ES 110 Engineering & Society – Spring 2012
Group Design Project

Submitted by: Jan E. DeWaters
Clarkson University
jdewater@clarkson.edu

Design of an Energy Conversion System for Air-Flow Power

Background: Fossil fuels currently provide about 85% of the energy used by most of the developed world. Because of concerns over the limited supply of fossil fuels, as well as the detrimental environmental effects associated with their use, renewable energy resources such as solar, wind, hydro and geothermal energy are attracting increased attention ranging from research and development efforts to wide scale implementation. Among these renewable resources, wind power is particularly attractive because of its long history of use, relatively simple mechanical design, and relatively low cost. Wind turbines convert the kinetic energy of moving air into rotational energy, which can be used to run machinery or, alternatively, can be converted into electrical energy for localized use or widespread distribution on the electrical "grid."

Wind is one of the fastest growing sources of renewable energy worldwide. In the U.S., the total wind capacity as of late 2011 was 43,461 MW,[1] which generated 94,650 thousand megawatt-hours of electricity, or 2.3% of the total U.S. electricity generation.[2] Presently, 37 states have at least some installed utility-scale wind power,[3] and the installed capacity is growing substantially, with 90 projects currently underway.[1] The Department of Energy predicts wind energy to supply 20% of the U.S. electricity demand by 2030.[4]

Design Objective: Design and demonstrate a prototype for a system that will convert the power in an air-flow to electrical power. Each design team will prepare several Progress Reports and give a summary presentation including a demonstration of the prototype (see Deliverable #5). A design report including peer evaluations will be submitted when the project is completed (see Deliverable #6).

Specifications/Performance Requirements: Each team is tasked to design and demonstrate a bench-scale air-flow turbine to drive a DC generator subjected to a load. Given an input flow, the overall turbine-generator combination should be sufficient to power a given DC motor coupled to a rotating mass (heretofore referred to as the *output* or *standard load*), including start-up power requirements (no other external power to start the output motor). The cost efficiency of the conversion of power from the flow to electrical output should be maximized as measured by the voltage output of the generator per unit cost of the turbine rotor (in millivolts/$U.S.) at each of three air flow velocities when the turbine is located at a distance of 50 cm from the source (outlet of the blower) of the air-flow provided and the generator is powering the standard load. The

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[1] AWEA 3rd Quarter 2011 Public Market Report. American Wind Energy Association (AWEA). October 2011. http://www.awea.org/learnabout/publications/reports/upload/3Q-2011-AWEA-Market-Report-for-Public.pdf. Retrieved 2011-10-26.)
[2] Electric Power Monthly - April 2011, Table 1.1A.
[3] AWEA: U.S. Wind Power Surmounted Challenges In 2010. North American Windpower. January 3, 2010. http://www.nawindpower.com/e107_plugins/content/content.php?content.7122.
[4] Strengthening America's Energy Security with Offshore Wind. U.S. Department of Energy. February 2011. http://www.nrel.gov/docs/fy11osti/49222.pdf).

designated flow source (blower) and load (output motor), along with terminals to connect the output of the generator, will both be made available for testing.

Materials Provided and Constraints:

1. **Materials**: Each team will be provided with one standard 1.5-3V DC motor ***for use as a generator*** **(no load voltage-speed characteristic attached)**; the shaft of the generator will have a 3/16 inch O.D. collar and electrical leads will be provided. A plastic sleeve into which the generator can be inserted will also be provided for coupling to whatever structure the team fabricates to mount the turbine machine. Additional materials for construction may include standard craft materials and throwaways or recyclables, such as empty containers, beverage cups/containers, string, wire, etc. Additional construction materials may be purchased, including adhesives and fasteners (screws, bolts and nuts) as long as the total charges do not exceed the maximum allowable budget. All materials used to construct the turbine rotor must be accounted for using the **ES 110 Special Regulations Governing Turbine Rotor Procurement and Construction** (attached).

2. **Tools**: Construction of the prototype and final product may employ typical hand tools used in crafting. Hand tools such as pliers, wire cutters, saw, and screwdrivers are allowed; hot glue guns are allowed. In general, power tools and machine tools *are not* to be used by students. If you need a hole drilled or a special cut made, you may request assistance from shop personnel. In addition to the tool kits, a work area will be made available to the design teams.
3. **Cost**: The cost of materials used to construct the turbine and any structure to support the turbine-generator should not exceed $35.00 U.S. A detailed budget must be included in Progress Report #3. The detailed budget, detailing all costs and including copies of receipts for all purchased materials, must be provided in an appendix of the Final Report. The cost includes any items purchased and all materials and components regulated under the **ES 110 Special Regulations Governing Turbine Rotor Procurement and Construction. A 10 point penalty will be assessed on the final report for any design with a cost exceeding $35.00 U.S. as demonstrated.** The cost of the generator does not need to be included in the cost of the turbine rotor or the total cost.

4. **Internet Purchasing Procedure:** If a team does not have any means for making on-line purchases and needs to make on-line purchases, then the team will need to make arrangements for assistance from Ms. Eileen Winters in CAMP 102.

Teams: Teams will be self-selected (form your own teams) and consist of 3-5 members each.

Deliverables: **(all report deliverables must be prepared according to the attached guidelines – See ‘Team Design Project Reporting Guidelines‘)**

1. **Progress Report #1: Background/Introduction, Project Description, and Specifications (due 2/13, 10 points)**. Based on the Design Objective stated and the answers to the energy related

questions from Homework Assignments #1, #2, and #3, prepare and submit a Progress Report that includes:

a. Project background. Using the materials compiled from energy-related homework questions, as well as additional resources, provide background information that explains the societal context of – or societal need for – renewable resources and wind in particular. At a minimum, include information on energy consumption both globally and nationally, and energy production by various energy resources, including renewable sources. Also provide a discussion of the pros and cons related to utility-based wind turbine installations. *Include references for the information you use.*

b. A brief description of the project task. Explain what you were tasked with, and why the design of this product is important to obtaining energy from wind. Describe who will benefit from your design, how your design will be marketed or distributed, and how your design will impact society at large. *Include references for the information you use.*

c. A list of specifications that includes a) the performance requirements of the design and b) the constraints for the project (these are provided in the problem statement).

d. Any additional performance goals and constraints that may be identified by your team (include an explanation for these additional items).

2. **Progress Report #2: Results of Brainstorming; Identification and Evaluation of Possible Design Strategies; Description of Preferred Approach (due 2/13, 10 points)**.
   Submit a Progress Report that includes:

   a. A summary of the factors that influence the power output from a wind turbine, including a description of which ones can be controlled by engineering design. *This will be based on the answers found for Question #6, Homework Assignment #2.*

   b. A description of how the energy from wind is converted to energy we use. *This will be based on the answers found for Question #6, Homework Assignment #2.*

   c. A description of the results from the brainstorming process completed in class. This should include both a description of the process itself and a summary of the ideas (design approaches) that were generated as a result of the process.

   d. A description of the preferred design approach and why it was selected over the other approaches identified in (c), and an explanation of why the others were eliminated. Try to put these design decisions in the context of 1) the information you provide in parts (a) and (b), and 2) the feasibility of each approach.

Note: A formal brainstorming process will be conducted in class using the methods outlined in Chapter 2, Section 5 of ES 110 Engineering and Society (Moosbrugger, et al.) with summary similar to that shown on p. 52 (Example 2). Deliverables 1 and 2 may be combined into one document, but must have separate authors.

3. **Progress Report #3: Design of Prototype (due 3/2, 10 points)**: Provide a Progress Report containing:

   a. A summary (~ one page) of the main features of the prototype design (this should be understandable by a non-technical person, much like a patent disclosure);

b. A professional quality, scaled drawing showing the key features and dimensions of the prototype design. *Either* hand sketches *or* computer-aided drawings are acceptable, but drawings *must* be to scale and hand drawings must be of professional quality; rough sketches prepared without measurements or a straight edge (ruler) *will not* be accepted.

c. A detailed budget, including a complete list of supplies, where they will be obtained from, and with itemized costs.

Note: Your report should provide enough accurate detail to enable a person not familiar with your design to reconstruct your prototype using the drawing and text you provide.

4. **Progress Report #4: In-class critique of Prototype Build and Test procedures (due 3/16, 25 points): Each design team will provide an in-class "Proof-of-Build" (a, POB) and a Progress Report describing the build process, the test procedures, and the test results (b-e, PR):**
   a. POB: Each team will bring their "built" prototype to the demonstration location and be prepared to describe the features of the design. *There is no "PowerPoint" presentation required for this, but the prototype presentation should be done in a professional manner.*
   b. PR: a description of the build process and any iterations required;
   c. PR: a description of the test procedures;
   d. PR: a summary of the test results (both qualitative and quantitative);
   e. PR: a brief summary and explanation of any design modifications resulting from the testing process. *Optional: Include a photo showing build and test.*

5. **In-Class Presentation and Final Product Demonstration (7 minutes): Design Iterations; Final Design and Prototype; and Prototype Demonstration (due ca. 4/18, TBA, 25 points): Prepare and present a power point presentation (~ 7 minutes or less) that includes:**
   a. A summary of your prototype design (original design, and design iterations, and prototype design);
   b. A summary of the main features and advantages of your prototype;
   c. A summary of your test procedures and results including design modifications;
   d. A description of the final design; and
   e. A demonstration of the final product showing that it meets the specifications and adheres to the design constraints. ***While all team members must be present, it is not a requirement that all team members speak.***

   10 points for performance:

   1. **Wind energy is harnessed to produce a measurable generator output voltage;**
   2. **No-load generator output voltage per unit cost is greater than or equal to 25mV/$U.S;**

3. **Power conversion is sufficient to start and power the output (motor with rotating mass) at an observable speed.**

- **0 points: (0/3 of above)**
- **3 points: (1/3 of above)**
- **6 points: (2/3 of above)**
- **10 points: (3/3 of above)**

6. **Final Report* (due 4/27, 20 points):** Submit a final report that is prepared according to the attached guidelines. Deliverables submitted previously (or materials included in them) may be included as appendices and referred to in the main body of the report for details.

