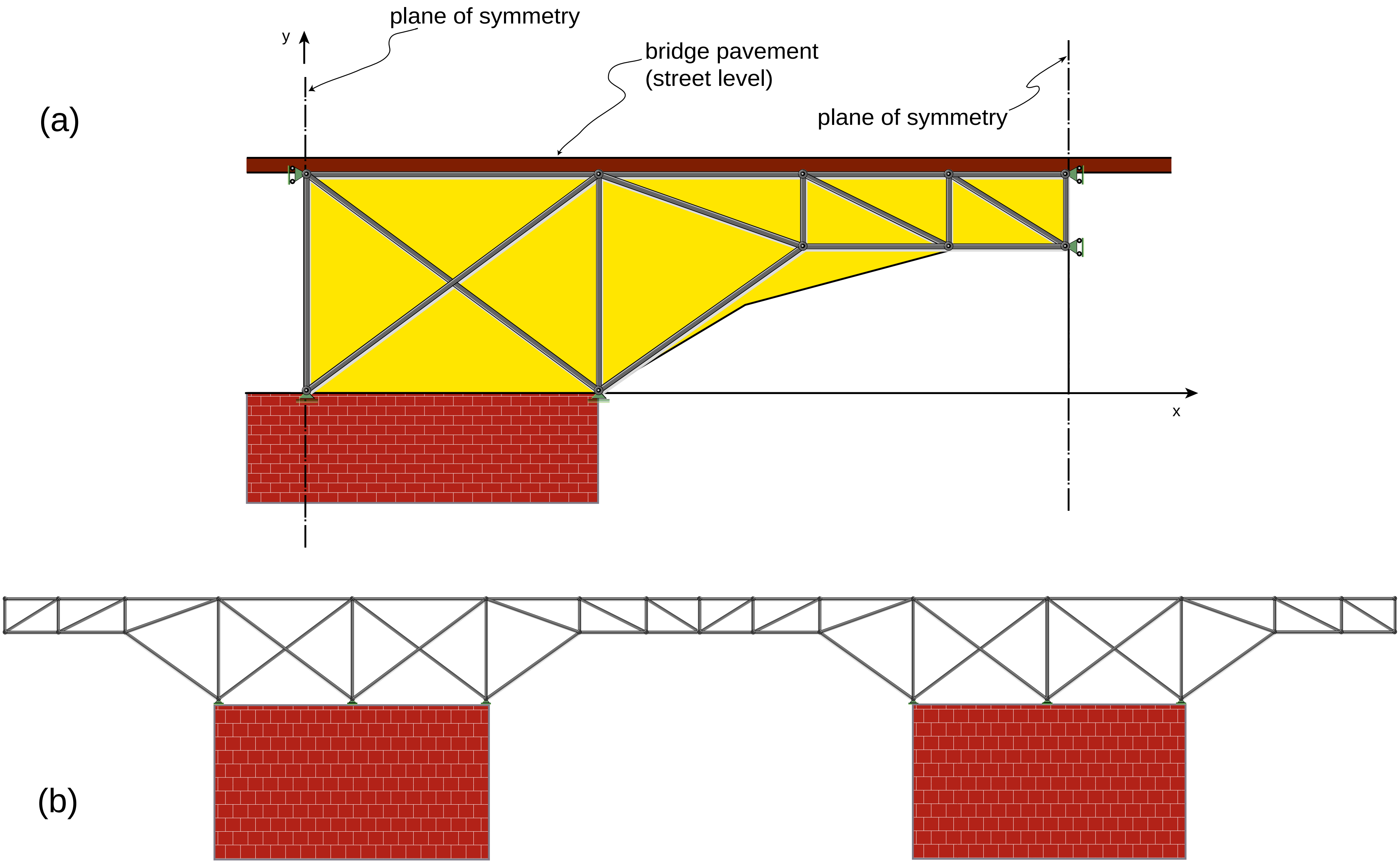


Figure 3. Structural symmetry:
(a) truss design: notice roller boundary conditions on symmetry planes. (b) Modular structure simulated by the boundary conditions applied in (a).

APPENDIX

Example of truss design

For the first design iteration, we select a simple truss geometry, see Fig. A1. Notice that, on purpose, this configuration violates the length constraint and thus cannot be used for the first design iteration. Only half of the truss is modeled. To represent the symmetry condition, joints D, I, and J are attached to rollers, which allow motion in the vertical direction only. Joints A and C are pin-connected to the surface of the pier

The element properties are listed in Table A1. For this iteration, all bars have the same 40cm x 40cm cross section and are composed of timber. The applied dead loads and live loads are also listed in Table A1. The element forces and support reactions due to dead loads are shown in Fig. A2. Those due to live loads are in Fig. A3. The total applied stress, the allowable stress, and the critical load (for elements in compression) are given in Table A2. All applied stresses are smaller (in magnitude) then the allowable stresses (in tension or compression). Also, for the elements in compression, the element forces are below $P_{critical} / f.s.$ The verification of the displacements is given in Table A3. Thus, the truss is verified.

Design considerations

The results suggest several approaches for modifying the truss for weight reduction:

- Reduce the cross section of bars that are under-stressed in tension;
- Try to remove bars that are almost unloaded;
- Reduce the cross section of bars in compression that carry forces well below the critical loads.
- Make the truss as efficient as possible by combining timber and wrought iron elements in your design.

Most importantly, different truss configurations should also be tested and compared to the present one, in order to provide different avenues for weight minimization

Figure A1. Bridge Truss Example : Geometry and Load Table

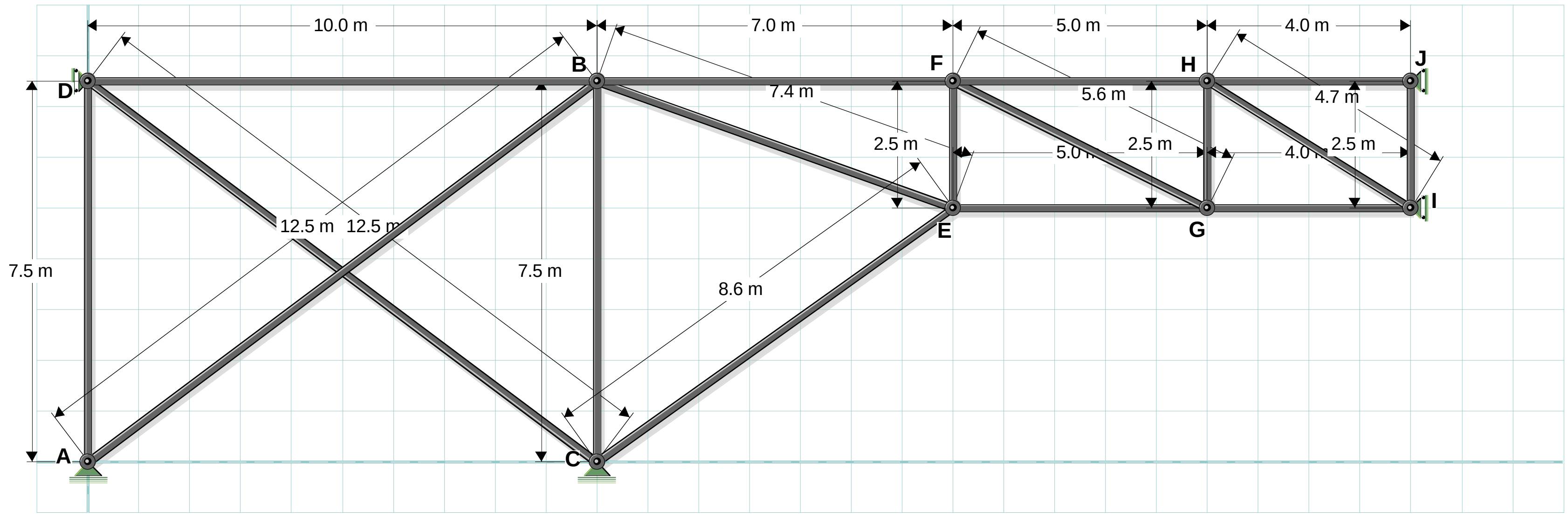


TABLE A1 - BRIDGE TRUSS EXAMPLE
LOAD TABLE

R. PERUCCHIO 11/25/02

element	side [m]]	area [m^2]	2nd Area mom. [m^4]	length [m]	dead load [kN]	live load [kN]	joint	dead load [kN]	live load [kN]
AD	0.4	0.16	0.0021	7.5	4.12		A	5.49	
AB	0.4	0.16	0.0021	12.5	6.87		B	12.20	41.65
DC	0.4	0.16	0.0021	12.5	6.87		C	7.86	
DB	0.4	0.16	0.0021	10	5.49	49.00	D	8.24	24.50
BC	0.4	0.16	0.0021	7.5	4.12		E	6.45	
CE	0.4	0.16	0.0021	8.6	4.72		F	5.52	29.40
BE	0.4	0.16	0.0021	7.4	4.07		G	4.70	
BF	0.4	0.16	0.0021	7	3.85	34.30	H	4.45	22.05
FE	0.4	0.16	0.0021	2.5	1.37		I	3.08	
FH	0.4	0.16	0.0021	5	2.75	24.50	J	1.79	9.80
FG	0.4	0.16	0.0021	5.6	3.08				
EG	0.4	0.16	0.0021	5	2.75		Total	59.77	127.40
HG	0.4	0.16	0.0021	2.5	1.37				
GI	0.4	0.16	0.0021	4	2.20				
HI	0.4	0.16	0.0021	4.7	2.58				
HJ	0.4	0.16	0.0021	4	2.20	19.60			
IJ	0.4	0.16	0.0021	2.5	1.37				
			Total	108.80	59.77	127.40			

Figure A2. Bridge Truss Example : Dead Loads

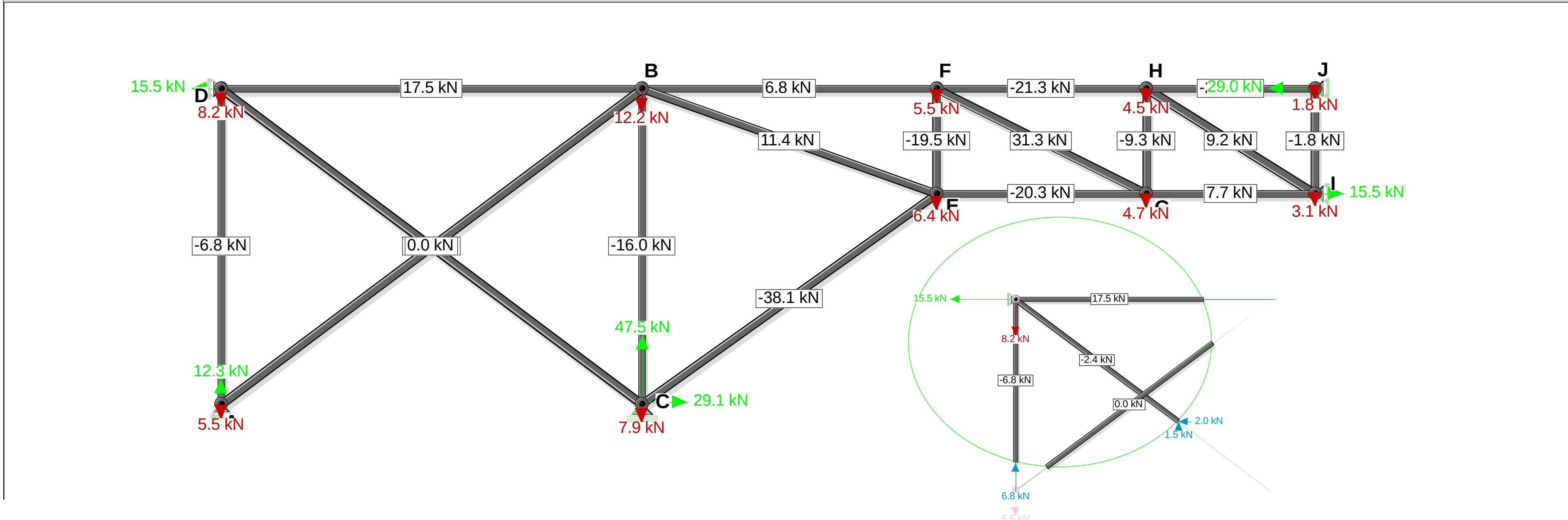


Figure A3. Bridge Truss Example : Live Loads

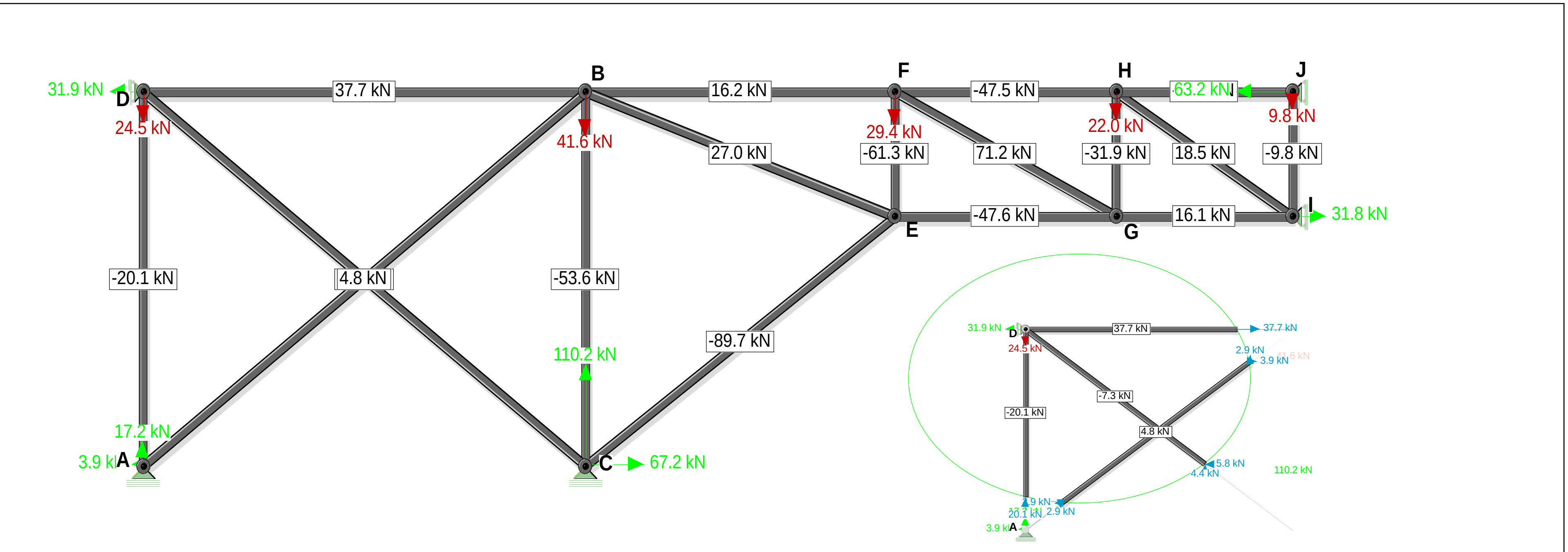


TABLE A2. BRIDGE TRUSS EXAMPLE
VERIFICATION TABLE - FORCES

R. PERUCCHIO 11/25/02

element	el. Force (dead load) [kN]	el. Force (live load) [kN]	el. Force total [kN]	applied stress [Mpa]	allow. stress [Mpa]	Pcritical [kN]	Pcrit./s.f. [kN]	buckling failure	crush failure	streng. failure
AD	-6.8	-20.1	-26.9	-0.17	-5.4	-3743	-749	safe	safe	
AB	0	4.8	4.8	0.03	20					safe
DC	-2.4	-7.3	-9.7	-0.06	-5.4	-1348	-270	safe	safe	
DB	17.5	37.7	55.2	0.35	20					safe
BC	-16	-53.6	-69.6	-0.44	-5.4	-3743	-749	safe	safe	
CE	-38.1	-89.7	-127.8	-0.80	-5.4	-2847	-569	safe	safe	
BE	11.4	27	38.4	0.24	20					safe
BF	6.8	16.2	23	0.14	20					safe
FE	-19.5	-61.2	-80.7	-0.50	-5.4	-33688	-6738	safe	safe	
FH	-21.3	-47.5	-68.8	-0.43	-5.4	-8422	-1684	safe	safe	
FG	31.3	71.2	102.5	0.64	20					safe
EG	-20.3	-47.6	-67.9	-0.42	-5.4	-8422	-1684	safe	safe	
HG	-9.3	-31.8	-41.1	-0.26	-5.4	-33688	-6738	safe	safe	
GI	7.7	16.1	23.8	0.15	20					safe
HI	9.2	18.5	27.7	0.17	20					safe
HJ	-29	-63.2	-92.2	-0.58	-5.4	-13159	-2632	safe	safe	
IJ	-1.8	-9.8	-11.6	-0.07	-5.4	-33688	-6738	safe	safe	

TABLE A3. BRIDGE TRUSS EXAMPLE
VERIFICATION TABLE - DISPLACEMENTS

R. PERUCCHIO 11/25/02

joint	v. displ. -live load [mm]	v. displ. -dead load [mm]	v. displ. total [mm]	V_J - V_D [mm]
A				
B	0.25	0.08	0.33	3.82
C				
D	0.09	0.03	0.12	
E				
F	1.08	0.45	1.53	
G				
H	2.38	1.02	3.4	
I				
J	2.75	1.19	3.94	

total truss weight	**59.77**	**[kN]**
total vertical support	**187.17**	**[kN]**
diff. vertical deformation	**3.82**	**[mm]**

TRUSS PASSES VERIFICATION IN TENSION AND COMPRESSION

Submitted by: Farid Farahmand
Sonoma State University
farid.farahmand@sonoma.edu

Designing a Throwing Machine

Final Project
ES110: Introduction to Engineering
Dr. Farid Farahmand (farid.farahmand@sonoma.edu)
Sonoma State University

The final project will be based on the current needs of physically disabled students enrolled at Sidekicks program (in particular a teen with Cerebral Palsy). The design project must be completed in groups with no more than three members. The group design solution must follow the client's specified requirements and needs.The project will have both mechanical and electrical aspects. The project grade will be for the entire group.