Note: The self- and peer-evaluations (described below) must be completed by each team member using the attached form and submitted with the final report in order that the final design project be considered "complete" and project grades computed and assigned!!

Grading: Each team member will receive an individual score for the project, computed according to the attached grading procedure and rubric. In most cases, each member of a team will receive the same score. Occasionally, however, someone will simply not put forth much effort or will contribute virtually nothing to the project and this will be clear from the peer evaluations. Such individuals will receive a lower score, accordingly.

Team Design Project Reporting Guidelines

Progress and Final Reports do not need to be extensive, but must convey the necessary information in a clear, concise manner. Ideally, one group member will be responsible for the final written portion of **each** of the 5 deliverables (the 4 progress reports and the final report). The designated person will change for each new deliverable. This method is to provide each student with a chance to have technical writing practice in the course.

All reports are to be typed in 11 or 12 point font, with 1-inch margins and page numbers bottom center or bottom right. Hand-written reports will be returned with a 0 grade. Calculations, where present, can be hand-written, but must follow the same guidelines for that of typed fonts. (However, use of an Equation Editor is strongly recommended.) When possible print all reports double sided.

Each Report must contain a Title Page with the following information:
- Title (e.g., Progress Report #3: Design of Prototype)
- Date
- Team Members (names *with signatures*)
- Group member responsible for writing the report

The **Final Report** should be roughly 5 to 6 pages long *excluding* sketches, drawings, appendices, figures, tables, etc.). Deliverables submitted previously (or materials included in them) may be included as appendices and referred to in the main body of the report for details. A word of caution: if a progress report was poorly graded, do not include this as an appendix – rather, correct your mistakes as you re-write these sections in the final report document.

In addition to the Title Page, the **Final Report** must contain the following sections:

1. Introduction (introduce the design problem at hand; provide background information similar to what you prepared for Progress Report #1)
2. Design Criteria and Performance Standards (briefly summarize; include technical, societal and economic constraints)
3. Prototype Design Summary (summarize the process used to design prototype and the results of that process)
4. Build and Test (describe the building and testing procedures; include results and modifications)
5. Prototype Demonstration (summarize results of the in-class demonstration; present and discuss the results that your team achieved and briefly discuss your observations of the other demonstrations; specifically note any observations/conclusions that you can make regarding design choices and their effects on performance)
6. Recommendations (present recommendations for improving the design for "commercial development;" specifically, based on (5), what design changes do you recommend based on your demonstration and your observation of the other demonstrations?)
7. Appendices (include detailed budget, receipts for purchases, recalculations, sketches and drawings, progress reports, figures and tables that are not embedded in the text)

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Team Design Project Final Report Grading Rubric

		Weight	Points (1-10)
Introduction	Design problem clearly defined	0.1	
Completeness	All required report sections are included; materials submitted as earlier progress reports that are included as appendices are briefly described in text and clearly located in appendix; incomplete or weak progress report information is sufficiently improved in the appropriate sections of the final report	0.5	
Demonstration	Process and results of in-class demonstration are clearly described	0.2	
Recommendations	Brief; potential improvements are discussed that would enable wide scale production and implementation	0.1	
Appendices	Extra materials well organized, appropriate, and easy to interpret	0.2	
Professional presentation and communication, Mechanics	Text, graphics, drawings and tables neat and generated with appropriate computer tools; Tables, figures, drawings, calculations are used appropriately and effectively	.3	
Organization, Focus	Logical flow of material between sections that aligns with basic design process; Purpose of report overall, and each section, clearly defined; Reasonable number of section headers to guide reader	.3	
Grammar, paragraphs, spelling	Sentence structure concise and appropriate for technical communication No spelling, tense or plural/singular agreement errors	0.3	

Total points: (max 20)

Team Design Project Overall Grading Procedure
(descriptions apply to max positive or negative points)

A. Group Assessment: The product of 0.75 and the sum of point allocations for deliverables 1 through 6 ______ (maximum 75 points)

B. Individual Assessment (25 points; points assigned based on peer evaluation and at the discretion of the instructor)

Team member contributed at or above average for the group _______ (maximum 25 points);

or Team member did not do anything _______ (minimum of $-1\times$total of A. Group Assessment, so that project grade = 0);

or somewhere in between the above __________ (between -75 and 25).

C. Project Grade = Score for A + Score for B

______________________ (maximum 100 points)

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Team Design Project Self-Evaluation and Peer Evaluation Form

This form must be completed in confidence at the completion of the project by each team member on the project team, and submitted with the project in individually signed and sealed envelopes.

Please rate the contribution toward the team project of each team member in your group **including your own**. Provide a score between 0 and 10 for each member and then elaborate on what particular each member contributed. Feel free to write additional comments at the bottom of the form.

Estimated Time Required
To Complete Project (hours): __________

Time You Actually Spent
on Project Tasks (hours): ___________

Group: ___________

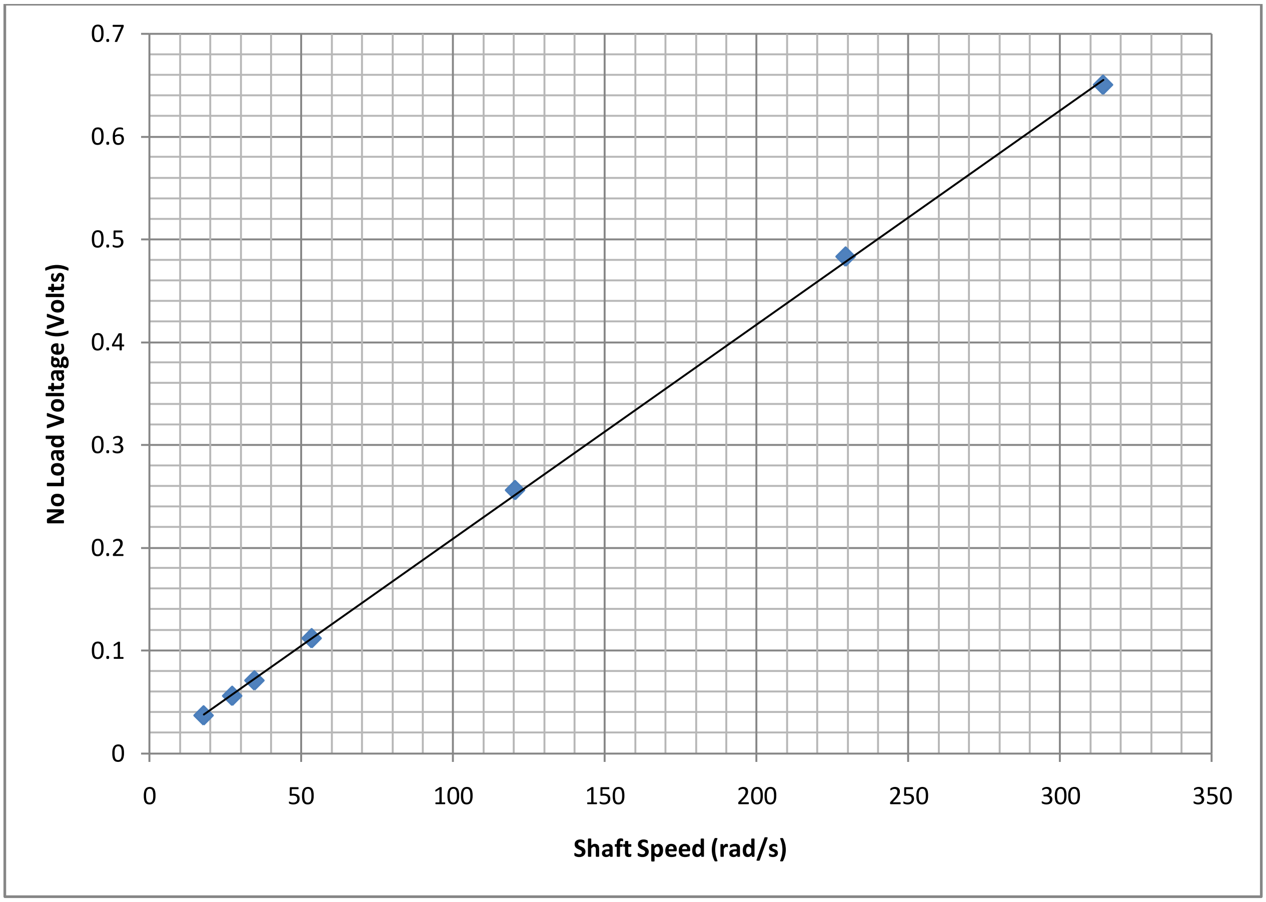
Name	**Score (0 – 10)**	**Contribution to the Project**

Comments on team contributions/performance:

____
____
____
____

Signature and Date: ____
Name (print): ____

No-load voltage generated vs. generator shaft speed for the generator provided:



Generator Resistance at Zero Shaft Speed = 0.65 Ohms

ES 110 Special Regulations Governing Turbine Rotor Procurement and Construction

In order to promote local engineering and labor content, the following regulations apply to the Spring 2012, ES 110 Group Design Project.

Materials and components subject to these rules include materials or components used for blades, vanes or buckets of the turbine rotor; hub or any other component(s) used to couple the turbine rotor to the generator shaft; any materials or components used to contain or channel the air from which power is extracted.

The following costs shall be assessed for computing the cost of the turbine rotor:

1. Paper-based materials (paper, card stock or cardboard): \$0.00075 U.S./cm^2
2. Polymeric materials (plastic), not including finished components, such as blades, vanes or buckets or hub: \$0.005 U.S./cm^2
3. Engineered materials such as foam core poster or sign board: \$0.002/cm^2
4. Sheet metal:\$0.01 U.S./cm^2
5. Wood: \$0.006/cm^2
6. Polymer matrix composites: \$0.03
7. Finished, pre-shaped blades, vanes or buckets (a limited selection of finished blades is available from the ES 110 Turbine Rotor Procurement and Construction Authority): at cost per finished component
8. Pre-manufactured KidWind hub available from the ES 110 Turbine Rotor Procurement and Construction Authority: \$6.50 U.S.
9. Pre-manufactured hubs, shaft collars, etc. from any other source: at cost
10. Pre-manufactured turbine rotors purchased or obtained as a complete unit with integrated blades, vanes or buckets and hub or other component for attaching to the generator shaft are assessed a surcharge of \$35.01 U.S.
11. Other materials: cost as determined by the ES 110 Turbine Rotor Procurement and Construction Authority.

ES 110 Engineering & Society – Spring 2011
Group Design Project

Submitted by: Jan E. DeWaters
Clarkson University
jdewater@clarkson.edu

Design of a Spill-Proof Table Candle Holder

Design Objective: Design and demonstrate a prototype for a spill-proof table candle/candle holder. If knocked over, it should right itself without spilling any wax, and the flame should not extinguish. The type of candle to be used can be considered part of the design, as long as it is an inexpensive wax table candle or tea light candle.

Additional Constraints

1. Materials: the prototype (excluding the candle) may be constructed from standard craft materials and throwaways or recyclables, such as empty containers, beverage cups/containers, common substances like water, sand or gravel, and off-the –shelf adhesives and fasteners (screws, bolts and nuts are allowed).
2. Tools: construction of the prototype may employ typical hand tools used in crafting; hand tools such as pliers, wire cutters, screwdrivers are allowed; hot glue guns are allowed. Power tools and machine tools *are not* allowed.
3. Cost: the cost of materials used to construct the prototype (including the candles) should not exceed $30.00 U.S.

Teams: Teams will be self-selected (form your own teams) and consist of 3-5 members each.

Deliverables

1. **Specifications (due 2/8, 5 points)**: Based on the Design Objective stated, additional constraints placed on the design, and other information gathering your team may have done, produce a list of specifications that includes the performance requirements of and constraints on the design. You can include additional performance goals and constraints as you see fit, but you may be asked to explain your reasons.
2. **Results of Brainstorming; Identification and Evaluation of Possible Design Strategies; Preferred Approach (due 2/8, 10 points)**: Identify and evaluate possible design strategies. Use the methods outlined in section 2.5 of *Design Concepts for Engineers* by Horenstein to generate ideas. Produce a compiled list of everyone's ideas like the one on p. 52 of Horenstein. Select the preferred approach and provide a one page or less summary explaining why this is the preferred approach. Ideally, this summary should explain why ideas were eliminated and how they were combined to achieve the preferred approach.
3. **Design of Prototype (due 2/24, 15 points)**: Provide a one page sketch (hand sketches are okay; if you know how to use a drafting application, like AutoCAD, that is also okay) of the prototype design. Provide an additional one page (or less) summary of the main features of the design. This should be understandable by the "average" person, much like a patent disclosure.

4. **Build and Test (due 3/10 **Changed to 3/24**, 25 points):** Produce a summary (1-2 pages) of the results of testing, describing the test(s) performed, the results (qualitative, and quantitative if possible), and both the conclusions reached from the results and any design modifications suggested or supported by the results. ****Show proof of build ****
5. **Design Iterations; Final Design and Prototype; Presentation and Prototype Demonstration (due ca. 4/14, TBA, 25 points):** Produce and deliver a PowerPoint presentation lasting 7 minutes that includes a summary of the main features and advantages of your prototype design and describes the original design, design iterations, and final design. Demonstrate your prototype ("light up and knock over!").
   10 points for performance: self-rights, does not spill wax, stays ignited
   - **0 points: (0/3 of above)**
   - **3 points: (1/3 of above)**
   - **6 points: (2/3 of above)**
   - **10 points: (3/3 of above)**

6. **Report* (due 4/21, 20 points):** This should be brief (approximately 5-6 pages or less, excluding sketches or drawings, appendices and tables) and should summarize the process used to design your prototype and the results of that process. Documents produced earlier in the design process can be included as appendices and referred to in the main body of the report for details.

Self-Evaluations and Peer Evaluations: Self-evaluations and peer evaluations (using the attached form) must be filled out by each team member and submitted with the final report for the project to be considered complete and a score awarded to the team members.

Grading: Everyone will receive an individual score for the project, computed according to the attached grading procedure and rubric. In most cases, each member of a team will receive the same score. Occasionally, however, someone will simply not put forth much effort or will contribute virtually nothing to the project and this will be clear from the peer evaluations. Such individuals will receive a lower score, accordingly.

Reimbursement for Cost of Materials: You can receive reimbursement for the cost of materials (up to $30.00 total for each team), provided you complete the attached form and provide itemized, original receipts for purchased items.

***** see the attached Report writing rubric

Team Design Project Report Grading Procedure and Rubric
(descriptions apply to max positive or negative points)

A. Group Assessment: The product of 0.75 and the sum of point allocations for the deliverables submitted ______ maximum of 75 points.

B. Individual Assessment (25 points; points assigned at the discretion of the instructor)

Team member contributed at or above average for the group _______ maximum of 25 points;

or team member did not do anything _______ (minimum of $-1\times$total of A. Group Assessment, so that project grade = 0);

or somewhere in between the above __________ (between -75 and 25).

C. Project Grade = Score for A + Score for B

* **Report writing rubric**

	Below Standard	**Approaches Standard**	**Meets Standard**	**Exceeds Standard**
Focus: Is/are the purpose of the report/report sections clear?	0-2points	3points	4points	5points
Organization: Is the organization logical, appropriate and conducive to facilitating understanding by the reader?	0-2points	3points	4points	5points
Details: Do details enhance and or clarify understanding by the reader?	0-2points	3points	4points	5points
Mechanics: Does the writing show command of grammar/usage/sentence structure/subject vocabulary?	0-2points	3points	4points	5points
Mechanics: Are tables/figures/drawings/equations used effectively and appropriately?	0-2points	3points	4points	5points

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Team Design Project Self-Evaluation and Peer Evaluation Form

This form must be completed in confidence at the completion of the project by each team member on the project team, and submitted with the project in individually signed and sealed envelopes.

Estimated Time Required To Complete Project (hours): __________

Time You Actually Spent on Project Tasks (hours): ___________

Self-Evaluation of Your Performance Relative to Your Group
(A=Above Group Average, B=Group Average, C=Below Group Average, D=Contributed Nothing): Letter Grade ________

Evaluation of Your Peers Performance Relative to Your Group

1. **Team member's name _____________________________**
   (A=Above Group Average, B=Group Average, C=Below Group Average, D=Contributed Nothing): Letter Grade________

2. **Team member's name _____________________________**
   (A=Above Group Average, B=Group Average, C=Below Group Average, D=Contributed Nothing): Letter Grade________

3. **Team member's name _____________________________**
   (A=Above Group Average, B=Group Average, C=Below Group Average, D=Contributed Nothing): Letter Grade________

4. **Team member's name _____________________________**
   (A=Above Group Average, B=Group Average, C=Below Group Average, D=Contributed Nothing): Letter Grade________

5. **Team member's name _____________________________**
   (A=Above Group Average, B=Group Average, C=Below Group Average, D=Contributed Nothing): Letter Grade________

Comments on team contributions/performance:
____
____
____
____

Signature and Date: ____

Name (print): ____

ES 110 Engineering & Society – Fall 2011
Group Design Project

Submitted by: Jan E. DeWaters
Clarkson University
jdewater@clarkson.edu

Design of a One-Handed Shovel

Background: As technology advances we are increasingly able to provide effective and ergonomic ways to assist those with physical disabilities. This includes but is not limited to providing:

a. Wheelchairs for those with severe spinal cord injuries,
b. Hip, knee and shoulder replacements for those whose joints have been damaged or worn out, and
c. Artificial limbs to those that may have lost an arm or leg.

In a local hardware company's attempt to better serve their community, they would like your assistance in the research and development of a snow shovel that can requires only one hand for normal, comfortable use.

Design Objective: **Design and demonstrate a prototype for a one-handed (single-arm) snow shovel. Each design team will give a summary presentation including a demonstration of the prototype (see Deliverable #5). A design report including peer evaluations will be submitted as well (see Deliverable #6).**

Shovel Constraints:

1. Shovel must be safe. (no sharp extruding objects i.e. screws)
2. Shovel must help customer lift at a rate comparable to that if they shoveled two-handed.
3. Maximum Weight of Shovel Adaptation: 2 lbs

Additional Constraints:

1. Materials: Each team will be provided with one standard snow shovel that will be modified for use with one arm. Materials for prototype and final product construction may include standard craft materials and throwaways or recyclables, such as empty containers, beverage cups/containers, string, wire, etc. Additional construction materials may be purchased, including adhesives and fasteners (screws, bolts and nuts) as long as the total charges do not exceed the maximum allowable budget.

2. Tools: Construction of the prototype and final product may employ typical hand tools used in crafting. Hand tools such as pliers, wire cutters, saw, and screwdrivers are allowed; hot glue guns are allowed. Power tools and machine tools *are not* allowed.

3. Cost: The cost of materials used to construct the prototype and modify the shovel for the final product should not exceed $30.00 U.S.

Teams: Teams will be self-selected (form your own teams) and consist of 3-5 members each.

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Deliverables: (all report deliverables must be prepared according to the attached guidelines)

1. **Progress Report #1: Specifications (due 9/28, 10 points)**: Based on the Design Objective stated, additional constraints placed on the design, and other information gathering your team has done, submit a Progress Report that includes:

    a. A brief summary of the societal context for your product –i.e., the societal situation that you are responding to by developing this product. Describe who will benefit from your design, how your design will be marketed or distributed, and how your design will impact society at large. For information cited include at least one reference.
    b. A list of specifications that includes a) the performance requirements of the design and b) the constraints on the design; and
    c. Any additional performance goals and constraints that may be identified by your team (include an explanation for these additional items).