Design Project Grade: The project grade will be based on the following criteria:

- how closely the design matches the client's requirement; (10%)
- how user friendly the design is; (10%)
- how accurately the design process is described in the weekly blog; (5%)
- how reliable the design is; (5%)
- how well the team interacted together and everyone participated. (10%)

Blog Page: Each group is required to have a blog page for the final project. One easy way to create a blog is to use Google's blogger. You can watch video tutorial to learn more. Here is my blogger example for the ES Department. Here is a cool example of a student project blog. All progress reports have to be posted on the blog. Teams are expected to have weekly post in their blogs.

YouTube Presentation: Each project must have a YouTube presentation (5-10 min. long). ALL group members must be present for the YouTube presentation.

Project Schedule: Each group must submit a project schedule indicating all the major deadlines and each member's responsibilities. Please see below for more information.

Previous Projects: Over the past several years students enrolled in ES110 have completed similar final projects. Here are the links to the previous projects:

Fall 2009	Project Focus: Building a functional throwing machine with a simple push button. • Wheelchairs Pictures • First Prototype Pictures • Final Presentation Pictures	• Group 1: http://throwingmachine.blogspot.com/ • Group 2: http://ssuengineering.blogspot.com/ • Group 3: http://engineeringbadasses.blogspot.com/ • Group 4: http://esgroupblog.blogspot.com/ • Group 5: http://www.kittenscrawlinginthevents.blogspot.com/
Fall 2010	Project Focus: Building a functional device that moves the ball. Various user interfaces can be considered.	• Group 1: http://www.edg-engineering.webs.com/ • Group 2: http://electricdesign2010.blogspot.com/ • Group 3: http://bloggerface-parmesan.blogspot.com/ • Group 4: http://teamhufflepuff1.blogspot.com/ • Group 5: http://xcapedesign.net/robot/ • Group 6: http://ajainfinity.blogspot.com/!
Fall 2012	Project Focus: Building a functional device with special effect, such as light and noise, that moves the ball. Various user interfaces can be considered.	• Group 1: Psychedelic Snails http://psychsnails.blogspot.com • Group 2: T.A.P www.tapgroup.webs.com • Group 3: The Avengineers www.avengineers110.blogspot.com • Group 4: Prestige Worldwide www.prestigeworldwidees110.blogspot.com • Group 4:The Short Circircuits www.the-shortcircuits.blogspot.com • Group 6: Team Sparky www.teamsparky110.blogspot.com

Media Coverage:

- Creative Play for special children, Press Democrat, Sunday, January 29, 2012
- A Kicking-and-Throwing Machine Gives New Life to a Teen with Cerebral Palsy - Sonoma State News Center, January 18, 2012

Example Project Schedule:

Designing a Throwing Machine

My Team Name

Project Lead: ES110 Class

Start Date: 9/1/12

WBS	Tasks	Task Lead	Start	End	Duration (Days)	% Complete
1	Form a group	Farid	9/1/12	9/22/12	22	
1.1	get to know group members	Steve	9/1/12	9/17/12	17	100%
1.2	domain name		9/18/12	9/17/12	0	23%
1.2.1	what information?		9/18/12	9/17/12	0	23%
2	Visit Sidekicks	all	9/22/12	9/22/12	0	24%
2.1	Make sure you go to sidekicks	All	9/1/12	8/31/12	0	23%
3	Create a blog	Farid	9/22/12	10/1/12	24	
3.1	review previous projects	Steve	9/22/12	9/26/12	5	100%
3.2	Find a domain name		9/27/12	9/28/12	2	23%
3.3	Post your name and group name		9/29/12	9/30/12	2	23%
4	Post first progress report	Mary	10/1/12	10/15/12	5	
4.1	What is the basic framework?	Steave	10/1/12	10/5/12	5	100%
4.2	Design Function/how does it work	Bill	10/1/12	10/2/12	2	23%
4.3	Release method	Steph	10/1/12	10/2/12	2	23%
4.4	Interface	Chris	10/1/12	10/5/12	5	100%
4.5	Sound	Mary	10/1/12	10/2/12	2	23%
4.6	Light	Mary	10/1/12	10/2/12	2	23%
5	First working prototype /Post	all	10/15/12	10/22/12	15	
5.1	Must present in class	All	10/15/12	10/22/12	8	100%
6	Attend Last Sidekick meeting / Post	all	10/22/12	10/29/12	0	
6.1	Must take your prototype with you	All	10/22/12	10/22/12	1	100%
6.2	Post a short report	All	10/22/12	10/22/12	1	100%
7	Post second progress report	Mary	10/29/12	11/12/12	5	
7.1	What is the basic framework?	Steave	10/29/12	11/2/12	5	100%
7.2	Design Function/how does it work	Bill	10/29/12	10/30/12	2	23%
7.3	Release method	Steph	10/29/12	10/30/12	2	23%
7.4	Interface	Chris	10/29/12	11/2/12	5	100%
7.5	Sound	Mary	10/29/12	10/30/12	2	23%
7.6	Light	Mary	10/29/12	10/30/12	2	23%
8	Presentation/Post	all	11/12/12	12/3/12	29	
8.1	Must present	All	11/12/12	11/19/12	8	100%
9	You tube presentation	all	12/3/12	12/10/12	1	
9.1	Must be available in you blog!	All	12/3/12	12/3/12	1	100%

Design, Construct, and Demonstrate a Self-Propelled Vehicle

Submitted by:Bonnie Boardman
University of Texas at Arlington
boardman@exchange.uta.edu

Self Propelled Vehicle
Team Project

Objective

Each team will design, construct, and demonstrate a vehicle that will travel over a flat surface. Points will be awarded for the distance travelled divided by the total initial weight of the vehicle. The vehicle must move under its own internal "engine" – the team can only release the stationary vehicle when the test begins.

Requirements

1. Batteries/electricity cannot be used to propel the vehicle.
2. No combustion or other chemical reaction can be employed.
3. Your vehicle must weigh between 100g and 500g.
4. Every part of the vehicle must finish the travel as one piece.
5. When demonstrating your device, no trial runs will be allowed.
6. The maximum time for project demonstration is 4 minutes.
7. A group member will start the demonstration; afterwards, the demonstration is "hands-free." Additional human intervention to complete the demonstration will be penalized.
8. The maximum cost for materials used in the vehicle must be less than $30. You may not buy or use a preassembled vehicle for this project. You must design and build your own.
9. A cost estimate must be included for any items already owned by a team member. This cost estimate must be included in the $30 team limit.
10. No live (or otherwise) animals may be used in this project.
11. Creativity is an important part of any engineering project. There will be bonus points awarded for the creativity and the simplicity of design of the project (see scoring section.)

Demonstration

1. The project demonstration will be held during your class hour. We are likely to start a half hour early for groups who can be there. You will be notified well before the day of the demonstration. (You may need to stay up to 30 minutes beyond the class time to complete the voting.)
2. Your group's project demonstration can begin only when your entire group is present.
3. A group member or members selected by the judge will verbally describe the operation of the project.
4. You will have two attempts, and the best value will be recorded. The two attempts as well as any resetting of your device must all happen within the four minute time limit.

Scoring

1. Points will be awarded for the distance travelled for the better of your two attempts divided by the total initial weight of the vehicle.
2. Your vehicle must be stationary and entirely behind the start line to begin. The distance recorded will be between the start line and where a judge determines the front of your vehicle to stop.

3. **Your grade will be determined as follows: (Best distance/weight) + bonus (10, 8, or 6 points for creativity and simplicity)**
4. **Teams will display their device for up to 30 minutes after all teams have been tested.**
5. **During this display one or two team members will stay with the device in order to answer any questions from viewers about the design or operation. The remainder of the team will view the displays of the other teams.**
6. **Each team will be given a slip of paper on which they will rank their top three teams with respect to creativity and also with respect to simplicity. These will be tallied and the top 3 teams in each category will receive 10, 8, or 6 bonus points.**
7. **You will not be allowed to vote for your own team in either category.**

Design, Construct, and Demonstrate a Ball Shooter

Submitted by:Bonnie Boardman
University of Texas at Arlington
boardman@exchange.uta.edu

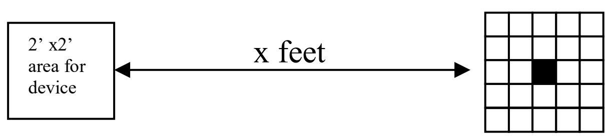
Ball Shooter
Team Project

Objective

Each team will design, construct, and demonstrate a device that will successfully hit a target with a tennis ball. The target will be a flat grid of 1 foot x 1 foot boxes. The total size of the grid will be 5 feet x 5 feet. The grid will be placed on the floor with the center box designated as the bull's-eye box and surrounding boxes used for scoring.

Requirements

1. Your device must have a footprint of no greater than 2 feet by 2 feet. There is no height restriction. The entire device must stay within the 2' x 2' square before, during, and after operation.
2. The front edge of the target will be placed at a location somewhere between 5 feet and 25 feet from the front edge of 2' x 2' box in which your device sits and the front edge of the bull's-eye box. You will not know the exact distance of the target until the day of testing. Your device will need to be adjustable and you will need to calibrate prior to test day so that you know what adjustments to make on test day.



3. Only the portions of the device in contact with the floor before firing the tennis ball may be in contact with the floor after the ball is fired.
4. Once the ball is released, your score will be based upon where the ball first hits the floor. The decision of the judges is final.
5. When demonstrating your device, no trial runs will be allowed.
6. You will provide your own standard tennis ball for the demonstration.
7. No chemical reactions can be used.
8. The maximum time for project demonstration is 4 minutes.
9. A group member will start the demonstration; afterwards, the demonstration is "hands-free." Additional human intervention to complete the demonstration will be penalized.
10. The maximum cost for materials used in the tennis ball shooter must be less than \$30. This includes all materials used in the shooter. A cost estimate must be included for any items already owned by a team member. This cost estimate must be included in the \$30 team limit.
11. No live animals may be used in this project.
12. Creativity is an important part of any engineering project. There will be bonus points awarded for the creativity and design of the project (see scoring section.)

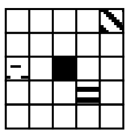
Demonstration

1. The project demonstration will be held during your class hour. We are likely to start a half hour early for groups who can be there. You will be notified well before the day of the demonstration. (You may need to stay up to 30 minutes beyond the class time to complete the voting.)
2. Your group's project demonstration can begin only when your entire group is present.

3. Your group will be directed to a location where you will set up your project. You will have two minutes to set up.
4. A group member or members selected by the judge will verbally describe the operation of the project.
5. The tennis ball to be used during demonstration will be provided by you.
6. Your device will be scored based upon two consecutive shots. The two shots as well as any resetting of your device must all happen within the 4 minute time limit.

Scoring

1. The target will consist of a grid of 1'x1' squares. The center square will represent the bull's-eye. A ball that hits outside the bull's eye will be scored based upon the square in which it hits. 5 points will be deducted for every square in the grid. Rectilinear distance will be used to measure. See the examples below.



= 100- (4*5)=80 points
= 100-(2*5)=90 points
= 100-(2*5)=90 points

2. Any ball that does not hit the grid but has forward displacement will be awarded 35 points.
3. The score recorded will be where a judge determines that the tennis ball first hits the ground after being released by your shooter. All judges' determinations are final.
4. Your grade will be determined as follows: (Average numerical score of both shots) + bonus (10, 8, or 6 points for creativity and simplicity)
5. Teams will display their device for up to 30 minutes after all teams have been tested.
6. During this display one or two team members will stay with the device in order to answer any questions from viewers about the design or operation. The remainder of the team will view the displays of the other teams.
7. Each team will be given a slip of paper on which they will rank their top three teams with respect to creativity and also with respect to simplicity. These will be tallied and the top 3 teams in each category will receive 10, 8, or 6 bonus points.
8. You will not be allowed to vote for your own team in either category.

Submitted by: John Crepeau
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University of Idaho, ME 123, Introduction to Mechanical Design
Professors John Crepeau and Bob Stephens
Design Project: H2Go: The Untapped Energy Source
(Adapted from the 2011 ASME Student Design Competition)

Green energy is being used more each day. Wind turbines, wave turbines, hydroelectric dams, geothermal heating/cooling, biofuels and solar panels are all being constantly improved to be more efficient and environmentally friendly. Roughly 7% of the world's energy is currently generated from these sources. However, there is another source of energy that has not been tapped – rain. The potential energy of 1 inch of rain fall on the average single-story house, if captured at the roof height provides approximately 120 kJ of energy, and even more if the rain can be captured in motion. Devices to convert and store this energy could be created, utilizing an untapped and readily available energy source. In addition, the water itself could be stored for a variety of everyday uses.

Your challenge is to design a scaled, proof-of-concept prototype for rain energy conversion. Your prototype device will propel a model car as far as possible in a straight line by converting the potential energy of one-half liter of water at a height of 60 cm. **All water must be contained within the device and a penalty will be assessed for any water spilled**.

Course Description

At the competition, ½ liter of water will be provided. The competition will be held in the hallway in front of EP 103.

Device Requirements

1. The only power source to be used is the ½ liter of water. If any stored energy is used in the device besides elevated water, teams must prove that the amount of additional stored energy after the device operates is equal to or greater than the initial stored energy.
2. The device must have an easily removable and drainable water storage container capable of storing at least 0.7 liters of water.
3. Each team must provide their own car which must be no longer than 18 inches and 12 inches wide. The car may not be used as a projectile.

Contest Operation

The mentors will pour the ½ liter water into the car's water storage device, then give the signal for the car to go. Once the car is started, it may not be touched by a team member.

At the end of the run, the water will be measured to ensure no loss.

During the first run, the straight line distance traveled from the initial location of the front of the car to the final position will be recorded. The goal of the first run is to travel as far as possible in a straight line without losing any water. During the second run, you will be given a target distance ranging from 5 to 8 meters from the starting line. The object of the second run is to add sufficient water so that the car lands on the specified target. The second run will begin immediately after measurements have been made from the first. The team may manually reset their device between runs.