    *Don't forget to include economic, sustainability, and humanistic issues when you describe your product specifications and constraints.

2. **Progress Report #2: Results of Brainstorming; Identification and Evaluation of Possible Design Strategies; Preferred Approach (due 9/28, 10 points)**: Submit a Progress Report in which you:

    a. Present the results of your brainstorming process;
    b. Identify and evaluate possible design strategies (describe capability of various alternatives to meet your criteria);
    c. Describe the preferred approach; and
    d. Explain why this approach was selected and other approaches eliminated.

A formal brainstorming process will be conducted in class using the methods outlined in Chapter 2, Section 5 of Engineering and Society *with a summary similar to that shown in Example 2. <u>Deliverables 1 & 2 may be combined into one document</u>.*

3. **Progress Report #3: Design of Prototype (due 10/17, 10 points)**: Provide a Progress Report containing:

    a. A one page (or less) summary of the main features of the prototype design (this should be understandable by the "average" person, much like a patent disclosure);
    b. A scaled drawing showing the main features and dimensions of the prototype design (*either* hand sketches *or* computer-aided drawings are acceptable, but drawings must be to scale and hand drawings must be of professional quality; rough sketches prepared without measurements or a straight edge (ruler) will not be accepted).

4. **Progress Report #4: Build and Test Prototype (due 10/31, 25 points):** Provide a Progress Report in which you present:

   a. A clear description of the test procedures;
   b. A summary of the test results (both qualitative and quantitative);
   c. Conclusions drawn from the testing; and
   d. A brief summary and explanation of any design modifications resulting from the testing process. *Optional: Include a photo showing build and test.*

5. **In-Class Presentation and Final Product Demonstration (7 minutes) : Design Iterations; Final Design and Prototype; Presentation and Prototype Demonstration (due ca. 11/30, TBA, 25 points):** Prepare and present a PowerPoint presentation lasting **7 minutes** that includes:

   a. A summary of your prototype design (original design, and design iterations, and prototype design);
   b. A summary of the main features and advantages of your prototype;
   c. A summary of your test procedures and results including design modifications;
   d. A description of the final design; and
   e. A demonstration of the final product showing that it meets the following requirements. ***While all team members must be present, it <u>is not</u> a requirement that <u>all</u> team members speak.***

   10 points for performance:

   1. **Shovel can be held horizontally with one arm;**
   2. **Shovel can transfer packing peanuts from point A to point B (established in class);**
   3. **Shovel can transfer sand (or snow if available) from point A to point B.**

   - **0 points: (0/3 of above)**
   - **3 points: (1/3 of above)**
   - **6 points: (2/3 of above)**
   - **10 points: (3/3 of above)**

6. **Final Report* (due 12/9, 20 points):** Submit a final report that is prepared according to the attached guidelines. Deliverables submitted previously (or materials included in them) may be included as appendices and referred to in the main body of the report for details.

Note: The self- and peer-evaluations (described below) <u>must</u> be completed <u>by each team member</u> using the attached form and submitted with the final report for the final design project to be considered "complete" and project grades computed and assigned!!

Grading: Each team member will receive an individual score for the project, computed according to the attached grading procedure and rubric. In most cases, each member of a team will receive the same score. Occasionally, however, someone will simply not put forth much effort or will contribute virtually nothing to the project and this will be clear from the peer evaluations. Such individuals will receive a lower score, accordingly.

ES 110 Engineering & Society – Fall 2011
Group Design Project

Team Design Project Reporting Guidelines

Progress and Final Reports do not need to be extensive, but must convey the necessary information in a clear, concise manner. One group member will be responsible for the final written portion of **each** of the 5 deliverables (the 4 progress reports and the final report). The designated person will change for each new deliverable. This method is to provide each student with a chance to have technical writing practice in the course.

All reports are to be typed in 11 or 12 point font, with 1-inch margins and page numbers bottom center or bottom right. Hand-written reports will be returned with a 0 grade. Calculations, where present, can be hand-written, but must follow the same guidelines for that of typed fonts. (However, use of an Equation Editor is strongly recommended.) When possible print all reports double sided.

Each Report must contain a Title Page with the following information:

- Title (e.g., Progress Report #3: Design of Prototype)
- Date
- Team Members (names *with signatures*)
- Group member responsible for writing the report

The **Final Report** should be roughly 5 to 6 pages long *excluding* sketches, drawings, appendices, figures, tables, etc.). Deliverables submitted previously (or materials included in them) may be included as appendices and referred to in the main body of the report for details. A word of caution: if a progress report was poorly graded, do not include this as an appendix – rather, correct your mistakes as you re-write these sections in the final report document.

In addition to the Title Page, the **Final Report** must contain the following sections:

1. Introduction (introduce the design problem at hand; use a minimum of one paragraph but not more than one page)
2. Design Criteria and Performance Standards (briefly summarize; include technical, societal and economic constraints)
3. Prototype Design Summary (summarize the process used to design prototype and the results of that process)
4. Build and Test (describe the building and testing procedures; include results and modifications)
5. Prototype Demonstration (summarize results of the in-class demonstration)
6. Recommendations (present recommendations for improving the design for “commercial development”)
7. Appendices (include calculations, sketches and drawings, progress reports, figures and tables that are not embedded in the text)

ES 110 Engineering & Society – Fall 2011
Group Design Project

Team Design Project Final Report Grading Rubric

		Weight	Points (1-10)
Introduction	Design problem clearly defined	0.1	
Completeness	All required report sections are included; materials submitted as earlier progress reports that are included as appendices are briefly described in text and clearly located in appendix; incomplete or weak progress report information is sufficiently improved in the appropriate sections of the final report	0.5	
Demonstration	Process and results of in-class demonstration are clearly described	0.2	
Recommendations	Brief; potential improvements are discussed that would enable wide scale production and implementation	0.1	
Appendices	Extra materials well organized, appropriate, and easy to interpret	0.2	
Professional presentation and communication, Mechanics	Text, graphics, drawings and tables neat and generated with appropriate computer tools; Tables, figures, drawings, calculations are used appropriately and effectively	.3	
Organization, Focus	Logical flow of material between sections that aligns with basic design process; Purpose of report overall, and each section, clearly defined; Reasonable number of section headers to guide reader	.3	
Grammar, paragraphs, spelling	Sentence structure concise and appropriate for technical communication No spelling, tense or plural/singular agreement errors	0.3	

Total points: (max 20)

____

Team Design Project Overall Grading Procedure:
(Descriptions apply to max positive or negative points)

A. Group Assessment: The product of 0.75 and the sum of point allocations for deliverables 1 through 6 ______ **(**maximum 75 points)

B. Individual Assessment (25 points; points assigned based on peer evaluation and at the discretion of the instructor)

Team member contributed at or above average for the group _______ (maximum 25 points);

or Team member did not do anything _______ (minimum of $-1\times$total of A. Group Assessment, so that project grade = 0);

or somewhere in between the above __________ (between -75 and 25).

C. Project Grade = Score for A + Score for B

______________________ (maximum 100 points)

ES 110 Engineering & Society – Fall 2011
Group Design Project

Team Design Project Self-Evaluation and Peer Evaluation Form

This form must be completed in confidence at the completion of the project by each team member on the project team, and submitted with the project in individually signed and sealed envelopes.

Please rate the contribution toward the team project of each team member in your group including your own. Provide a score between 0 and 10 for each member and then elaborate on what particular each member contributed. Feel free to write additional comments at the bottom of the form.

Estimated Time Required
To Complete Project (hours): __________

Time You Actually Spent
on Project Tasks (hours): ___________

Group: ___________

Name	Score (0 – 10)	Contribution to the Project

Comments on team contributions/performance:
____
____
____
____

Signature and Date: ____

Name (print): ____

Submitted by: Gayle E. Ermer, Calvin College, germer@calvin.edu

Introductory Design Project – Soda (Pop) Bottle Rockets

Engineering 101 – Fall 2012

Introduction

For the introductory design project, you will be using 2 liter plastic soda (pop) bottles to design, and launch, water-propelled rockets. The rocket launchers will be provided. The bottles will be pressurized to 60 psi and the launch angle is fixed at 45 degrees. Your team's objective is to maximize the distance your rocket can travel. Water is the only allowable propellant.

The only modifications you may make are to vary the amount of water in your bottle, the shape of the fins, and the amount of modeling clay (e.g. Play-Doh™) on your rocket's "nose." The following restrictions apply:

- The amount of water used must be between zero and 2L. The remaining volume is air only.
- The fins must be separated at 120 degree angles and must all three be identical. They may only be made from foam core poster board (provided). They must be attached to the rocket body with duct tape.
- You will be provided with a specific amount of modeling clay. You may use some or all of this clay on the nose of your rocket (the bottom of the soda bottle). Only clay may be used, and you may not use more than is provided (e.g. 4 ounces).

Grading will be as follows:

30 points for distance. One point will be given for each 10 feet of travel up to a maximum of 30 points for 300 feet. The distance considered will be the average of your 3 best launches. A five point bonus will be awarded to the team that achieves the maximum distance in a single launch.

10 points for style. You may decorate your bottle with anything that does not add significant weight, is essentially flat against the surface of the bottle, and does not affect the aerodynamic characteristics of the rocket (e.g. paper, cellophane tape, markers, crayon). Your final report should include a color image (at least 4.0 in. by 5.0 in. in size) of your rocket. The most stylish rocket (as decided by me) gets 5 bonus points.

60 points for the report. In engineering, documentation is everything. Your report should demonstrate why your design is optimal. Explain why you decided to design the rocket the way that you did. A separate memo will give guidelines for the report format.

Timetable

There are only 3 launch days: September 14, 21, and 28. All launches must be performed during class time under the supervision of your instructor. The final report is due on Friday, October 5 be 5:00 pm.

As with any open-ended project the guidelines given above are subject to modification.

Team Assignments

Team Number	Member 1	Member 2	Member 3	Member 4
1				
2				
3				
4				
5				
6				
7				
8				

Submitted by: Gayle E. Ermer, Calvin College, germer@calvin.edu

ENGR 101 Fall 2012

Engineering 101 Design Project #2

Project Description

The major Engineering 101 project will involve designing a device or system to help an organization or individual (the client) better perform a particular task or improve the functionality of facilities. Some of these projects will involve dealing with individuals with disabilities. In solving this problem, design teams will meet with their client to determine project specifications, follow a structured design process to develop a solution, implement the solution to test the viability of the idea (typically by building a prototype and testing with the client), and document the design to present to the client and the rest of the class. A budget of $20 may be provided for each team, if needed, along with the resources available in the Engineering Building.

Process

This project will be completed in teams of 4 or 5 students. The teams will be assigned by the professor based on availability of vehicles to drive off-campus and on compatible schedules. The projects will be presented to the teams in the form of a brief description and the name of a contact person. One member of the design team should function as the communicator for the team and work to set up a meeting with the client ASAP in which all teams members can assess the problem.

All materials generated in the course of the project will be stored in a Moodle course wiki for each team. A detailed list of the types of materials that need to be documented in the wiki is included later in this handout. The project will proceed with some intermediate deadlines at which time particular sections of the wiki need to be completed.

Team Grading

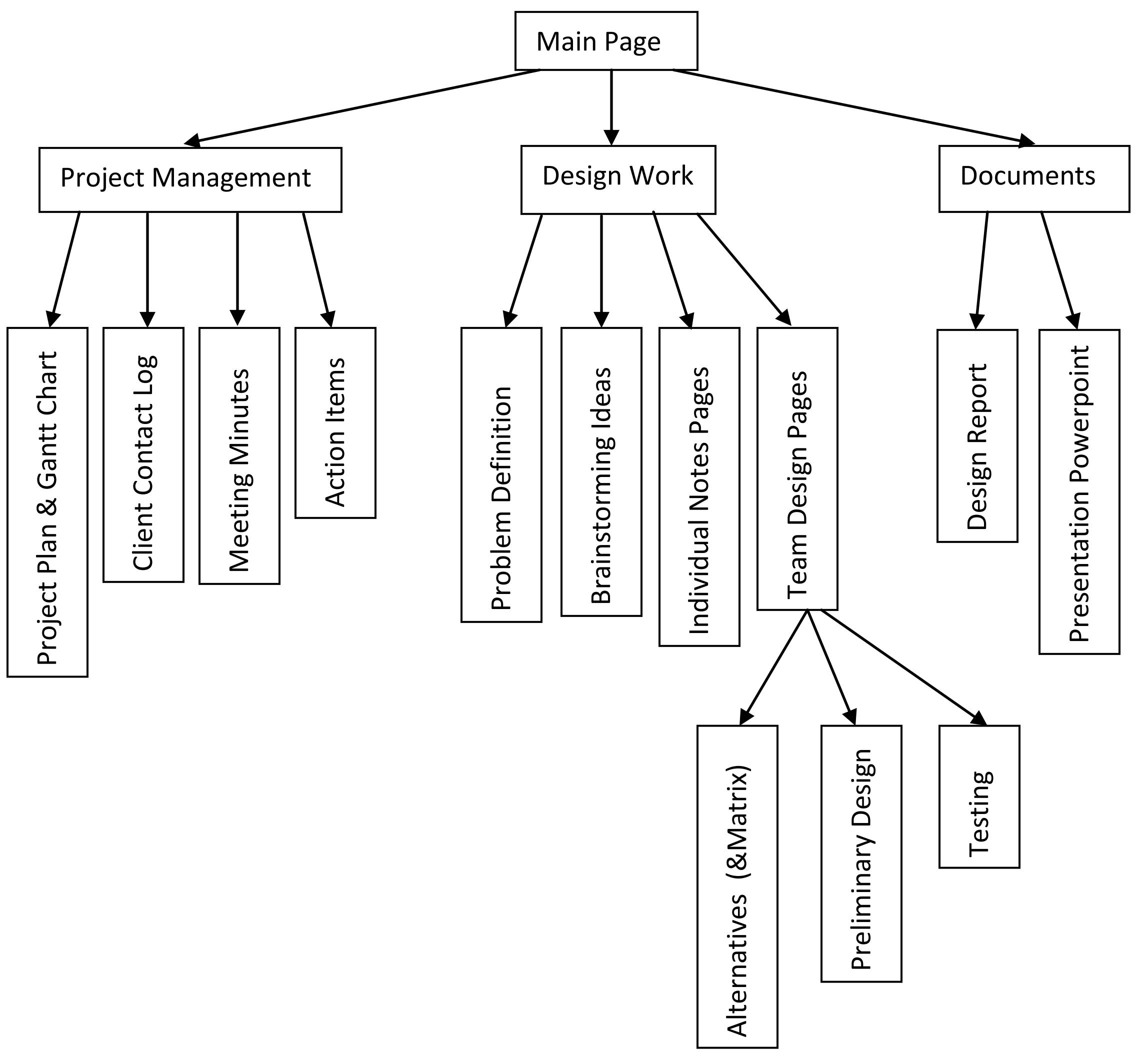
Each project will be given a single team grade. This grade will be based on: success in meeting design requirements, on-time completion of the wiki documentation, oral presentation quality, design report quality, and team effort. All team members should participate in project activities and contribute to the wiki. At the end of the project, team members will participate in peer evaluations of the effort and contribution of various team members. An assessment by the professor of each team member's contribution to the wiki will also be completed. An individual team member grade may be adjusted up or down from the overall team grade based on the peer evaluations and individual assessment. Keep in mind that, even if particular team member grades are adjusted, the average of the individual grades for all the team members must remain the same as the overall team grade.

Design Process and Timeline The project will be completed by following the steps of the engineering design process. The following table lists some of the steps in the design process along with the date by which that work should be completed in your wiki. These dates are to be considered final deadlines unless your professor announces, in advance, that a particular due date will be delayed. All due dates assume a deadline of 5:00 pm on the specified date.

Project Plan (including Gantt Chart)	Monday, Oct. 8
Problem Definition (including Design Specifications)	Monday, Oct. 15
Brainstorming Results	Monday, Oct. 22
Alternative Design Evaluation (including Decision Matrix)	Monday, Oct. 29
Preliminary Design	Monday, Nov. 5
Prototype Construction	Monday, Nov. 12
Testing Results Summary and Project Report Draft	Monday, Nov. 26
Oral Presentation	Monday, Dec. 3 or Wednesday, Dec. 5
Final Project Report	Friday, Dec. 7

Project Management and Wiki Structure

The following pages must be constructed in order to manage your work and document the design.



Submitted by: Matt Siniawski
Loyola Marymount University
Matthew.Siniawski@lmu.edu

Loyola Marymount University

Project 1

Introduction to Engineering

Project Overview

The goal of this project is for teams of three students to design, construct, and test the most efficient bridge within the specifications. Model bridges are intended to be simplified versions of real-world bridges, which are designed to accept a load in any position and permit the load to travel across the entire bridge.

Project & Class Schedule

Day	Date	Design Activities
Friday	8/31	Team Formation, Project Requirements
Monday	9/3	*No class – Labor Day*
Wednesday	9/5	Research and Modeling
Friday	9/7	Design 1 Implementing
Monday	9/10	Design 1 Testing
Wednesday	9/12	Design 1 Testing
Friday	9/14	Design 2 Implementing
Monday	9/17	Design 2 Testing
Wednesday	9/19	Design 2 Testing
Friday	9/21	Technical Presentations

Technical Presentation Information

Each team will deliver a 5-minute technical presentation. Every team member must participate in the presentation. The presentation should briefly discuss the design selection process, the construction stage, and the testing results.

Milestones

September 10 (September 12)
Design 1 Testing

September 17 (September 19)
Design 2 Testing

September 21
Technical Presentations

Submitted by: Matt Siniawski
Loyola Marymount University
Matthew.Siniawski@lmu.edu

Dimensional Requirements

1. The bridge must span a distance of 20 in.
2. The maximum dimensions of the bridge are: 22 in. length, 5.5 in. width, and 4.5 in. height.
3. Bridge roadway must have a minimum 4" width and 3" height clearance to accommodate traffic (toy truck).
4. The bridge must weight no more than 1 lb. (453.6 g)

Material and Construction Requirements

5. Only white all-purpose glue may be used to hold together all bridge elements.
6. All bridge elements must be made of common wooden craft sticks (4 - 1/2 in. x 3/8 in. x 1/12 in.).
7. The number of wooden craft sticks and the amount of glue used for each bridge is unlimited.
8. No more than 50% of the 3/8 in. side of a stick may be glued to other sticks (i.e. 50% of each side of all sticks must remain unglued).
9. Craft sticks may not be altered or modified in any way, with the following exceptions:
   a. Roadway sticks may be cut and/or sanded (but roadway must adhere to all dimension requirements). Roadway sticks are defined as those that will come in contact with the wheels of the toy truck as it crosses over the bridge.
   b. Sticks may be sanded slightly to remove waxy film prior to gluing.

Loading and Testing Requirements

10. The bridge must accommodate a 4 in. x 4 in. square loading plate to apply the load. The loading plate must be positioned halfway between the loading supports and at approximately the same height as the loading supports.
11. The load will be applied from above.
12. Bridge failure is defined as the inability of the bridge to carry additional load, or a load deflection of 1 in. under the loading, whichever occurs first.
13. Structural efficiency, *E*, is determined according to the following equation:

$$E = \text{Load supported in pounds} \,/\, \text{Weight of bridge in pounds}$$

Submitted by: Matt Siniawski
Loyola Marymount
University

Matthew.Siniawski@lmu.edu

Loyola Marymount University

Project 2

Introduction to Engineering

Submitted by: Matt Siniawski
Loyola Marymount University
Matthew.Siniawski@lmu.edu

Project Overview

The goal of this project is for your teams to design, construct, and test an inexpensive solar oven. Solar ovens, or solar cookers, are devices that use the energy of sunlight to heat food or drink to cook or sterilize it. The majority of solar ovens are relatively cheap, low-tech devices that do not require fuel or cost to operate.