Scoring and Penalties

The devices will be scored using the following formula:

$$S = \left(D_1 - 100W_1 - O_1\right) - \left(\Delta_2 + 100W_2\right)$$

where:

D = Distance car traveled (mm)
W = Water spilled over 25 mL (mL)
O = Distance off the centerline (mm)
Δ = Distance from the target (mm)

Materials:
Hot glue
Dowels, straws
Plastic containers
Popsicle sticks
Tubing
Binder clips
Cardboard
String
Rubber bands
Any recyclable materials you can find on your own

Schedule

Week #1	Introduction of project; team formation; team meeting schedule; initial brainstorming; begin recording ideas (keep a lab book!)
Week #2	Review of concepts; sketches; research background; decision matrix. We want to see the ideas that you have explored.
Week #3	Snapshot presentations (poster presentation showing ideas, sketches finalized decision matrix, building and testing schedule). We want to see your tentative final decision and know why you chose it.
Week #4	Testing and calibration. Physical prototype should be built.
Week #5	Competition and final presentation.

Plan/Do/Check!

Submitted by: John Crepeau
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ME 123 Introduction to Mechanical Design

Design Project # 1 Build your Bridge

September 1, 2011

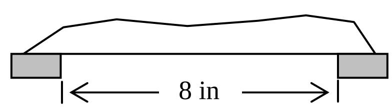
Professors Bob Stephens and John Crepeau

University of Idaho

Mechanical engineers are expected to be good at solving problems and developing designs. Important parts of the problem solving/design process are: brainstorming, structured decision making, building the design, testing the prototype and then improve the design. This is an iterative, interactive and creative process.

Problem (Design Project)

Using only an 8 ½" x 11" sheet of paper and no more than three paperclips, design a bridge or structure that spans 8 inches that will support the maximum number of pennies. No tools (**scissors, pliers**) may be used to help construct your bridge. All pennies must be placed within the 8 inch span and the bridge **MUST** be positioned **ABOVE** the end supports prior to any penny placement. Team members will take turns placing pennies in/on the bridge until the bridge collapses. Team members may add as many pennies as they would like at a time. Only the pennies on the bridge prior to the addition that collapses the bridge will be counted. Additionally, for each paperclip **NOT USED** in the design, the team receives **25** additional pennies counted toward their total penny count. For example, if you only use 2 paperclips and your bridge design supports 150 pennies, and another team uses 3 paperclips and their bridge supports 170 pennies, your team receives 150 + 25 = 175 pennies, thus you win! The team will have no more than 10 minutes to construct the structure from a single sheet of provided paper and three paperclips prior to the competition. Should the team ruin their bridge during the construction, they will be provided with more material, but the clock will not be stopped. The team will have 3 minutes (or until the bridge collapses) to place as many pennies as possible. This project will span two lab section periods.



Tasks

1. What is important in this design?
2. Brainstorm to create at least 4 alternative design concepts. Sketch your ideas (don't lose these sketches).
3. Choose criteria to be used in selecting the best design.
4. Choose the relative weight of each criterion.
5. Create and complete a decision matrix (see example on board and as done in class).

   Rating scale: 4-excellent
   3-good
   2-poor
   1-unacceptable
6. Based on your decision matrix, select the best idea for your initial design.
7. Build your initial design.
8. Test it.
9. Improve your design.
10. Test your improved design, etc.
11. Prepare for the design competition to be held at our next lab (September 8, 2011). The competition will start 10 minutes after the beginning of the class. **All members must be present and participate during the bridge build.**

ME 123, Introduction to Mechanical Design
Design Project # 1 Build your Bridge

Design Project #1 Report

As a team, prepare one design report.

The sections required in the report **in order** are:

1. Title Page including team name, full names of team members, and their assigned roles.
2. Description of design problem.
3. Record (sketches, etc.) of multiple designs created during your brain storming process.
4. Decision matrix including at least 4 designs using the rating scale provided.
5. Detailed construction sketches and assembly instructions for final design. Highlight any key concepts/assembly procedures associated with your design that makes it the winning design.
6. Detailed description of your team's "Design Process" associated with this project. Give particular attention to development of your decision matrix and the "weights" given each criteria or constraint.
7. Participation log of team members (describe what each team member did to help the team succeed and the attendance of each team member for each team meeting).
8. Reflect as a team on what was learned regarding the design process by participating in this design project.
9. How many pennies did you support? Describe your team's performance regarding your design in comparison to the other designs in your lab.
10. If you were to do this project again, having experienced the competition and seen other teams' bridges, what changes would you make to your design? What changes would you make regarding your design process?

Submitted by: Roberto Cammino
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MMAE 100 – Intro to the Profession – Mechanical and Aerospace Engineering Track

Simple Mechanical Product Teardown

Objective:

In this module, you will be provided with some complex non-functional electronic devices, such as a cellular phone, computer tablet, portable DVD player, digital camera, digital camcorder or the likes of the above. You will study the construction of this product from a Mechanical Engineer's perspective.

Procedure:

You will carefully disassemble the product noting any possible mechanical engineering feature you observe. For example, how many screws are used, how many snaps, how parts there are and how they are mechanically reinforced (i.e. with ribs, metal stiffeners, ect..), which materials are used, how they are connected (snaps, screws, adhesives). If your product contains an LCD, you will note its construction. Your product will contain a Printed Circuit Board. For this, you will study its construction and how it is connected to the battery and the rest of the product. Make sure you take pictures of everything that appears important.

You will reassemble the product, making note of the difficulty level to assemble and disassemble. You will try to understand the reason behind every mechanical feature you observe and you will determine if anything can be modified and improved in the product either by making the product stronger or lighter. You will discuss the tradeoffs of making a product lighter vs. stronger.

Deliverables:

You will prepare a detailed powerpoint presentation detailing the parts that assemble to the finished product and its stackup in the z-direction. You will present your findings to the rest of the class as a group.

You will complement the presentation with a list of features you believe are necessary for the integrity of the product, a list of features that could be eliminated from the product, and a list of potential failure modes in the product.

If you have time, you will stress test your product using our new High Speed Video Camera, by subjecting the product to a series of drop tests and observing detailed deformations during impact. This should shed some light to the various mechanical features integrated in the product, or where the product needs improvement.

Submitted by: Roberto Cammino
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MMAE 100 – Intro to the Profession – Mechanical and Aerospace Engineering Track

Simple Method to Calculate Low Speed Drag on a Round Object

Objective:

In this module, you will be provided with a slingshot, a small foam ball, some weights, and measuring tape. The goal is to determine the drag co-efficient in a round object flying at low speeds. You will first calibrate the spring in the slingshot to obtain the slingshot's force vs. stretch curve. You will use the energy approach to determine the expected exit velocity for a ball shot from a certain stretch of the slingshot. You will measure the distance the ball travels in a projectile motion path and use this information together with the height at which the ball is shot, in order to obtain the drag effect on the ball. You will use the High Speed Video Camera to measure gravity and prove it is close to 9.8m/s^2.

Procedure:

1) Using the High Speed Video Camera, set up a basic experiment where you drop an object from a certain height and record the event. The timer on the camera will allow you to measure the drop time from beginning to end. Allow the object to drop vertically. Using basic dynamics equations and given the drop height and the time of drop, you can estimate the gravitational constant, expected to be 9.8m/m^s

2) Using weights and a linear measuring device, calibrate your slingshot. Prepare a curve of slingshot spring stretch vs. weights added and plot it using Newtons for force in the y-axis and (m) for stretch distance in the x-axis. The area under the curve will allow you to obtain the slingshot

energy that will be transferred to the ball and holder, for certain stretches that you will release the slingshot from in order to fire the ball. Use an energy balance to estimate the ball exit velocity from the holder of the slingshot.

$$Energy = \frac{1}{2} m v^2$$

Where

m is the mass of the ball and the holder

v is the velocity of the ball

3) Position the slingshot as horizontally as possible, so that you can fire the ball. Chalk the ball before you fire it, so that you can determine where it lands. Pick a slingshot stretch that is within your calibration limit, so you can always determine the energy that will be imparted on the ball. Fire about 5 times and measure the travel distance after every shot. You will notice that the ball travels less than expected from equations that do not include drag force. The travel time can be determined by knowing the launch height and gravity, just like you did in the High Speed Video experiment above.
4) Now, relate the ball exit velocity, the travel time and the Range of flight to the Drag Coefficient using the equation below. This is coming from a force balance for a ball in flight assuming the drag force is a Constant (the drag co-efficient) multiplied by the velocity of the ball squared.

$$R = \frac{m}{C} \times LN\left\{\frac{C}{m}t + \frac{1}{Ve}\right\} - \frac{m}{C} \times LN\left\{\frac{1}{Ve}\right\}$$

Where:

Ve is the exit velocity of the ball from the holder calculated from the energy equation above

t is flight time,

m is the mass of the ball

C is the drag co-efficient.

The nonlinear equation above must be plotted in order to find C.

Deliverables:

You will prepare a detailed powerpoint presentation detailing the various experimental portions going from the procedure to carry out the experiment to the end results for each section of the experiment.

You will show pictures of your experimental setup and data collected.

You will show equations used and how they allow you to achieve your final results.

You will present to the class as a group.

Submitted by: Anthony Svozil
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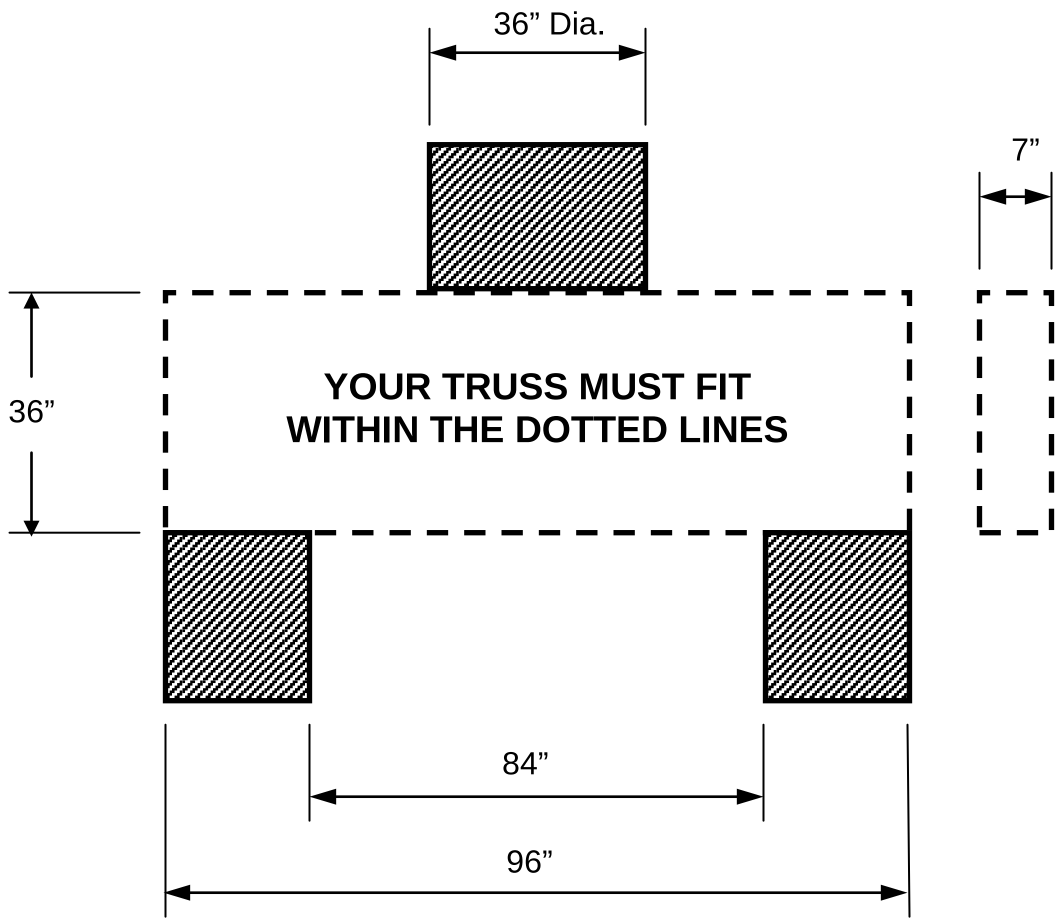
Honors College Engineering
Forces and Structures
2012/2013

Truss Project

Objective: To design and construct the lightest truss to hold the greatest weight.

Materials: 2” × 4” × 8’–0” pieces of wood.
No. 8 × 3” wood screws
1’–6” × 4’–2” sheet of rosin paper for template material.

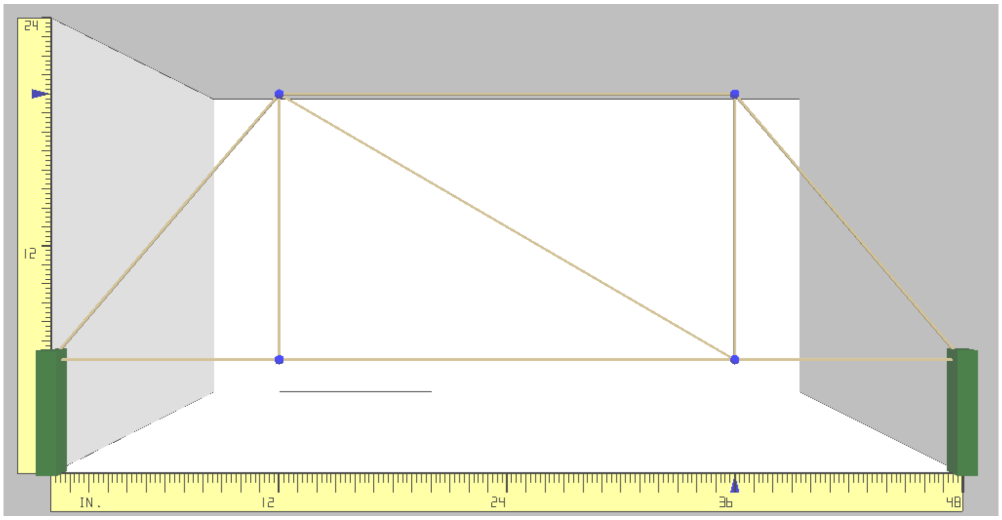
Specifications: See the drawing below.



- Glue, of any type, is not allowed.
- Pre-drilling of screw holes is not allowed.

Design Procedure:

- Design a simple truss in ModelSmart3D. Since the ModelSmart3D maximum material size is 1/2" × 1/2" and your truss material is 1 1/2" × 3 1/2", the program can only give you direction in making improvements to your design.



- Once you are satisfied with the design. Draw an accurate **one-half scale** plan of your truss on a sheet of rosin paper. Instead of 2" × 4"s, you are dealing with 3/4" × 1 3/4"s on your template.

- If you choose not to construct a truss 7" wide, a double truss, the minimum thickness of your truss must be 3 1/2".

- Produce a cutting list. The list will include the cut lengths of the truss members and indicate any cuts at angles. **No angle can exceed 45° from the normal.**

Schedule:

Complete Template and Cutting List	10/12
Cutting List and Material to Applied Academics	10/15
Cut Material Returned	10/19
Check Material	10/19
Begin Construction	10/23
Finish Construction	10/24
Load Completed Trusses into Van	10/26
Field Trip to U. of I.	10/29

Grading: Grades will be based on design efficiency.

$$\frac{Weight\ Supported}{Weight\ of\ Truss} \times 100 = Efficiency$$

Place	Points	Place	Points
1 st.	80	7 th.	68
2 nd.	78	8 th.	66
3 rd.	76	9 th.	64
4 th.	74	10 th.	62
5 th.	72	11 th.	60
6 th.	70		

Post-activity: Engineering memo detailing your design, test performance, possible design changes given test performance, etc.

Lego Mindstorms NXT Soccer Shoot Out

Submitted by: Carlotta Berry
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ECE 160
Design Project Overview
Fall 2009

Project Description:
The Moore Organization, a division of Voltmerguson Enterprises (MOVE), has oversight of The NXT Soccer Tournament. MOVE is soliciting your team's professional expertise in the design and construction of a *system* for entry into the competition.

Your team is required to design and construct a zero tailpipe emission robot that will execute the requirements of NXT Soccer Shoot-Out Tournament in a superior manner. The tournament playing field consists of a planar surface on which a scaled soccer pitch has been constructed. Your *system* must be designed to operate both as a defender of the goal and as an offender during each round of the double elimination competition.
The project specifications and contest rules have been sent out to many well-qualified and motivated teams. Will your team show its superiority in the competition by capturing one of the coveted awards?