Project & Class Schedule

Day	Date	Project Activities
Wednesday	9/26	Overview
Friday	9/28	Research
Monday	10/1	Project 2 Competition Proposal Presentations
Wednesday	10/3	Research & Modeling
Friday	10/5	Research & Modeling
Monday	10/8	Implementation
Wednesday	10/10	Implementation & Testing
Friday	10/12	*No Class*
Monday	10/15	Testing
Wednesday	10/17	Project 2 Competition
Friday	10/19	Project 2 Technical Report Due

Project 2 Competition Proposal Presentations

Each team will deliver a 3-minute proposal presentation. All team members must participate in the presentation and each team must turn in one copy of their presentation slides to the instructor. The presentation should discuss what the team thinks the competition rules and scoring criteria should be. After the presentations, the entire class will discuss and decide on the requirements and scoring metrics.

Project 2 Technical Reports

Each team will turn in a hard copy of a technical report. The report is limited to five pages maximum and should discuss the project requirements, the generation and evaluation of design concepts, the development of the design prototype, and the competition results.

Milestones

October 1
Project 2 Competition Proposal Presentations

October 17
Project 2 Competition

October 19
Project 2 Technical Reports Due

Submitted by: Ryan Underdown
Lamar University
ryan.underdown@lamar.edu

Project to Interview a Practicing Engineer

Interview Guidelines

Interview a practicing engineer in your chosen career field using the Practicing Interview Guidelines. The purpose of the interview is to strengthen your career choice by finding out what day to day activities an engineer in your chosen career field performs. The engineer does not have to be in your chosen field. If you are a Mechanical Engineering major, but know a Chemical engineer, feel free to interview that person. Of course, interviewing someone in your field will reveal more about your major, but interviewing outside your field may expose you to a new area of interest. If you do not know a practicing engineer, please contact your department secretary in Cherry 2000 for a referral. In many cases, members of your department advisory council will be willing to participate in your interview. I strongly suggest starting this project immediately. This project represents a large portion of your grade and can be difficult to schedule. You may conduct the interview over the phone or in person. I suggest asking the engineer if you can make a recording of the interview so you will not have to take notes during the interview. Recording the conversation will allow you to focus on the responses and ask additional questions not on the guidelines. Some engineers may not want to be recorded, so be prepared to take notes. My graduate assistant will be grading your interview on format and quality. Use the interview template provided. Follow the format exactly and submit a comprehensive interview (thus no one pagers - give me at least 2 good pages single spaced, 12 point font, one inch page margins). Submit your interview (using the interview template provided in Word 2003) via my blackboard email address BEFORE November 30, 2009 at 10:00 PM. Interviews submitted after the deadline may not be accepted. Interviews will only be accepted via email attachments. Interviews cannot be submitted in class or handing it to me in person. Only electronic submitals via email will be accepted.

The questions in the interview template file are not meant to be all-inclusive, but a good place to start in your interview. Expand each section of the document as needed for your responses, but keep the headings.

When contacting the engineer you wish to interview, remember, this person is taking his/her time to talk to you. Please be prompt, courteous, and respectful of that person's time. Try to keep your interview as close to ONE HOUR as possible. If the engineer chooses to extend-the interview, try to minimize the extra time. A short tour of the engineer's workplace might be helpful, if time permits.

INEN 1101 - Introduction To Engineering
Practicing Engineer Interview

Student name:
Date:

A. Introduction to Practicing Engineer
Name:
Degree:
Certifications:
Company:
Position:
Years of experience in various positions:
Phone:
Email:

B. Job/Career Related Information
1. Daily duties

2. Length of service with the company

3. Perception of his/her academic preparation

4. Career path if advancements have occurred

5. Personality strengths

6. Method of choosing that particular career

7. Method of choosing the company to work for

8. Recommendations for career-related activities to strengthen your academic program.

9. Recommendations for extra-curricular activities to strengthen your academic program

10. Recommendations For Your Academic Program

Additional Questions:

Submitted by: Andy Lau
asl1@engr.psu.edu
Elizabeth Wiggins-Lopez
exw16@psu.edu
Pennsylvania State University

Reverse Engineering of a Simple Machine

Project Purpose:
This project provides an opportunity to recreate an existing mousetrap simple machine design. The goal is to redesign the machine and build a more efficient, cost effective, safer simple machine. In this project, the physical concepts of work done by a variable force and work done by gravity are used as the basis for analysis.

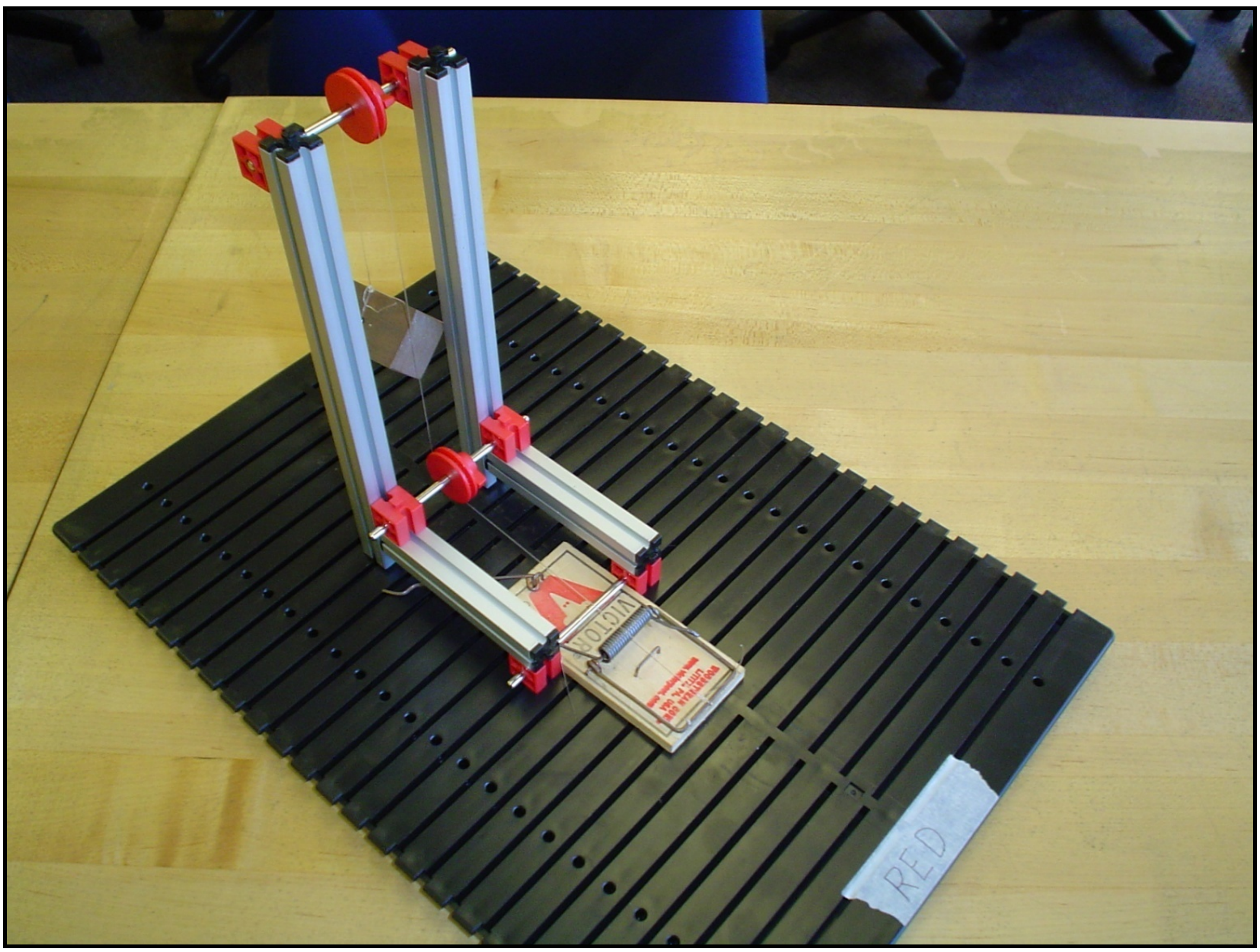


Figure 1: Baseline Simple Machine

Project Description:

Figure 1 shows the baseline simple machine which uses a mousetrap to raise an object using fishing line. When the mousetrap is set, the presence of the loaded spring gives it elastic potential energy in the form of strain. At the moment the spring is released, the potential energy is converted to kinetic energy. Once the object is raised, it stores gravitational potential energy.

Loaded Spring → Released Spring → Raised Object

Potential Energy → Kinetic Energy → Potential Energy

The goals of this project are as follows:

- to conceptually design a system to meet desired needs within realistic constraints.
- to participate effectively in small teams.
- to communicate effectively using written and graphical forms and oral presentations.
- to use software tools relevant to engineering

To accomplish the above goals, students will:

- generate multiple concept solutions and choose the best by methodically evaluating them for a given set of design objectives.
- construct a physical prototype of a design concept.
- assess the success of the concept vis-à-vis the design objectives.
- contribute fairly to team project work.
- take responsibility as team members.
- develop and follow a timetable to complete a task.
- explain and defend a decision based on substantiated data, both verbally and in written form.
- utilize a wide variety of resources and tools to communicate their ideas.
- communicate their ideas and concepts using hand sketches such as pictorial and multi-views.
- summarize and communicate design activities from problem development through final conceptual using oral, graphical, and written communication.
- use modeling for conceptual development and design communication.
- use word processing, spreadsheets, and presentation software.