Project Competition:
A project competition, "***NXT Soccer Shoot Out II***", will be held on Wednesday, 4 November, starting at ~~17:30~~ 19:00 in the Branam Arena (aka, the Kahn Room of the Hulman Memorial Union). Each team will show off their design to the amazement of their peers. Competition results do not impact your course grade, attendance at the competition is mandatory. The class period following the competition (Thursday, 5 November, or Friday, 6 November) will be canceled to account for attendance at the competition.

Project Award Categories:

1. "Ruler of the Pitch" Award - Overall Tournament Winner;
2. Designer Award - Most creative/elegant successful solution (chosen by students and officials);
3. "Stormy" Award - Most theatrical solution (chosen by audience)
4. "Goals of Berry" Award – Highest total tournament score
5. "Keeper" Award – Lowest average goals scored per game by opponents

Product Design Specification, Version 1.0, 14 September 2009
Version 2.0, 18 September 2009

The requirements placed upon the *system* are as follows:

General Requirements:

1. The *system* shall be designed to perform on the competition surface as is shown in Figure 1 under the Competition Surface section.
2. The *system* shall be constructed only from Lego pieces included in the provided kits as listed in the kit inventory, one additional light sensor, and one Wiimote.
3. The *system* shall have a footprint no greater than 12” x 12” while in the stationary starting configuration (location where the *system* will be located when the competition clock starts). A frame will placed around the *system*, with soccer balls (SBs) loaded, during the match set-up period preceding each match and subsequent shoot-outs to verify footprint compliance. No changes in the configuration may be made by any physical contact or wireless communication after the footprint check has been completed and before the competition clock has started.
4. The *system* shall be designed to operate for the entire match without any reconstruction/reconfiguration by physical contact with the *system*. Programming (software) adjustments may be made during halftime.
5. The *system* shall not damage the competition surface or any (SBs). SBs are standard ping pong balls with a nominal diameter of 40 mm.
6. The *system* shall be designed to operate without any physical contact (this includes wired connections) during each half of the competition. The Wiimote may be used to control the *system*.

C*ommunic*ation/Programming requirements:

7. The *system* shall be programmed in NXT-G (the drag and drop language supplied by Lego) or other appropriate programming language selected by each team. Any programming language/operating system software used must be available to all students at no cost, freeware, or available through existing Rose-Hulman licenses.
8. The Wiimote may be used to communicate with/control only your team’s NXT within the Bluetooth capabilities of the Wiimote. The Wiimote Bluetooth controller may not be positioned within or over the competition surface during the competition. The laptop may be used only as a wireless communication node between the Wiimote and the NXT. The laptop will be placed on the surface adjacent to the competition surface during the team’s competition. The laptop keyboard may not be used during the competition once the competition clock has been started.
9. The *system* shall communicate with external devices (team laptop and/or Wiimote) via Bluetooth or wired connection during the set up period before each half but only via Bluetooth during the competition.

Competition Rules

10. The *system* shall be defined to be that device constructed by the team to perform the designated tasks.
    a. The *system* shall not include a computer, infrared port or external wires, or any part of the competition surface.
    b. The *system* shall include the constructed device and any software loaded into the NXT.
11. The competition will consist of a double elimination tournament. Each match will consist of a 1 minute setup period, a first half, a 1 minute halftime, and a second half. Each half will end when the pitch is cleared of all SBs ~~have been shot~~ or 2 minutes after the start, whichever occurs first.
12. The tournament seeding will be based on the results of the **dry run** (conducted on class day 15).
13. Each team will be provided with 10 SBs during the setup period before each half. The SBs may be loaded into the *system* or placed on the team's half of the pitch surface ~~may be loaded~~ during the setup period. SBs not loaded must be placed in the designated SB storage area located on the table side holding the laptops. SBs may **NOT** be loaded during competition
14. During the 1 minute setup period before each half, the *system* may be programmed/reprogrammed and SBs loaded.
15. The *system* may be started from any point between the midfield line and the goal being defended.
16. The *system* shall be designed and operated such that the goal (Figure 1) must be completely unblocked at least once every 5 seconds. Unblocked time must be readily observable by the officials. Failure to meet this rule will result in a "**yellow card**" penalty for each infraction. The right rectangular cylinder 12" wide by 6" high extending from the frame of the goal to the midfield line.
17. There is no minimum time between shots.
18. No parts may be added to or removed from the *system* during the match.
19. Parts that become detached from the *system* during the match must be removed by the *system's* "owner". Any detached part not removed that is struck by an opponent's SB will result in a "**yellow card**" penalty against the part's "owner" for each infraction. The same "**yellow card**" penalty will apply if a team member removing the part is struck by an opponent's SB. Detached part(s) may be reattached during subsequent set-up periods or between matches.
20. SBs shot-but-not-scored may **NOT** be removed until the completion of the half. No penalty will be assessed if opposing team SBs come in contact with each other.
21. Teams will be assigned an end of the pitch by the officials for the first half. The teams will change ends for the second half of the match.
22. No part of the~~The~~ *system* shall not cross the vertical midfield plane during the competition. A "**red card**" (DQ) penalty will be assessed immediately if the *system* crosses the midfield line.

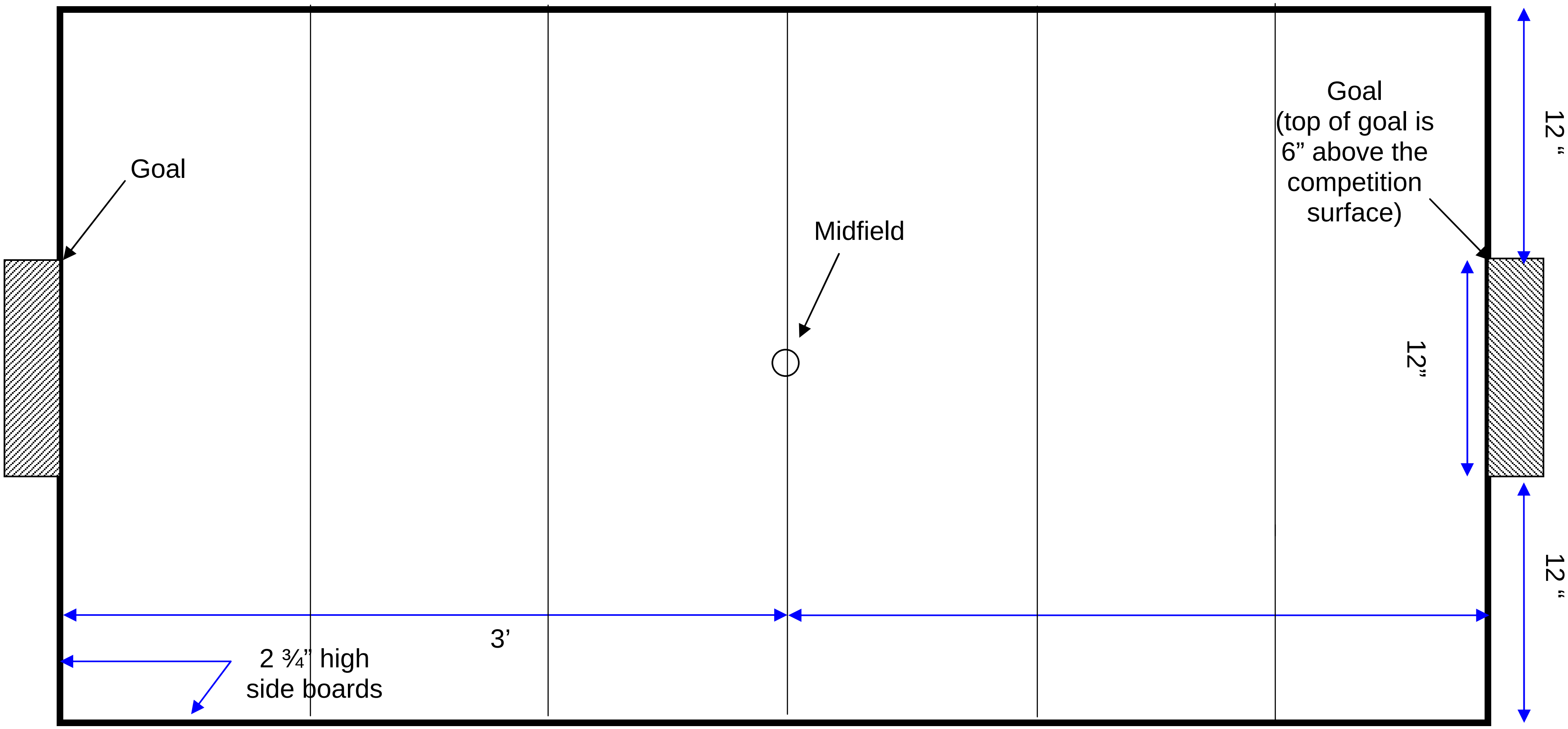
Scoring Rules

23. All SBs in ~~the~~ each net at the end of the half will be scored as 1 point each. The total score will be the sum of SBs scored for each half.
24. Each "yellow card" penalty will result in one shot on an undefended goal, immediately following the conclusion of the second half, by the match opponent. All "yellow card" penalty shots will be completed by one team before the other completes any of their penalty shots. The penalty shot order of teams will be assigned by the officials. Each successful penalty shot will be scored as 1 point. SBs will be provided for penalty shots. The officials will assign the goal to be used for all penalty shots. Penalty shots may be taken from any location as long as the *system* does not cross the midfiled line into the pitch half containing the assigned goal.
25. The final score for the match will be the sum of the total from match play (# 23) and any successful penalty shots (# 24). The team with the highest total is the winner of the match.
26. A recheck of the *system* footprint (no greater than 12" x 12") while in the stationary starting configuration (location where the *system* will be located when the shoot-out begins) will be conducted. No changes in the configuration may be made by any physical contact or wireless communication after the footprint check has been completed and before the shoot out begins.
27. NO Programming or *system* adjustments may be made prior to the sudden death and the angled shoot-out rounds. Parts that became detached during the previous competition must be replaced.
28. A sudden death shoot-out from midfield on an undefended goal will be conducted immediately after a tied match. Each team will be provided 3 SB's for the sudden death shoot-out. The shoot-out order of the teams will be determined by the officials. The team with the highest score in the sudden death shoot-out is the winner of the match.
29. A tied match after a sudden death shoot-out will result in an angled shoot-out. An angled shoot-out will be conducted by placing one team's *system* on the right outside edge of the midfield line and one team's *system* on the left outside edge. The side for each *system* will be determined by the officials.
30. The angled shoot-out will start at the referee's signal and will conclude when a goal is scored or 2 minutes have elapsed. The team that scores first in the angled shoot-out is the winner of the match.
31. The winner of a match that is tied after an angled shoot out will be determined as the team with the fewest "yellow card" penalties. A roll of the die will determine the winner if equal "yellow card" penalties exists.

Competition Surface

The competition will be held on a fixed operating surface. The competition surface is shown in Figure 1. The competition surface will be provided for practice during the project design and construction phase. The competition surface will be flat black. All lines will be solid white of ½″ width. .

Figure 1: Competition Field Layout



Materials

1. Student teams shall use only the parts provided by the ECE Stockroom (1 Lego Mindstorm NXT kits as listed in the kit inventory, one additional light sensor, and one Wiimote) in constructing and operating their *system*.
2. No additional parts shall be added to the inventory received from the ECE Stockroom without prior written approval by the ECE160 faculty.
3. Parts shall not be traded between teams.
4. Students shall not modify the kits or parts provided.
5. Students shall return the Lego Mindstorm NXT kits as listed in the kit inventory, one additional light sensor, and one Wiimote with all items accounted for at the final presentation session held during Finals Week.

Other Requirements

1. Students shall participate in teams for this project.
2. Each team member shall participate equally in the project work.
3. Each team member shall receive a grade on the project based upon the entire team's work as well as their individual work.
4. Students shall respect the creativity of others.
5. Students shall in no way interfere with another team's project work or interfere with another team during the competition.

Judging

1. Teams shall ask instructors for rule interpretations in a timely fashion. Requests for rule interpretations made after 09:50, 30 October may be rejected.
2. Officials shall be provided by MOVE and the ECE Department.
3. The decision of the officials shall be final.

Lego Mindstorms NXT Spiel-N-Spell Tournament

Submitted by: Carlotta Berry
Rose –Hulman Institute of Technology
berry123@rose-hulman.edu

ECE 160

Design Project Overview

Fall – 2011

Project Description:

Throne, Ltd., a division of Voltmooreguson Enterprises, has oversight of the NXT Spiel-n-Spell Tournament. Throne, Ltd., is soliciting your team's professional expertise in the design and construction of a *system* for entry into the Tournament.

Your team is required to design and construct a robot that will execute the requirements for the **Spiel-n-Spell Tournament** in a superior manner. The tournament playing field consists of a planar surface on which 42 blocks are located. Your *system* must be designed to collect the blocks and form them in a "free form" scrabble-type layout.

The project specifications and contest rules have been sent out to many well-qualified and motivated teams. Will your team show its superiority in the competition by capturing one of the coveted awards?

Project Competition:

A project competition, "**Spiel-n-Spell Tournament**", will be held starting at 17:30 on Wednesday, 2 November in the Kahn Arena (aka, the Kahn Rooms of the Hulman Memorial Union). Each team will show off their design to the amazement of their peers. Competition results do not impact your course grade, attendance at the competition is mandatory. Any conflicts, other than illness, must be discussed with, and approved by, your instructors before the dry run scheduled for 24/25 October. The class period following the competition (Thursday/Friday, 3/4 November) will be canceled to account for attendance at the competition.

Project Award Categories:

1. "**Speller Supreme**" Award - Overall Tournament Winner;
2. "**Designe**r" Award - Most creative/elegant successful solution (chosen by students and officials);
3. "**Stormy**" Award - Most theatrical solution (chosen by audience)
4. "**Team Spirit**" Award – Most "spirited" team

Product Design Specification, Version 2.0, 15 September 2011
~~**Product Design Specification, Version 1.0, 12 September 2011**~~

The requirements placed upon the *system* are as follows:

General Requirements:

1. The *system* shall be designed to perform on the competition surface as is shown in Figure 1 under the Competition Surface section.
2. The *system* shall be constructed only from Lego pieces included in the provided kit as listed in the kit inventory; one additional light sensor may be requested by each team; two (2) meters of orange string may be requested at the ECE stockroom by each team. One Wiimote and a team member laptop will be allowed to be used as control devices for the *system* but are not considered a part of the *system*.
3. The *system* shall be designed to operate for the entire match without any reconstruction/reconfiguration by physical contact with the *system* by any team member.
4. The *system* shall not damage the competition surface or any block.
5. The *system* shall be designed to operate without any physical contact (this includes wired connections) during each match of the tournament. The Wiimote and team member laptop may be used to control the *system* as long as there is no physical contact during the match. All controlling devices must be operated by the same team member during the entire match.

Communication/Programming requirements:

6. The *system* shall be programmed in NXT-G (the drag and drop language supplied by Lego) or other appropriate programming language selected by each team. Any programming language/operating system software used must be available to all students at no cost, freeware, or available through existing Rose-Hulman licenses. All teams using any software other than NXT-G must provide information for acquiring the software to the instructor (who will publicize this to all teams.)
7. The Wiimote and/or laptop (control devices) may be used to communicate with/control only your team's NXT within the wireless capabilities of the control devices. The control devices may not be positioned within, over, or under the competition surface during the match. The laptop may be placed on the surface adjacent to the competition surface during the team's competition.
8. The *system* may communicate with the control devices via wireless or wired connection during the set up period before each match, but only via wireless communication channels during the match.

Competition Rules

9. The *system* shall be defined to be that device constructed by the team to perform the designated tasks.
    a. The *system* shall not include a computer, infrared port or external wires, or any part of the competition surface.
    b. The *system* shall include the constructed device and any software loaded into the NXT.

c. All components of the system must remain connected to all other parts of the system during the match by parts supplied in the Lego kits.

10. The competition will consist of a paired match tournament. Each match will consist of a 1 minute setup period followed by a match lasting up to 3 minutes. The match will end 3 minutes after the setup period, when all EPs have been placed, or when both *systems* have stopped responding, whichever occurs first.
11. The seeding for the first round of the tournament will be based upon the **dry run** (conducted on class day 15, 24/25 October).
12. Forty two (42) lettered blocks will be placed by the officials during the setup time in the pre-defined locations on the competition board. The blocks will be located as shown in Figure 1. All blocks are 1 ¾" cubes with a mass of 35 g. Any block that drops from the competition surface during a match cannot be returned to the competition surface and will not be scored.
13. During the 1 minute setup period the *system* may be programmed/reprogrammed.
14. The *system* may be started from any point on the assigned side of the competition surface. No part of the *system* may extend across the center divider onto or above the other team's competition surface. Additionally, no part of the *system* may contact any of the blocks prior to the competition during the setup time.
15. No parts may be added to or removed from the *system* during the match.
16. If parts become detached from the *system* during the match they may not be removed from the competition surface until the conclusion of the match. Detached part(s) may be reattached during subsequent setup periods or between matches.

Scoring Rules

17. The letter blocks will be placed along all 4 sides of the competition surface prior to each match in the locations shown in Figure 1. The colored capital letter side of each block will be facing upward with the top of the letter against the wall. The inventory of blocks showing color and number of each letter block is shown in Table 1 below.

Table 1 – Inventory of Letter Blocks

A	2	E	2	I	2	M	2	Q	1	U	2	Y	1
B	2	F	1	J	1	N	2	R	2	V	1	Z	1
C	2	G	1	K	1	O	3	S	2	W	1		
D	2	H	1	L	2	P	2	T	2	X	1		

18. The *system* may place the letter blocks anywhere within the competition surface to spell words in a scrabble-like fashion. The words may be arranged with any x-y orientation; perpendicular words will share common letter blocks. All letter-faces must face upwards and be properly oriented for words to score. Only capital letters can be used for words to score.
19. Blocks must be placed contiguously with previously placed blocks in order for words to score points. Blocks can form words that score if they are
    a. no more than 30^o from orientation of adjacent letters,
    b. no more than ½" from alignment with adjacent letters, and
    c. no more than ½" gap from adjacent letters.
20. Valid English words must be in the Merriam-Webster Online Dictionary and two (2) or more letters in length. Proper names are not valid. No points will be awarded for the

letters within incomplete or invalid words. Words formed during the match but later contained within longer words or inadvertently moved during the match are not valid; words are determined at the close of each match.

21. Points will be awarded based upon the length of words and colors of letters. Bonus points will be awarded for words formed using only a single color of letters.
22. The score will be determined at the end of each match as follows:
    a. Letter scores are awarded based upon the number of letters on the table used in valid words as $\boldsymbol{LetterScore} = \sum \#\boldsymbol{Letters}$.
    b. Word scores are awarded based upon the number of letters in each valid word according to $\boldsymbol{WordScore} = \boldsymbol{2^N - 1}$ where N is the number of letters in the word; the total word score is the sum of scores for all valid words.
    c. A bonus of 25 points will be awarded for each valid word that is composed only of letters of the same color.
23. The total team score for a match will be the sum of points scored by methods # 22 a-c.
24. The first two rounds of competition will serve as qualifying rounds. The first round of competition will take place during the class preceding the competition (Monday, 31 October or Tuesday, 1 November.) The second round will take place during the competition beginning at 5:30 PM on Wednesday, 2 November.
25. The seeding for the second round of the competition will be based on the points scored in the first round with the highest two teams competing on the same table, the 3rd and 4th highest on the same table, etc.
26. The 8 teams with the highest cumulative score~~s~~ (round 1 plus round 2 scores) will move on to round 3 (quarterfinals) with the same seeding process as described in # 25.
27. Cumulative scores for all teams entering the third round will be reset to zero.
28. The 4 teams with the highest scores from round 3 will move on to round 4 (semifinals) with the same seeding process as described in # 25.
29. Cumulative scores for all teams entering the fourth round will be reset to zero.
30. The 2 teams with the highest cumulative scores from round 4 will move on to round 5 (finals) with the same seeding process as described in # 25.
31. Cumulative scores for the two teams entering the final round will be reset to zero.
32. A 1 minute tie breaker will be held immediately after the finals if both teams at the end of the finals have identical scores. The cumulative score for the quarter, semi, and final rounds will be used to determine the winner if the scores are equal in the 1 minute tie breaker. A roll of a die will be used to determine the winner if the cumulative scores are equal after considering the cumulative scores of rounds 3, 4, and 5.

Competition Surface

The competition will be held on a fixed operating surface. The competition surface is shown in Figure 1. The competition surface will be provided for practice during the project design and construction phase. The competition surface will be flat black.

Materials

1. Student teams shall use only the parts provided by the ECE Stockroom (Lego pieces included in the provided kit as listed in the kit inventory and one additional light sensor) in constructing their *system*. One Wiimote and a team member laptop will be allowed

to be used as control devices for the *system* but are not considered a part of the *system.*
2. No additional parts shall be added to the inventory received from the ECE Stockroom without prior written approval by the ECE160 faculty.
3. Parts shall not be traded between teams.
4. Students shall not modify the kit or parts provided.
5. Students shall return the Lego NXT kit as listed in the kit inventory and all additional parts supplied with all items accounted for one day before the final presentation session held during Finals Week.

Other Requirements

1. All students shall participate with their team in the competition.
2. All students shall participate with their team in the design process for this project.
3. All team members shall participate equally in the project work.
4. All team members shall receive a grade on the project based upon the entire team's work as well as their individual work.
5. Students shall respect the creativity of others.
6. Students shall in no way interfere with another team's project work or interfere with another team during the competition.

Judging

1. Teams shall ask instructors for rule interpretations in a timely fashion. Requests for rule interpretations made after 17:10, 26 October may be rejected.
2. Officials shall be provided by Throne, Ltd., and the ECE Department.
3. The decision of the officials shall be final. Decisions may be challenged for factual or interpretive errors; but, the officials have the final decision on the validity of challenges.

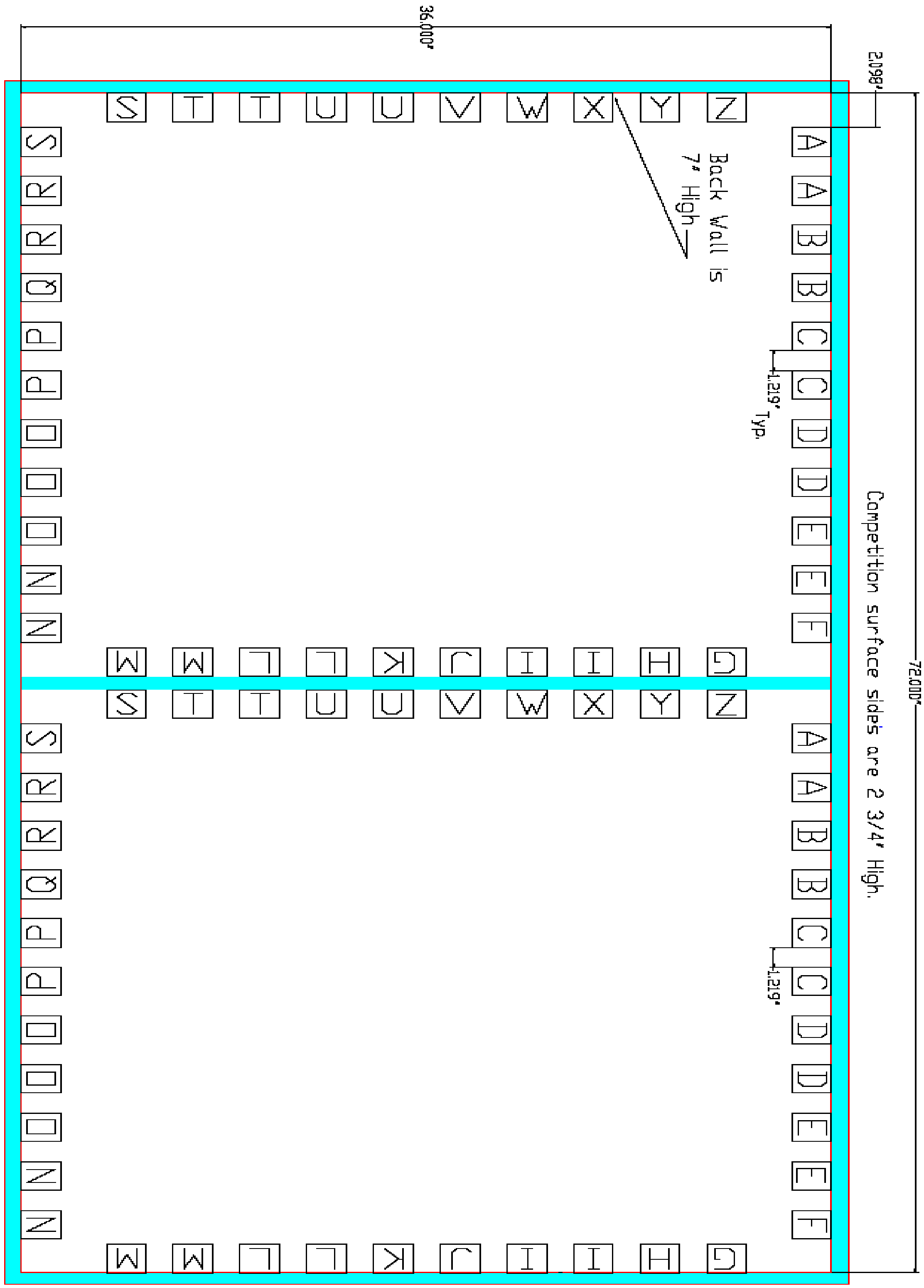


Figure 1 – Spiel-n-Spell Tournament Competition Surface

Lego Mindstorms NXT
The Third Task

Submitted by: Carlotta Berry
Rose –Hulman Institute of Technology
berry123@rose-hulman.edu

ECE 160
Design Project Overview
Fall 2008-09

Project Description:
The Moore Organization, a division of Voltmerguson Enterprises (MOVE), has oversight of The Third Task of the Try-Wits Tournament. MOVE is soliciting your team's professional expertise in the design and construction of a *system* for entry into the competition.

Your team is required to design and construct a zero-emission, autonomous robot that will execute the requirements of THE THIRD TASK in a superior manner. The tournament playing field consists of a planar surface on which a complex maze and several secure vaults are located[1]. Your robot must retrieve valuable Gems of Berry (GBs) from the maze and deliver them to the secure vaults (SVs). Treasures of significance can be accumulated by collecting more cherished GBs and delivering them to more secure SVs.

The project specifications and contest rules have been sent out to many well-qualified and motivated teams. Will your team show its superiority in the competition by capturing the coveted Gems of Berry Award?

Project Competition:
A project competition, "***The Third Task***", will be held on Wednesday, 5 November, starting at 5:30 pm in the Jakubowski Arena (aka, the Kahn Room of the Hulman Memorial Union). Each team will show off their design to the amazement of their peers. Performance at the competition does not impact your course grade. Attendance at the competition is mandatory. The preceding class period (Monday, 3 November, or Tuesday, 4 November) will be canceled to account for attendance at the competition.

Project Award Categories:
1. Gems of Berry Award - Best overall performance ranking (highest score);
2. Designer Award - Most creative/elegant successful solution (chosen by students and judges);
3. "Stormy Award" - Most theatrical solution (chosen by audience)

.

[1] The plane is known as the A-maze-ing Complex Plane.

Product Design Specification, Version 1.0, 18 September 2008
Version 2.0, 19 September 2008
Version 3.0, 23 September 2008
Version 4.0 2 October 2008
Version 5.0 21 October 2008

The requirements placed upon the *system* are as follows:

General Requirements:

1. The *system* shall be designed to perform on the competition surface (within the outer sides) as is shown in Figure 2 under the Competition Surface section.
2. The *system* shall be constructed only from Lego pieces included in the provided kit and listed in the kit inventory.
3. The *system* shall operate completely autonomous (no physical human or laptop or desktop computer contact with the *system*) once a competition run has started. Physical contact is defined as touching either directly or indirectly, the only exception is through Bluetooth communication.
4. Wiimote may be used to communicate with/control only your team's NXT within the Bluetooth capabilities of the Wiimote. The Wiimote Bluetooth controller ~~(laptop or Wiimote)~~ may not be positioned within or over the competition surface during the competition time. The laptop may be used only as a communication node between the wiimote and the NXT. The laptop will be placed on a table adjacent to the competition surface during the team's competition. The laptop keyboard may not used once the competition clock has been started.
5. The *system* shall be programmed in NXT-G (the drag and drop language supplied by Lego) or other appropriate programming language selected by each team. Any programming language/operating system software used must be:
   a. available to all students and
   b. be freeware or available through existing Rose-Hulman licenses.
6. The *system* shall collect GBs (ping-pong balls) from any of four (4) locations (aka, GBsites) within the maze.
7. The *system* shall deliver GBs to any of three (3) SVs.
8. The *system* shall not damage the competition surface or any GBs.

Communication requirements:

9. The *system* shall communicate with external devices (team laptop and/or Wiimote) via Bluetooth or wired connection during the set up time but only via Bluetooth Wiimote during competition.

Competition Rules

10. The competition *system* shall be understood to be that device constructed by the team to perform the designated tasks.
    a. The *system* shall not include the computer, infrared port or wires, or any part of the competition surface.
    b. The *system* shall include the constructed device and any software loaded into the NXT.

   c. The *system* may consist of multiple components either connected to or disconnected from the NXT as long as items 1 and 2 under General Requirements are not violated.
11. The competition surface shall not be modified or damaged in any way during practice or competition.
12. The competition will consist of two (2) rounds. Each round will consist of up to 60 seconds duration setup time and 180 seconds duration run time.
13. A setup period of up to 60 seconds will be allowed at the start of each competition run. During this time the device will be readied for competition.
14. The *system* may be started from any point on the competition surface within the SV region chosen by the student team. No portion of the *system* may extend outside the SV area before the start of the competition clock.
15. At the completion of the setup period (and prior to the roll of the die), the *system* will be activated by the team but may not move before the 180 second competition clock is started by the judge.
16. A roll of a die at the completion of the setup time will establish the data set (1-5) that sets the point values for the GBs at each GBsite. If the die reads blank, the team can choose which data set (1-5) to use.
17. The roll of the die indicates the GBsite for 5 point, 3 point, 1 point GBs as follows:
    Roll = 1 -- Code = 123
    Roll = 2 -- Code = 412
    Roll = 3 -- Code = 231
    Roll = 4 -- Code = 431
    Roll = 5 -- Code = 243
    Roll = blank – Any code (1-5) is selected by the team.
18. Immediately following the roll of the die, tournament officials will place the GBs at the proper GBsites according to the code listed in item 17.
19. The competition time begins once the GBs are placed and tournament officials give a verbal starting signal.
20. Each GBsite will contain two (2) GBs located in dimples on the playing surface with a 2" center to center separation and touching the back wall of the GBsite.
21. The GBs will be white with small, dark, numeric symbols indicating their value.
22. The SVs have a security value (Secval) inversely related to the width of the SV, i.e., the narrowest SV has a Secval=5, the intermediate SV has a Secval=3 and the widest SV has a Secval=1.
23. The narrowest SV can hold two (2) GBs; the intermediate SV can hold four (4) GBs; the widest SV can hold ten (10) GBs.
24. The SVs are recessed below the competition surface.
25. ~~The intermediate SV will be emptied by an authorized referee following a deposition. Only the first two (2) GBs deposited in the narrowest SV and first four (4) GBs deposited in the intermediate SV will be scored. All GBs deposited in the widest SV will be scored.~~ GBs must remain at rest within the SV and not in contact with the *system* for at least 10 seconds in order to be scored.
26. The value of each GB delivered to an SV is calculated as the GBdel=GBval*Secval.
27. The total value of GBs delivered to an SV is the sum all GBdel within an SV as TreasureSVi=Sum(All GBdel) to the SV. For example, a GBval=5 delivered to an Secval=3 is worth 15 points.