The equipment, a material list, and part descriptions are given in Tables 1 and 2.

Table 1: Equipment and Material List

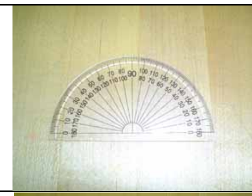
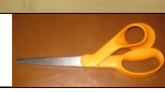
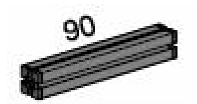
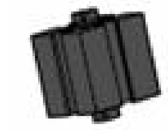
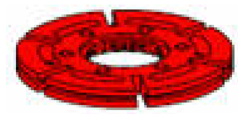
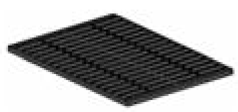
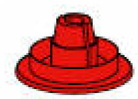
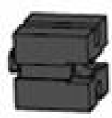
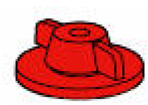
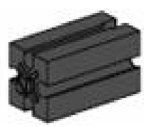
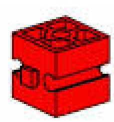
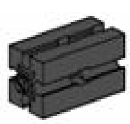
Part No.	Part Name	Quantity	Picture
1	Protractor	1	
2	Ruler	1	
3	Spring Scale(s)	2	
4	Base Plate	1	
5	Mousetrap	1	
6	Steel Weight	1	
7	Fishing Line	3 ft	
8	Scissors	1	

Table 2: Fischertechnik Parts

Picture	Description	Picture	Description
	Bar 90		Block Pegged
	Bar 210		Pulley 60
	BasePlate		PulleyHubChuck
	Block 15		PulleyHubNut
	Block 30		Rod 60
	BlockBored		Rod 110
	Block Holed		

Project Principles:

In this project, the physical concepts of work done by a variable force and work done by gravity are used as the basis for analysis.

Output Work: The gravitational potential energy represents the capacity of the particle to do work by virtue of its height above the surface of the Earth.

$$W = mg(y_1 - y_2) \qquad (1)$$

Input Work: When the mousetrap is set, the presence of the loaded spring gives it elastic potential energy in the form of strain. The mousetrap performs work on the simple machine, when it is released. The force the mousetrap exerts is not constant; it varies with the position/displacement of the spring arm.

Work Done by a Variable Force: The work done on a particle by such a varying force is defined as the product of the average value of the force and the displacement.

$$W = \bar{F}_x \Delta x \qquad (2)$$

Figure 2 shows the graphical interpretation of the work done by a variable force as the area between the curve of the spring force and the x axis, between the initial and final position.

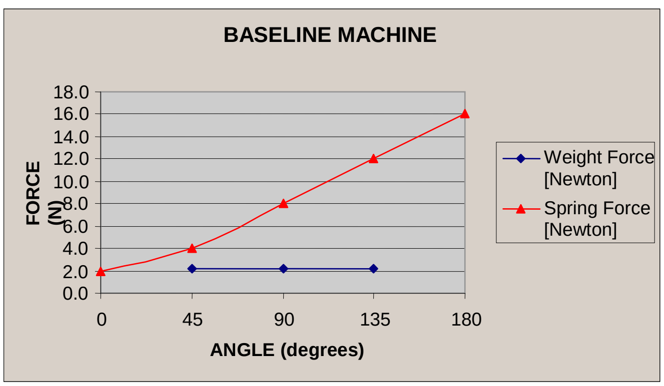


Figure 2: Work Done by a Variable Force at Angular Displacements

Since the spring arm of the mousetrap rotates, the displacement is angular, not linear. The rotational analog for work is as follows.

$$W = \bar{\tau}_\phi \Delta\phi \qquad (3)$$

The torque or "twist" provided by a force of a given magnitude F is maximum if the force is at right angles to the radius, $\theta = 90°$. (Hold the spring scale perpendicular to the spring arm in order measure the maximum force at each angular displacement.)

$$\tau = FR\sin\theta \qquad (4)$$

Note: $\sin\theta = 1, when \theta = 90°$

To calculate the displacement of the spring arm, the spring angle must be converted from degrees to radians, ϕ.

$$\text{Conversion Factor: } 360° = 2\pi \qquad (5)$$

The spring arc or magnitude of the displacement for the spring, s is calculated by the product of the spring radius, R, and the angular displacement, $\Delta\phi$.

$$s = R\Delta\phi \qquad (6)$$

Note the length *s* is the arc length the end of the mousetrap arm travels or half the circumference of a circle.

Figure 3 shows the graphical interpretation of the work done by the mousetrap as the area between the curve of the spring force and the x axis, between the initial and final position.

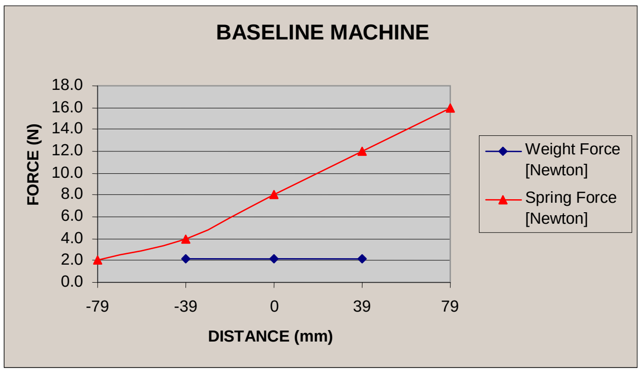


Figure 3: Work Done by a Variable Force at Linear Displacements
(in this case the angular displacement has been converted to linear displacement)

Hence, to calculate the input work of the mousetrap simple machine, calculate the area under the spring force curve. Similarly, the output work can be determined by calculating the area under the weight force line.

$$\text{Area of a triangle: } A_{triangle} = \frac{1}{2}bh \qquad (7)$$

$$\text{Area of a rectangle: } A_{rectangle} = bh \qquad (8)$$

To measure the efficiency of the baseline mousetrap machine, the following equation may be used.

$$Efficiency\ (\%) = (W_{output} / W_{input}) * 100\% \qquad (9)$$

To determine the cost of the mousetrap simple machine, the following equation may be used.

$$Cost\ (\$) = \$3.50\sqrt{(N * T)} \qquad (10)$$

where: *N* is the Number of Parts
T is the Number of Part Types
$3.50 is the average cost of a Fischertechnik Part

Project Analysis:

Decision Matrix/Pugh'sSelection Method:A decision matrix or Pugh's selection method is a tool that can be used to determine which simple machine design is the best based on a set of criteria. There are several configurations for a decision matrix. For this project, the decision matrix shown in Table 3may be used.

Instructions for Using the Following Pugh's Selection Method:

a. Select the attributes of the simple machines to be used for comparison in selecting the best machine. List them in the requirement column.
b. Assign a weight to each attribute indicating the importance in the decision making process.
    - 1 indicates an attribute has low importance.
    - 2 indicates an attribute has medium importance.
    - 4 indicates an attribute has high importance.
c. Rate each attribute for each redesigned simple machine.
    - -1 to -4 indicates the redesigned machine does not rate better than the baseline in that specific attribute.
    - 0 indicates the redesigned machine rates the same as the baseline in that specific attribute.
    - +1 to +4 indicates the redesigned machine rates better than the baseline in that specific attribute.
d. Multiply the weight and rate for each attribute to calculate a score.
e. Add the scores of each attribute to obtain a Total Score.
f. Select the concept with the highest score as the best simple machine.

Table 3: Simple Machine Pugh's Selection Method*

Requirement	**Weighting**	**Baseline Concept**		**Redesign 1**		**Redesign 2**		**Redesign 3**		**Redesign 4**	
	[1, 2, or 4]	rating	score	rating [-1,0 or +1]	score	rating [-1,0 or +1]	score	rating [-1,0 or +1]	score	rating [-1,0 or +1]	score
Cost		0	0								
Efficiency		0	0								
Safety		0	0								
Repeatability		0	0								
Manufacturability		0	0								
Ease of Use		0	0								
Functionality		0	0								
		0	0								
Total			0								

*Notes:
1. The attributes listed in Table 3 are samples. Cost, efficiency, safety and repeatability must be used. Other attributes may be added as needed.
2. There are two types of attributes that can be used when comparing alternatives.
   a. Quantitative – can be compared by calculated values (i.e. cost and efficiency)
   b. Qualitative – needs to be compared by observation or inspection (i.e. safety and repeatability)
3. If two or more machines are tied for the highest score, more attributes for comparison might need to be added.

The following Exercises will be completed through the duration of the Simple Machine Project.

Exercise1: Working Drawing

Your team will receive a set of Fischertechnik Parts.

- As a team, assign several parts to each team member.
- Determine the orthographic views of your assigned parts.
- Measure your assigned parts
- Practice sketching your assigned parts (isometric and orthographic views)
- Practice drawing the part to scale (isometric & orthographic views)
- Create a detail drawing of your assigned parts, (reference Detail Drawing from the Working Drawings Power Point presentation)
- Save the set of working drawings to your shared team in Angel.

Notes:

- Detail Drawing must be in landscape page orientation
- Title blocks must be consistent on every drawing
- Units must be consistent on every drawing

Exercise2: CAD Modeling& Assembly Modeling-Baseline Machine

Each individual student models all the Fischertechnik parts used in the Baseline Simple Machine in SolidWorksusing the detail drawings created. Submit all parts in the associated Angel drop boxes.

Each individual student models the baseline simple machine as an assembly in Solid Works using his/her own parts. Submit the assembly in the associated Angel drop box.

Activity1: Build and Test the Baseline Machine

Step 1 – Create a Bill of Material for the Baseline Machine. (Table 4 may be used as a starting point.)