28. Additional scoring can occur only if ALL non-zero point valued GBs have been successfully scored. Additional scoring occurs by successfully returning the GBs to their original GBsite. A successful GB return occurs when the GB is positioned on the original dimple and remains at rest and not in contact with the *system* for at least 10 seconds. GBs may scored only once by placement within an SV. No points are scored for return of a GB to other than the original GBsite.
29. The point value for each successfully returned GB is the same as the score for delivery of the GB to the SV, i.e., GBret=GBval*Secval. The total score for successfully returned GBs is TreasureRet=Sum(GBret).
30. <u>Scoring within a round of competition</u> will be calculated as the sum of the Treasures delivered to all of the SVs plus all of the treasures returned to the GBsites as: Round_Score=SUM(TreasureSVi)+SUM(TreasureRet).

31. At the completion of Round 1 competition, each team will choose one of the following 3 methods of scoring:
    a. The team's score for the competition will be the score of Round 1;
    b. The team's score for the competition will be the score of Round 2;
    c. The team's score for the competition will be the average of the scores of Round 1 and Round 2 multiplied by a factor of 1.2, i.e., (R1+R2)/2*1.2.
32. If scoring option *a* is chosen, the team will not compete in Round 2.
33. Modifications and adjustments may be made to the *system* between rounds. Recharging between rounds is allowed

Competition Surface

The competition will be held on a fixed operating surface. The competition surface is shown below. The competition surface will be provided for practice during the project design and construction phase. The background of the surface is flat black. White lines (of ½" width) connecting all of the GBs and SVs are provided on the surface; these are outlined by dashed green lines shown below. 1/4"x1/8" curbs are attached to the sides of the SVs as shown below.

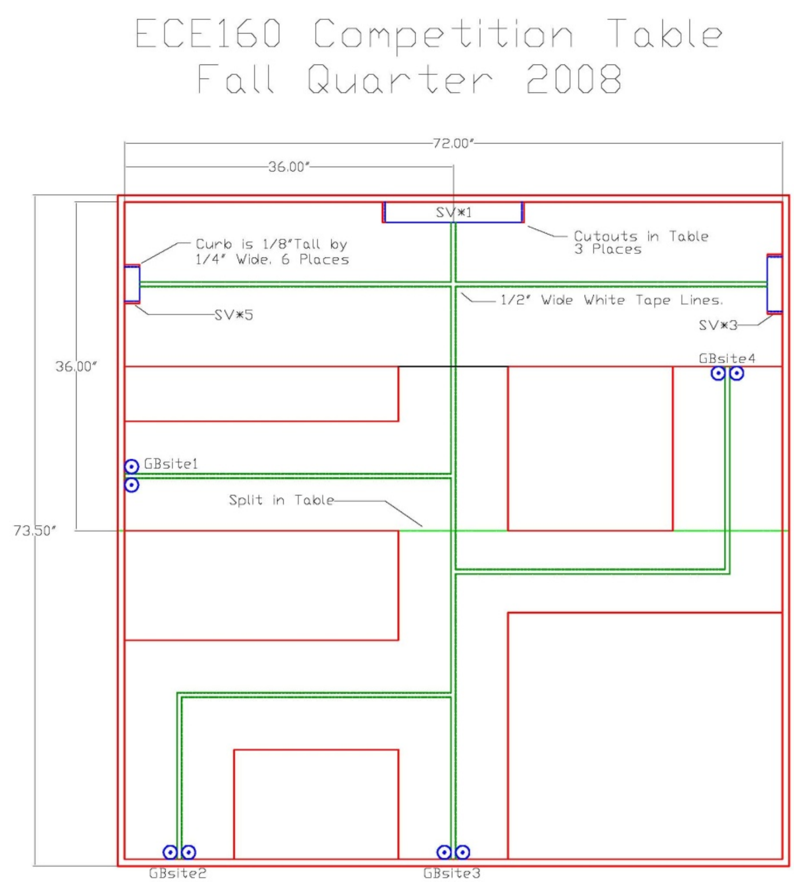


Figure 1 – Competition Board with Dimensions.

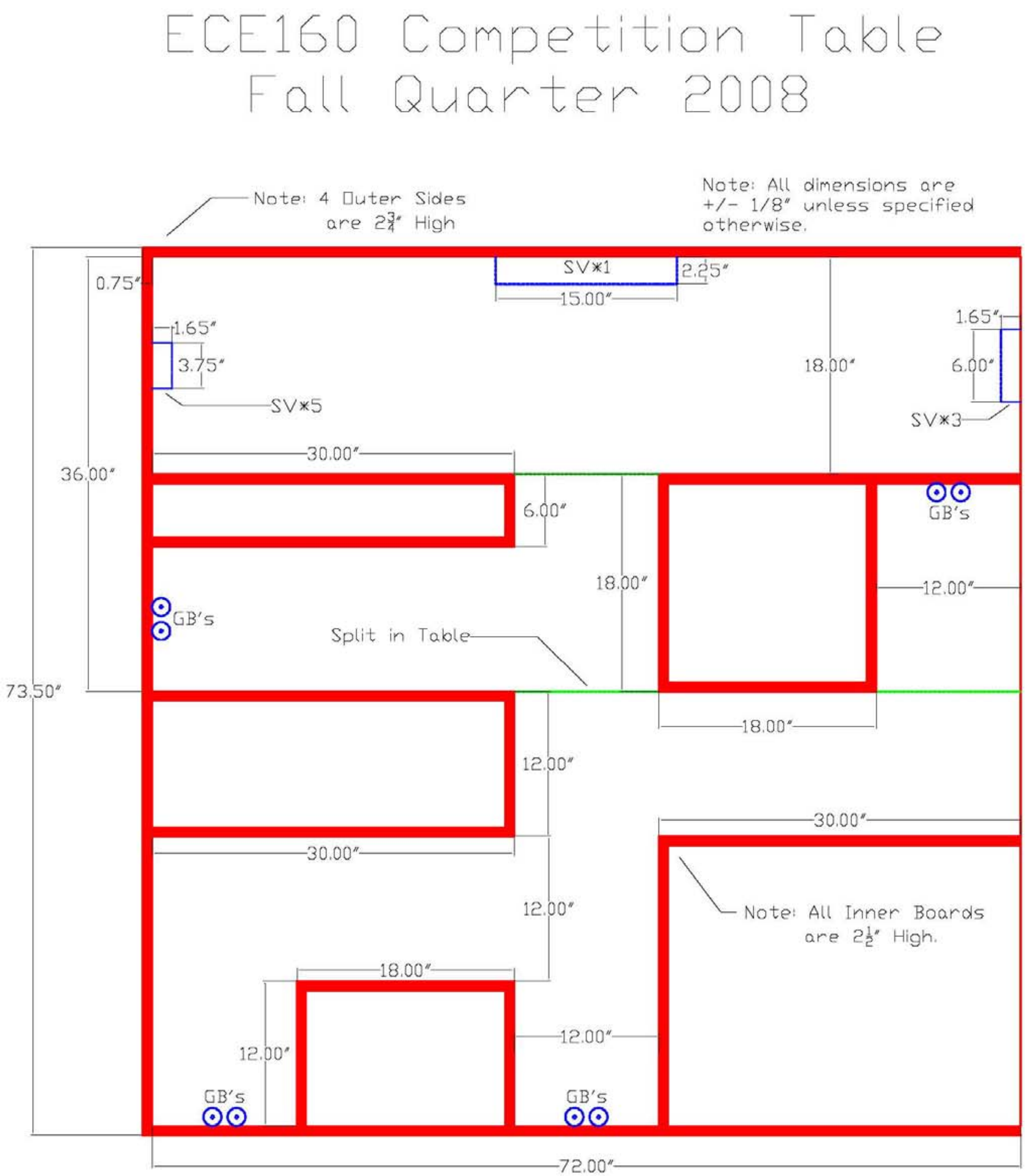


Figure 2 – Competition Board with Barriers, GBs, SVs, and Tape Layout.

Materials

1. Student teams shall use only the parts provided by the ECE Stockroom (1 Lego Mindstorm NXT kit) in constructing and operating their *system*.
2. No additional parts shall be added to the inventory received from the ECE Stockroom.
3. Parts shall not be traded between teams.
4. Students shall not modify the kits or parts provided.
5. Students shall return the Lego Mindstorm NXT kit with all pieces accounted for at the final presentation session held during Finals Week.

Other Requirements

1. Students shall participate in teams for this project.
2. Each team member shall participate equally in the project work.
3. Each team member shall receive a grade on the project based upon the entire team's work.
4. Students shall respect the creativity of others.
5. Students shall in no way interfere with another team's project work or interfere with another team during the competition.

Judging

1. Teams shall ask instructors for rule interpretations in a timely fashion.
2. Judges shall be provided by MOVE and the ECE Department.
3. The decision of the judges shall be final.

Submitted by: Jennifer Horner
University of Arizona
hornerj@email.arizona.edu

ENGR 102 Teambuilding Activity: The Marshmallow Challenge

Adapted from http://marshmallowchallenge.com/Welcome.html
(Time required: 60 – 75 minutes)

Supplies needed (per team):

- 20 sticks of spaghetti (uncooked)
- 1 yard of masking tape
- 1 yard of string
- Scissors
- 1 marshmallow (large, not small)
- A prize (only one needed – we often use a movie-sized package of Red Vines licorice)
- A tape measure (only one needed; for instructor use)

Instructions:

Tell the teams that they will have 18 minutes to build the tallest freestanding structure possible given the constraints of their materials.

Briefly explain the rules:

- The marshmallow must be the tallest point on your structure, and it must be in **one** piece
- You can break the spaghetti, string, or tape into pieces
- Your structure must be free-standing (self-supporting), but it can be secured at its lowest point only
- Once time runs out, no team member may touch any part of the tower until after measurement
- Your instructor and his/her trusted tape measure will determine the winning team and award prizes

Here is a helpful stopwatch application that can be used so that the instructor does not have to yell "TIME" to stop the teams from working: http://www.online-stopwatch.com/large-stopwatch/

After the eighteen minutes are up, measure the structures and award the prize.

Next, as a class, watch this excellent TED Talks video (approx. 6 minutes) that discusses the exercise and the nature of the collaboration as well as the meaning of the "marshmallow:" http://www.ted.com/talks/tom_wujec_build_a_tower.html

Finally, have each team reflect upon the activity and fill out the form on the next page.

Reflections on the Team Marshmallow Tower Project

Team Member Names (who are present today)

____

____

What went well on the project?

What didn't go well on the project?

Could participation have been improved? How?

Could leadership have been improved? How?

Could results have been improved? How?

Submitted by: Patty Mucino
Cal Poly Pomona
pjmucino@csupomona.edu

EGR 100 FINAL REFLECTION PROJECT

Prompt:
- What specific sections / topics were beneficial to you this year?
- How did they help you in your transition?
- Based on this, what advice would you give your "high school senior self", or the next generation that is currently in their senior year, and will be coming to CPP for engineering next year?

A quality project will meet the following criteria:
- **Creativity** in media/method of expression
- **Level of engagement:** Is this interesting for the class? Were you able to keep the class' attention during your presentation? Note: While everyone loves chocolate, use of candy and similar incentives should not be your method of maintaining class interest.
- ***Substantive*and *concrete*expression** of how material/concepts were integrated into your experience, actions, thoughts/perceptions, and the results that came from your using the strategies. Use of quality examples, analogies, etc. is only one of many ways this can be achieved.
- **Synthesis*:*** Presentations are expected to go beyond Recall, Understanding, and Analysis stages and should go into the Synthesis stage. Review ch. 3, page 116 – Synthesis is a hybrid of both "Evaluating" and "Creating" categories (ex: simply *stating* what sections helped you and what resulted is basic "Recall", and therefore is not sufficient).
- **Self-reflection**: this presentation is about you and your journey. Therefore, avoid using third person language (ex: do not use "you" and "your"…instead use "I", "me", etc.). Your classmates been given "advice" all quarter long – now it's time for you to talk about *yourself* and share *your* experiences in transitioning into college engineering.

Timing/Technical:
- **For the sake of time, presentations will be cut off at 3 minutes max.** There will be a 1 minute transition period between presentations.
- Please ensure that you know how to operate all equipment involved, that all technical equipment is working, etc. **Test your presentation before/after class prior to the day of the final.**

Progress report due on blackboard &presented (1-2 min.) on Monday, November 26th. Report needs to include:
1) Media/Method of delivery
2) Synopsis of project – what should we expect when we see your presentation?
3) Relevant sections included
4) Detailed timeline for completing the project (include testing the media on the classroom computer)

Submitted by: Timothy Cochran
Alfred State College
cochratj@alfredstate.edu

ELET 1001-01 Seminar (Wednesday)
Fall Semester 2011
Homework Assignment #8

Due at precisely 11:00 AM, October 19, 2011

The objective of this assignment is to assist you in gaining a respect for diversity and knowledge of contemporary professional, societal and global issues.

Research four areas of diversity in the engineering workplace of the future:

a) ethnic diversity in the engineering workplace

b) gender diversity in the engineering workplace

c) cultural diversity in the engineering workplace

d) global diversity issues in the engineering workplace

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Answer the six questions below, with a minimum of 500 words – not counting the page headers, each about 30 words - describing what you expect the workplace to look like in terms of the ethnic, gender and cultural backgrounds of your fellow professional employees when you enter in roughly two to four years. Be sure to address each question below with a separate paragraph. Indicate the question number but do not type the question. Use the word count feature in Microsoft Word and type the total number of words at the bottom of your paper.

1. Do you expect to be working with professionals from different ethnic, gender and cultural backgrounds than your own? List some statistics.

2. Are there advantages to working with people of different backgrounds? What are a few advantages? What can you learn?

3. Why will your understanding of people with ethnic, gender and cultural backgrounds, other than your own, be important in the workplace? What can you learn?

4. Why will it be an advantage to learn to respect and value people from different ethnic and cultural backgrounds?

5. Would you expect mastery of a foreign language to be an advantage in your career? What are some reasons for your answer?

6. If your workplace in the future were representative of society as a whole, what would be the

percentage of women employees?

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On the top of all pages put your name, the date and the six (6) line header that is at the top of this assignment sheet. STAPLE the pages together.

This is to be your own work. If the work you hand in resembles another student's work, both of you may receive negative credit.

Submitted by: Anita Singh, PhD
Rowan University
singh@rowan.edu

The Design of a Plate System for Posterior Spinal Fusion

PROJECT AIM:

The underlying goals of the proposed design should be to:

Provide the necessary motion restriction of the spine between adjacent vertebral levels comprising a spinal motion segment, in order to aid and promote a strong bony fusion capable of restoring spinal stability to a compromised spine.

Provide said motion restriction both for a single disc-level fusion as well as for a multiple disc level spinal fusion.

DESIGNING CRITERIA:

Functional Criteria	**Installation Criteria**
The proposed device must be strong enough to carry the loads it will experience in situ	Minimally invasive limiting the need for any access to the device
The proposed device must possess a fatigue life that is longer than the time needed for successful fusion	Removable if necessary
The proposed device must restore stability to the unstable spine	Specifically designed tool to ease and speed up installation
	Each plate must span the posterior elements of only two adjacent vertebral levels
	Hardware should be extendable in both the caudal and rostral directions at the time of insertion or at any later time point.

DELIVERABLES:

1. A prototype of the implant.
2. A written report (10 pages maximum) including the product name, design details and a sale flyer.
3. A powerpoint presentation (20 minutes) for the medical device implant companies detailing the product, its benefits and marketing strategies from engineering point of view.

The Autonomous Hovercraft Project

SUBMITTED BY: The Keystone Program
University of Maryland

Contact:
Kevin Calabro
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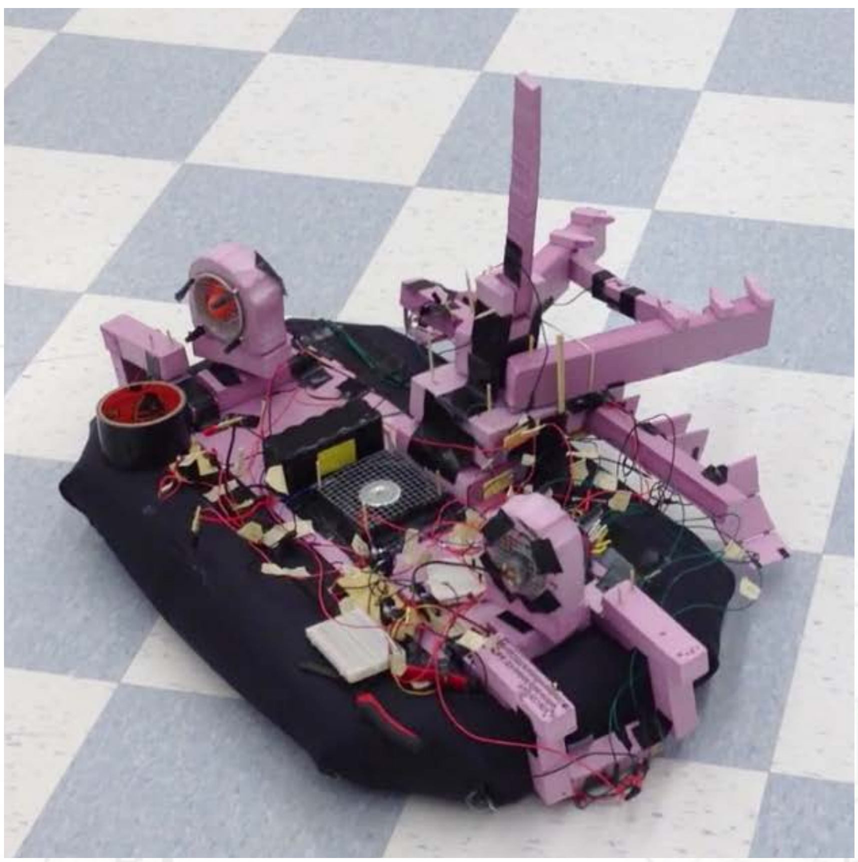
The autonomous hovercraft project is a required course for all first-year engineering students at the University of Maryland. This is a single semester design-build-test project that culminates in a final design competition between many unique alpha prototypes.



Product Development Contract

Overview

ENES 100 involves the design, construction and testing of an autonomous hovercraft capable of performing a timed overland payload navigation mission. This will require a semester-long, multidisciplinary team effort. The instructor will create teams of about 10 students with diverse backgrounds and skill sets. Each team will subsequently divide into sub-teams consisting of 2-4 students. Possible sub-teams required to complete this project could be: (1) structure, levitation and payload acquisition mechanism, (2) propulsion and power, and (3) sensors and control.

Development Constraints

The team must develop, build and test a hovercraft based on the Hovercraft Product Specifications Rev. A, 30 August 2012. Additionally, the team must meet the global product development milestone schedule provided below:

Milestone	Description	Due date
1	Product Development Plan Presentation	Sept. 24-25, 2012
2	Preliminary Design Presentation	Oct. 15-16, 2012
3	Preliminary Design Report	Oct. 17-18, 2012
4	Prototype Fabrication Start	Oct. 17-18, 2012
5	Preliminary Testing	Nov. 12-13, 2012
6	Final Testing	Dec. 5-6, 2012
7	Final Design Competition	Dec. 10, 2012
8	Final Design Report	Dec. 13-19, 2012
9	Final Design Presentation	Dec. 13-19, 2012

While electric fans and propellers are an obvious possibility for levitation and propulsion, alternative propulsion sources may be acceptable. It will be up to the instructor's discretion to determine if the chosen source meets the low noise/pollution requirements needed to compete indoors in the Kim Building rotunda.

I agree to the following rules of conduct for my ENES100 project. **I have read and understand this development contract and the hovercraft design specifications and I accept the terms of the class project.**

1) I agree that when subgroup meetings are created, all team members will be informed of the meeting time, location, and agenda. Any members that miss the meeting will be informed of the nature of the discussions and the resulting action items.
2) I agree to check for email from team members at least once a day.
3) I agree that if I miss a mandatory meeting, I will find out what happened and what my assigned tasks are. When possible, I will notify the team in advance of any absences.
4) I agree that everyone will take ownership for an equal portion of the work to be completed. I will provide my deliverables to the team on time. The tasks I undertake will be decided by consensus, and documented in the reports.

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Approved:________________________

Hovercraft Product Specifications
Rev. A, 30 August 2012

1. **Structure and levitation requirements**
   (a) Only the skirt (rigid or soft) may contact the ground when the levitation fan is powered and it may leave no residue.[1]
   (b) The use of lighter than air materials is prohibited.
   (c) Skirts must be fabricated in-house.

2. **Power and propulsion requirements**
   (a) The use of internal combustion engines (gas and glow fuel engines) is prohibited.
   (b) The use of lithium based battery technologies is prohibited.
   (c) The hovercraft must be able to levitate for at least 10 minutes without replenishing/recharging its energy source and without modulating the lift fans' power.
   (d) Moving parts of the propulsion system may not contact the ground or walls of the course.

3. **Sensor and control requirements**
   (a) The hovercraft must be controlled by an Arduino brand microcontroller.
   (b) The hovercraft operation during testing must be autonomous.[2]

4. **Payload requirements**
   (a) The hovercraft must locate and acquire the provided payload detailed in Fig. 2.
   (b) Modifications to the payload are prohibited.

5. **Safety requirements**
   (a) All fans must have protective fan guards to reduce the risk of bodily injury. The fan guards must prevent a 9 mm diameter dowel from penetrating the guard.
   (b) The use of pins and/or needles on your hovercraft is strictly prohibited.
   (c) All batteries must be charged using an appropriate smart charger that is in accordance with the battery manufacturer's recommended charging procedure.

6. **Cost requirements**
   (a) Total as-built replacement cost of the hovercraft must be less than $350.
   (b) The cost must be broken down in a Bill of Materials (BOM), in which the Fair Market Value (FMV) of each component must be listed.[3]

7. **Testing requirements**
   (a) The hovercraft must be capable of completing the mission detailed in Fig. 1 in less than 10 minutes.

8. **Product deliverables**
   (a) The Hovercraft.
   (b) The final oral presentation (PowerPoint slide file).
   (c) The final written design report which includes the final BOM, Gantt chart and all design drawings and schematics.

[1] Other parts of the hovercraft may contact the ground when the levitation fan is powered off.
[2] For testing purposes, power to the microcontroller and propulsion/levitation systems may be manually provided, but no further direct contact or remote control is permitted.
[3] Cost is calculated by adding the FMV of all components used during final testing on the hovercraft. There is no cost for the provided payload. Cost does not include shipping costs or costs for parts that were bought but later discarded/returned. Costs must be shared equally among group members.

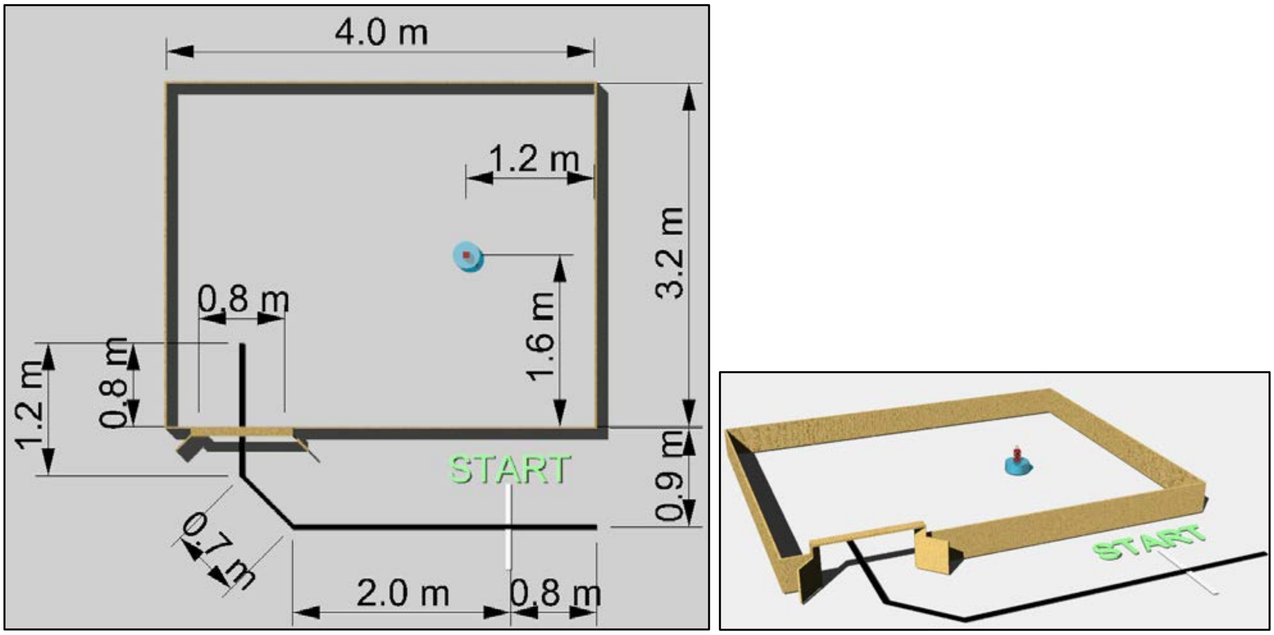

Figure 1: (a) Top view of test course layout with dimensions and (b) isometric view of track

The course (shown in Fig. 1) will be indoors on a smooth, flat surface. At the start of the mission, the hovercraft must begin fully behind the white tape line marked "START" with at least some portion of the hovercraft over the black tape line. The boundaries of the track are created by 290 mm tall sidewalls. A continuous black tape line composed of straight segments creates a pathway from the starting line to the arena. All tapelines are 51 mm wide. To enter the arena, the hovercraft must pass under an 89 mm wide plank that is located 400 mm above the ground.

The payload (shown in Fig. 2) must be manually positioned atop the 254 mm diameter x 100 mm tall solid cylinder pedestal prior to beginning a timed trial. The bottom surface of the payload must be centered on and flush with the pedestal. The payload is not permitted to touch the ground at any time. An infrared beacon with an IR modulation frequency of 56 kHz is located within the pedestal. The beacon transmits a signal radially outward in all directions with the signal source at a height of 76 mm.

A red LED must be illuminated at all times when the hovercraft is within the arena. A gold LED must be illuminated as soon as possible after the hovercraft has controlled possession of the payload. The mission will end when the hovercraft acquires the payload from the pedestal and fully supports the weight of the payload off the pedestal for 10 seconds with the gold LED illuminated.

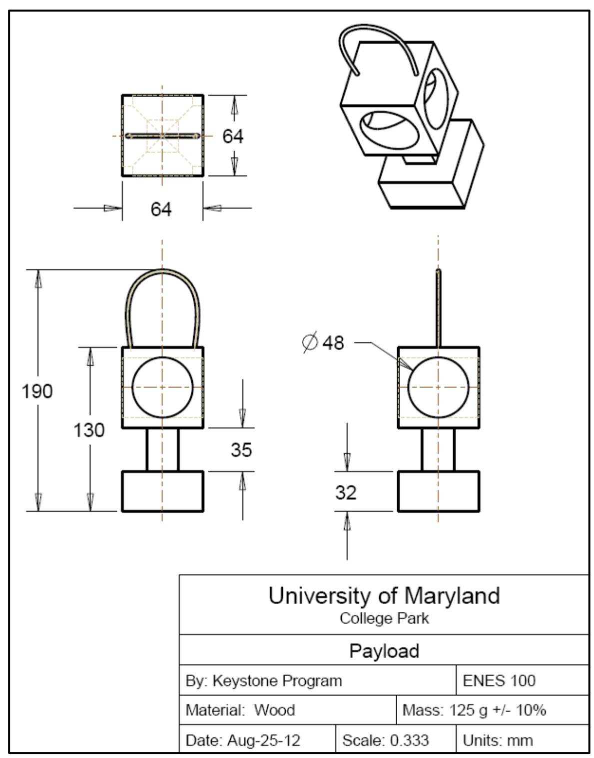

Figure 2: Drawing of payload

Milestone 7
ENES 100 Competition

Due: Monday, December 10, 2012

Value: 0% of course grade

Summary

Upon completion of Milestone 6.1, your team will be entered in the ENES 100 Competition in the Kim Engineering Building on December 10 from 9:00 am – 5:00 pm.

Monetary prizes will be awarded to the three top-placed teams. Additionally, the team with the top performing hovercraft in an academic year will be honored at the Clark School's annual Honors and Awards Ceremony and Reception.

Additional non-monetary awards will also be awarded. These include:

- Faculty Pick for Most Innovative Hovercraft Design, and
- Craftsmanship Award for Best Constructed Vehicle.

Competition Rules

1. Each hovercraft must meet the Product Specifications and adhere to the spirit of the competition.
2. Teams are allowed practice runs when no team is ready for a scoring run.
3. Each team may have up to three scoring runs on the competition track. A team's best scoring run will be used for its placing in the competition.
4. The team must position their hovercraft at the starting location. A scoring run begins with the release of the hovercraft.
5. A scoring run ends with any of the following:
   - the team touches their hovercraft,
   - the payload contacts the floor,
   - the red LED is illuminated before the hovercraft enters the arena,
   - the gold LED is illuminatated before the payload is acquired,
   - a hovercraft is motionless for an extended time, or
   - 10 minutes elapses.
6. There will be 3 scoring levels as follows. Level 1 is attained when the hovercraft enters the arena and illuminates a red LED. Level 2 is attained when the hovercraft physically contacts the payload. Level 3 is attained when the hovercraft lifts the payload off of the pedestal for 10 seconds with a gold LED illuminated.
7. Level 3 scoring runs will be ranked above those of Level 2, followed by those of Level 1. Multiple scoring runs that attain the same level will be ranked according to elapsed time.

Competition Results

Team Name: ____________________ *Section:* __________

(1) Participation in the ENES 100 Final Design Competition.

____
Instructor Approval and Date

(2) Summary of your best scoring run:

____

____
Instructor Approval and Date

Automated Guided Vehicle Project

Submitted by: Steven J. Covey
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MME 101

Automated Guided Vehicle (AGV)

Background

Most companies earn profits by producing or adding value to products which involves having raw materials enter and finished products leave a facility. Many products have thousands, or even millions for an airplane, of parts needing to be received, inventoried, allocated, and assembled. Having all the right parts in all the right places at all the right times is no easy task. Robots are very helpful and common in this process. While robots in the form of automated guided vehicles move these parts around, robots in the form of arms assemble via welding, bolting, etc. Design, fabrication, and programming of all these robots is an interesting and challenging responsibility for many engineers. The engineer's job frequently has complex and contradictory constraints which must be addressed to arrive at an optimal solution. Constraints typically include things like cost, weight, speed, size, flexibility, reliability, safety, and attractiveness. While we can't address all these issues here in this class, we will try to simulate reality the best we can.

Project

Each team will design, fabricate, and program a functioning automated guided vehicle (AGV) to perform a specified task in the class at the completion of the project. Grades will be based upon execution of the task, vehicle size, weight, appearance, and completion time while obeying all rules. Team member contributions will also affect grades.

Details

Teams

Teams of five students will be assigned either a Lego (http://mindstorms.lego.com/en-us/history/default.aspx and http://www.ni.com/academic/mindstorms/) or VEX (http://www.vexrobotics.com/vex-classroom-lab-kits-cortex.html and http://www.vexrobotics.com/easyc-v4.html) kit from which the AGV will be constructed. It is strongly recommended that each team member take ownership of a specific aspect of the project such as design, fabrication, programming, testing, etc. Team skills such as planning, communication, scheduling, and effectiveness will be important. Team members will rate each other for contributions and effectiveness.

Production Facility Lay-out

Companies have a wide variety of facility lay-outs. While optimization of these lay-outs is important, for this task the lay-out is specified and the AGV is focus of our design project. The lay-out has two storage bins (labeled 1 and 2 each ~3 inch/7.5 cm diameter by ~4 inch/10 cm high), four locations (labeled A, B, C, and D), three steel poles (~2 inch/5 cm diameter by ~6 inch/15 cm high), and defined routes (~2 inch/50 cm wide) between them. See Figure 1. Dimensions of the facility, in cm, are shown in Figure 2.

At the beginning of the test, your AGV is in location A, storage bin 1 is in location B, and storage bin 2 is in location D. Poles can be used for location indicators.

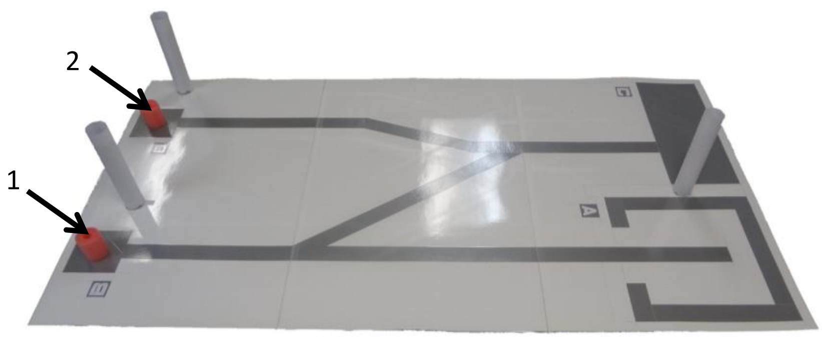

Figure 1: Production facility lay-out.

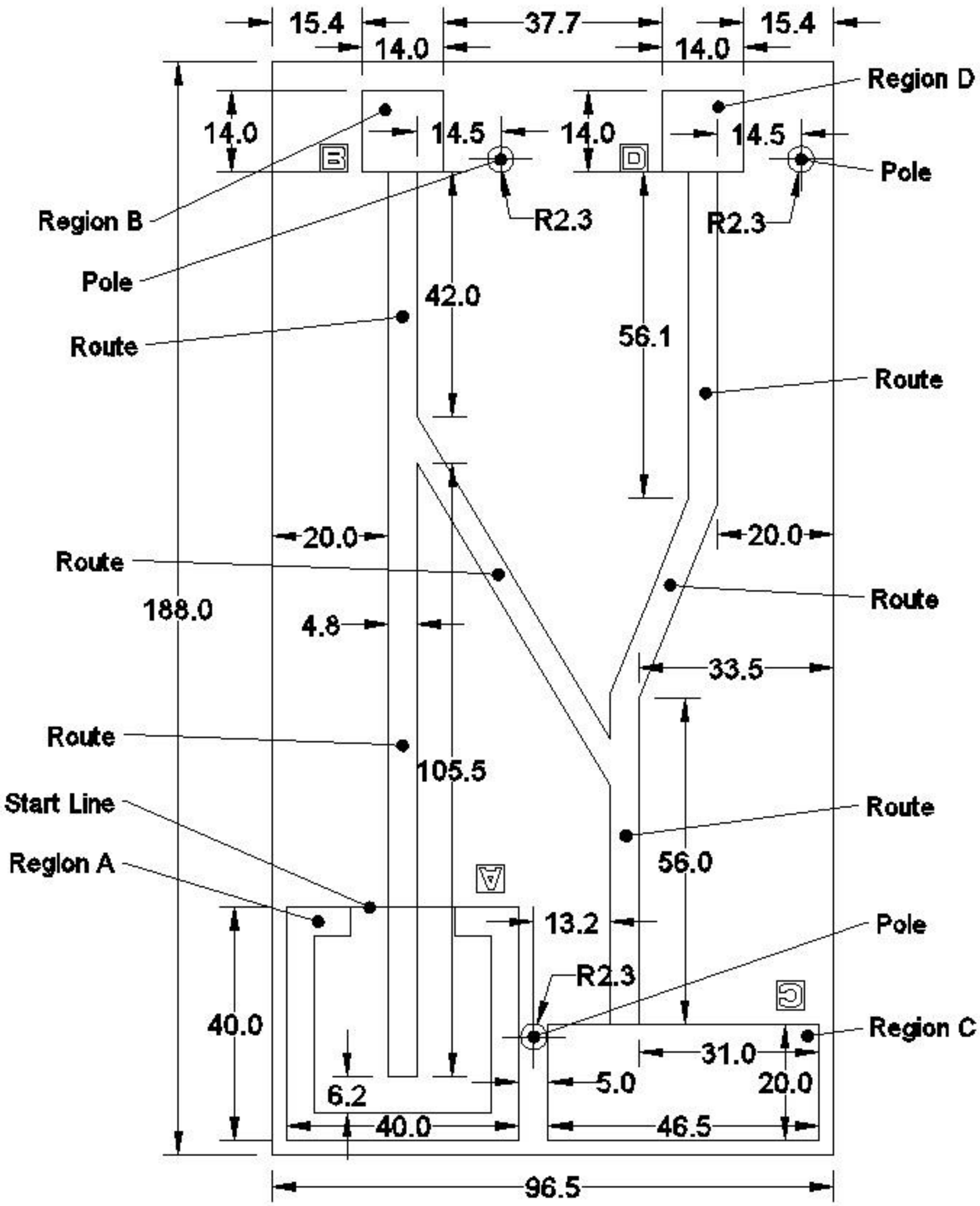

Figure 2: Dimensions (cm) of the production facility lay-out.

Task

Each AGV must follow the route at all times and complete the Task shown below in four (4) minutes or less (less time results in a better grade):

1) Starting from region A, move storage bin 1, initially in region B, to region C.

2) Move storage bin 2 from region D to region B.

3) Move storage bin 1 from region C to region D.

4) Return to region A.

An information video showing this Task sequence can be found on YouTube: http://goo.gl/pN6Yh

Project Constraints

During the test of the AGVs, while performing the above Task, the following constraints apply:

1) Only one builder set per team is allowed. No extra material can be used except cable ties or rubber bands, which require prior approval.

2) Regardless of the builder set contents, only three (3) motors, two (2) touch sensors, and one (1) light sensor can be used in design and fabrication of the AGV.

3) The AGV must fit with the perimeter of region A (a square with sides 15.75 inch/40 cm) with a height less than 12 inch/30 cm.

4) Weight, speed, route, and other requirements as identified below in Rules and Grading.

Rules

During testing the following Rules apply:

1) The AGV must complete the Task autonomously (i.e., no remote control). Once the AGV is activated, any touching by the team counts as a ‘restart’ and must start again in the original configuration.

2) Each team is allowed a maximum of three (3) restarts.

3) The AGV will be stopped at a time of four (4) minutes if the Task has not yet been completed.

4) The AGV must follow the routes between regions using sensor feedback at all times. If the AGV loses the route, a restart from the original configuration is required.

5) The storage bins must be entirely within the outer perimeter of the region or a restart from the original configuration will be required.

6) If the AGV knocks over or moves the poles, a restart from the original configuration will be required.

7) Any robot designs or programs deemed too similar to other team’s AGVs will be required to provide an explanation and lower scores or disqualification may occur. Secrecy for proprietary ideas is recommended.

Grading

Team scores for the AGV project will be determined as follows for teams successfully completing the Task while satisfying all Constraints and Rules:

Score = 0.3*(time rank) + 0.5*(weight rank) + 0.2*(cool rank)

Where
- time rank = 10 for fastest, 8, 6, 4, 2, and 0 for slowest teams (Tests will be timed)
- weight rank = 10 for lightest, 8, 6, 4, 2, and 0 for heaviest teams (AGV will be weighed)
- cool rank = 10 for coolest, 8, 6, 4, 2, and 0 for least cool (student votes will be counted)
- 0.3, 0.5, and 0.2 = weighting per design priority so total score = 10 maximum

Team AGV scores drive grades for those teams successfully completing the Tasks within the Constraints without breaking the Rules. Successful teams will either earn 10 pts (A, highest 50% of scores) or 8.5 pts (B, lowest 50% of scores). Teams not completing the Tasks and/or with Constraints or Rule problems will get between a maximum of 7 pts and minimum of 0 pts. Each student grade may be shifted downward if their project contributions are poor. Students making no contribution will receive 0 pts.

It is hoped that the top three team scores will receive prizes: $250 to the team with the highest score, $100 to the second placed team, and $50 to the third placed team. Fundraising is underway.

Test Details

The AGVs will be tested in ECC 111 on Tuesday, 10/16, and Thursday, 10/18, **starting at 7:30 am**. All Lego tests will be done on 10/16 and all VEX tests on 10/18. More details will be announced later.

Lab Access and Etiquette

The AGV lab is in ECC 103A and will be open MWF 8:00 – 10:45 am and TR 6:00 – 8:00 pm for consulting, fabrication, and programming. Technical help will be available during open time lab times.

No food or beverages in the lab. Wash hands before entering. Keep the parts organized. Some parts may be sharp and there may be pinch points in some AGV designs.

Lego and VEX instructional tutorials with useful links are available on D2L.

Schedule

It is recommended that each team meet the following schedule of intermediate events to successfully complete the AGV project. Teams can be checked out in the lab during open hours whenever the team is ready. Teams not meeting these dates may be required to explain reasons.

Event	Date
Demonstrate mastery of three programming goals or elements	9/17
Present drawings (or a detailed concept sketch) of your design	9/24
Demonstrate mastery of fabrication/programming/sensor interaction	10/1
Demonstrate mastery of a portion of the required Tasks	10/8

Helpful videos explaining programming goals or elements:

VEX: Goal 1 http://goo.gl/GHjNu, Goal 2 http://goo.gl/GQTtI, Goal 3 http://goo.gl/GQTtI
Lego: Goal 1 http://goo.gl/EThjT, Goal 2 http://goo.gl/7cpTx, Goal 3 http://goo.gl/7cpTx

Hints

1) Plan as a team before lab. Meet regularly to discuss ideas and progress.

2) Come to lab weekly to learn, get ideas, and get motivated.

3) Read and reread this handout carefully regarding dates, Tasks, Constraints, and Rules.

4) Review videos on YouTube or other locations on the web.

5) Try to fabricate, program, and run the AGV early so it successfully completes the Tasks. Then, try to optimize the AGV by increasing speed and decreasing weight.

6) Don't neglect other course work. Fit this into your schedule using a priority-based plan.

Design Project
Rural Village

Submitted by: Richard Bennett
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Final Design Project

Objectives

- Solve an open-ended problem while working as a team
- Research and learn about an engineering challenge that is of interest to you
- Demonstrate ways that engineers communicate: presentations, written reports
- Apply principles you've learned in EF 152
- Have fun

Task

A small village in rural Outer Slombovia has many issues that need to be resolved. The village has an intermittent stream that they utilize as a water source, but it only flows half of the year. Therefore they have to collect water from the six month wet season and store it in a large water storage tank that collects water from the roof of a large community building. Due to population increases, the village needs to build a second storage tank. They need a water diversion system that will divert water from one storage tank to the other once it is full and once both tanks are full divert the water to the farmland. (Task 1)

The community building is located at the top of a hill next to the village. The villagers spend a large amount of time hauling water from the top of the hill down to the individual homes. A water distribution system needs to be designed to distribute the water from the storage tanks to the homes. (Task 2)

The water in the tanks is stored for up to six months and therefore needs to be filtered before it is used in the homes. The primary concerns for the filtration are particulates in the water and a low pH due to acid rain. (Task 3)

Many children in the village spend their time in the carrot fields picking carrots and are not able to attend school full time. Since most of their time is spent carrying the carrots back to the farm, an automatic carrot collecting and transporting machine is needed to allow the children to get a good education. (Task 4)

The nearest school to the village is only a few miles away, but in the wet season the stream flows extremely fast and is very dangerous to cross. Therefore the children have to walk over 15 miles to get to the nearest bridge before they can cross the stream to get to school. A bridge is needed to make the trip quicker and prevent children from risking crossing the dangerous stream. (Task 5)

The village would also like a simple form of lighting to enable them to work at night. They need a way to power one light bulb. (Task 6)

Task Requirements

Design and construct scale models of the devices necessary to help this small village.

- You are encouraged to use readily available materials.
- Bonus points will be given for use of naturally occurring biological materials (wood from the hardware store does not count)
- The device must be original - i.e. not built from a kit.

- Your device must be 'hand-made'.
- You will primarily complete this project outside of class time, but you may use recitation time for meeting and planning.
- Estabrook 13 will be available as a work and storage area - here are the guidelines for the use of this room.
- Your team is limited to a budget of $40. You are responsible for assigning a reasonable cost to everything you use, whether or not you actually purchase it.
- The device must be able to be operated in a safe, clean, and non-destructive manner in Estabrook 111.

Task 1: Water diversion device

- Your device should not exceed dimensions of 3’ X 3’ X 3’
- 1 gallon buckets should be used as the storage tanks
- Your device must have a short section of gutter or tubing that water can be poured down
- This must be a diversion device, not simply an overflow device
- You must perform approximate calculations on your device
- Sources provided on Test Day: water (5 gallons), 3 buckets (1 gallon, if needed).

Task 2: Water distribution system

- The water storage tank with spout will be provided.
- Buckets must be filled uniformly.
- Houses (1 quart pails) will be evenly spaced at 2 ft elevation increments.
- You must perform approximate flow calculations of your device.
- Sources provided on Test Day: Water tank (5 gallons), 1 quart pails.

Task 3: Water filtration system

- Your device must filter out small size particulates and raise the pH of the water by at least 1
- Your device should not exceed dimensions of 3’ X 2’ X 2’
- You must perform approximate flow calculations of your device.
- Sources provided on Test Day: Water (5 gallons), calcium carbonate.

Task 4: Carrot Collector

- Your device must pick up 5 baby carrots in a row spaced at 5” intervals, store them, and transport them to a location 12" beyond the final carrot.
- Your device should not exceed dimensions of 2’ X 2’ X 2’
- The carrots will be laying flat on the table
- You must perform approximate calculations on the mechanical efficiency of your device.
- Sources provided on Test Day: 5 baby carrots.

Task 5: Bridge

- Your device should span 3 ft
- Hold 20 pounds of weight at any location along the bridge
- Maximum size of a member is 1/4 x 1/4 inch. No laminations.
- Material must be naturally occurring. (e.g. wood, plants, cotton string, etc.)
- You must perform static calculations of your device.
- Sources provided on Test Day: 20 lb weight.

Task 6: Light Generator

- Develop a way to generate enough electricity to continuously power one light bulb
- Your device should not exceed dimensions of 2’ X 2’ X 2’
- You must perform efficiency calculations.
- Sources provided on Test Day: Small LED light bulb. Check with Profs. White or Bennett for items needed to power your device, such as a fan or worklight (solar).

Choose your project

Complete the online form to indicate your first three choices for the project. We will match you as much as possible to your first choice, but cannot guarantee that.

Estimation - Team Project

Submitted by: Richard Bennett
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Recitation 1.6 Estimation Team Project

Objectives
- Make estimates
- Work as a team to solve a problem
- Write a short report, with clear documentation of a problem solution

Task 1: Make a 2-minute estimate of the volume of Estabrook Hall and the number of bricks on the exterior of Estabrook Hall. Turn this in to your TA.

Task 2: Refine your estimate of the volume of Estabrook Hall and the number of bricks on the exterior of Estabrook Hall. Remember, these are estimates, so don't try to get too precise (e.g. counting the number of windows would not be a good idea). It is recommended you spend no more than 30 minutes on this task.

Task 3: An architect builds a ¾ in. = 1 ft scale model of Estabrook Hall. The architect is going to paint the model dark red on the exterior to represent the brick. A gallon of paint covers 400 ft^2 and there are 128 fluid ounces in a gallon. How many 2 ounce bottles of red paint should the architect buy to paint the model?

Task 4: Turn in a 1-2 page report. The report should include the following:
- Names of all team members
- Date
- Statement of problem
- All relevant assumptions
- Any necessary diagrams
- Calculations
- The 2-minute estimate of the volume of Estabrook Hall and the number of bricks on the exterior
- Final estimate of volume of Estabrook Hall and the number of bricks on the exterior clearly indicated
- The number of 2 ounce bottles of red paint the architect should buy (with calculations)

The report should be done in pencil, and must be NEAT.

Task 5: Remember to fill out the online feedback form. You will need the names of your team members for the form. Every student must fill out the form.

Estimation Project Feedback Form

Did your team choose a leader?	◯Yes ◯No ◯Not applicable
Did your team make a plan before starting the project?	◯Yes ◯No ◯Not applicable
Did your team divide up the tasks?	◯Yes ◯No ◯Not applicable
2 minute estimate:	Volume: ______ ft^3 # bricks: ______
30 minute estimate:	Volume: ______ ft^3 # bricks: ______
Bottles of paint calculation:	# bottles: ______
List all members of your team: (first and last name, one name per line, include yourself)	
In 2-3 sentences, describe how your team could have functioned better.	