Table 4: Baseline Simple Machine Bill of Material

Item	Name	Description	Quantity
1	Base Plate	Mounting Platform	1
2	Mousetrap Spring	Energy Supply	1
3	Steel Weight	Work Extractor	1
4	Fishing Line	Connecting Device	1
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Step 2–Obtain the Input Work Data(Energy Provided/Potential Energy).

a. Measure the mousetrap torque arm and record the data in Table 5.
b. Measure the force of spring from 0° to 180° in 45° increments and record them in Table 6. (The spring scale must be held perpendicular to the torque arm for a correct value of force.)
   - Clip the spring scale to the mousetrap torque arm.
   - Hold a protractor to the mousetrap so that the center point of the protractor is in the middle of the spring.
   - To measure the force at 0°, apply force with the spring scale and record the force exerted before lifting the torque arm.
   - Pull up the spring scale to 45°. Record the force required to maintain the torque arm at 45°, 90°, 135°, and 180°.

Table 5: Spring/Torque Arm Measurements Data Collection

Spring/Torque Arm Radius (in)	Trial 1	Trial 2	Trial 3
R			

Table 6: Input Work – Angular Displacement Data Collection

Angular Displacement	FORCE Trial 1 (N)	FORCE Trial 2 (N)	FORCE Trial 3 (N)
$F_{0°}$			
$F_{45°}$			
$F_{90°}$			
$F_{135°}$			
$F_{180°}$			

Step 3 – Obtain the Output Work Data (Useful Work).

a. Attach thesteel weight to the fishing line.
b. Using the spring scale, weigh thesteel weight, and record the data in Table 7.
c. Recreate the baseline mousetrap simple machine from the picture.
d. Set the mousetrap and record the initial position of the steel weightrelative to the baseplate ($y_{initial}$) in Table 8.
e. Release the mousetrap and record the final position of the steel weightrelative to the baseplate (y_{final}) in Table 8.

Table 7: Weight of Steel Weight Data Collection

Weight of Object (N)	Trial 1	Trial 2	Trial 3
F_{object}			

Table 8: Baseline Machine Output Work – Displacement of Steel Weight Data Collection

Displacement (in)	Trial 1	Trial 2	Trial 3
$y_{initial}$			
y_{final}			

Step 4 – Analyzethe Baseline Simple Machine.

a. Determine the qualitative attributes of the simple machine to be used for the decision matrix and record them in Table 9.
b. Observe the baseline simple machine in use and create a list of advantages and disadvantages and record them in Table 9.

Table 9: Baseline Machine Analysis

Attributes:	
Advantages:	
Disadvantages:	

Exercise 3: Analysis of Baseline Machine

Create a dynamic spreadsheet using functions to complete the analysis of the baseline machine per the following steps.

Step 1 – Compute the Input Work (computer analysis).

a. Convert the spring radius (in)to the spring arc (mm) using the data from Table 5 and completing Table 10. Note: 1 in = 25.4 mm.
b. Calculate the average force required to maintain the torque arm at 45°, 90°, 135°, and 180° using the data from Table 6 and completing Table 14.

Table 10: Input Work – Spring Arc

Spring/Torque Arm Radius (mm)	Trial 1	Trial 2	Trial 3
R			
Average Spring/Torque Arm Radius			mm
Maximum Spring Angle of Rotation		π	rad
Spring Arc			**mm**

Table 11: Input Work – Angular Displacement

Angular Displacement	FORCE Trial 1 (N)	FORCE Trial 2 (N)	FORCE Trial 3 (N)	Average (N)
$F_{0°}$				
$F_{45°}$				
$F_{90°}$				
$F_{135°}$				
$F_{180°}$				

Step 2 – Compute the Output Work (computer analysis).

a. Convert the steel weight displacement to mm and calculate the average steel weight displacement for all of the machines using the data from Tables 8 and 11 and completing Table 12.
b. Calculate the average weight of the steel weight using the data from Table 7 and completing Table 13.

Table 12: Output Work – Displacement of Steel Weight

Baseline Machine	Object Displacement (mm)	Trial 1	Trial 2	Trial 3	Average
	Initial Position				
	Final Position				
	Displacement				

Table 13: Weight of Steel Weight

Weight of Steel Weight (N)	Trial 1	Trial 2	Trial 3	Average
F_{object}				

Step 3 –Calculate the Machine Performance (computer analysis).

a. Convert the input work angular displacement to linear displacement and record in Table 14.Reference Figures 2 and 3.
b. Using the data from Tables 11 through 14, graph the output work versus the input work using linear displacement for the baseline machine.
c. Calculate the output work for the baseline machine and record the data in Table 15.
d. Calculate the input workfor the baseline machine and record the data in Table 16.
e. Calculate the efficiency of the baseline machine per equation 9 and record the data in Table 17.

Table 14: Input Work Angular to Linear Displacement

Angular Displacement	Linear Displacement (mm)
0°	0
45°	$r\ \pi/4 =$
90°	$r\ \pi/2 =$
135°	$r\ 3\pi/4 =$
180°	$r\ \pi =$

Table 15: Output Work Analysis of Simple Machines

Simple Machine	**Output Work (mJ) (Area under Weight Force Curve)**
Baseline	

Table 16: Input Work Analysis of Simple Machines

Simple Machine	**Input Work (mJ) (Area under Spring Force Curve)**
Baseline	

Table 17: Efficiency Analysis of the Simple Machines

Simple Machine	**Output Work (mJ)**	**Input Work (mJ)**	**Efficiency**
Baseline			

Exercise 4: CAD Assembly Modeling-Redesigned Machines

As a team, develop one redesigned simple machine per team member. Model eachredesigned simple machine per team member as a CAD assembly in Solid Works.

Activity 2: Build and Test Each Redesigned Machine

Complete the Bill of Material foreach redesigned simple machine and record the data in Table 18.

Table 18: Redesigned Simple Machine Bill of Material

	Item	Name	Description	Quantity
Redesign 1	1	Base Plate	Mounting Platform	1
	2	Mousetrap Spring	Energy Supply	1
	3	Steel Weight	Work Extractor	1
	4	Fishing Line	Connecting Device	1
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
Redesign 2	**Item**	**Name**	**Description**	**Quantity**
	1	Base Plate	Mounting Platform	1
	2	Mousetrap Spring	Energy Supply	1
	3	Steel Weight	Work Extractor	1
	4	Fishing Line	Connecting Device	1
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			

Table 18: Redesigned Simple Machine Bill of Material (continued)

	Item	Name	Description	Quantity
Redesign 3	1	Base Plate	Mounting Platform	1
	2	Mousetrap Spring	Energy Supply	1
	3	Steel Weight	Work Extractor	1
	4	Fishing Line	Connecting Device	1
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
Redesign 4	**Item**	**Name**	**Description**	**Quantity**
	1	Base Plate	Mounting Platform	1
	2	Mousetrap Spring	Energy Supply	1
	3	Steel Weight	Work Extractor	1
	4	Fishing Line	Connecting Device	1
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			

Build each redesigned simple machine.

Record displacement of weight block for each redesigned simple machine and record the data in Table 19.

Table 19: Redesigned Machine Output Work – Displacement of Steel Weight Data Collection

Redesign 1	**Displacement (in)**	**Trial 1**	**Trial 2**	**Trial 3**
	$y_{initial}$			
	y_{final}			
Redesign 2	**Displacement (in)**	**Trial 1**	**Trial 2**	**Trial 3**
	$y_{initial}$			
	y_{final}			
Redesign 3	**Displacement (in)**	**Trial 1**	**Trial 2**	**Trial 3**
	$y_{initial}$			
	y_{final}			
Redesign 4	**Displacement (in)**	**Trial 1**	**Trial 2**	**Trial 3**
	$y_{initial}$			
	y_{final}			

Record qualitative performance data for each redesigned simple machine.

Table 20: Redesigned Machine Analysis

Redesign 1	**Attributes:**	
	Advantages:	
	Disadvantages:	
Redesign 2	**Attributes:**	
	Advantages:	
	Disadvantages:	
Redesign 3	**Attributes:**	
	Advantages:	
	Disadvantages:	
Redesign 4	**Attributes:**	
	Advantages:	
	Disadvantages:	

Exercise 5: Comparative Analysis of All Machines

Step 1: Using the data from tables 12 and 20, complete table 21.

Table 21: Output Work – Displacement of Steel Weight

	Object Displacement (mm)	Trial 1	Trial 2	Trial 3	Average
Baseline Machine	Initial Position				
	Final Position				
	Displacement				
Redesign 1	**Object Displacement (mm)**	**Trial 1**	**Trial 2**	**Trial 3**	**Average**
	Initial Position				
	Final Position				
	Displacement				
Redesign 2	**Object Displacement (mm)**	**Trial 1**	**Trial 2**	**Trial 3**	**Average**
	Initial Position				
	Final Position				
	Displacement				
Redesign 3	**Object Displacement (mm)**	**Trial 1**	**Trial 2**	**Trial 3**	**Average**
	Initial Position				
	Final Position				
	Displacement				
Redesign 4	**Object Displacement (mm)**	**Trial 1**	**Trial 2**	**Trial 3**	**Average**
	Initial Position				
	Final Position				
	Displacement				

Step 2: Complete table 22& show efficiency graphs for all designs, see figure 3.

Table 22: Efficiency Analysis of the Simple Machines

Simple Machine	Output Work (mJ)	Input Work (mJ)	Efficiency
Baseline			
Redesign 1			
Redesign 2			
Redesign 3			
Redesign 4			

Step 3 - Cost

a. Calculate the cost of the baseline machine and all of the redesigned machines based on the number of parts using equation 10 and record the data in Table 23.

Table 23: Cost Analysis of the Simple Machines

Simple Machine	No. of Parts	No. of Part Types	Cost
Baseline			
Redesign 1			
Redesign 2			
Redesign 3			
Redesign 4			

Step 4 – Compare qualitative attributes of the Baseline versus the Redesigned Simple Machines

Table 24: Redesigned Machine Analysis

Baseline	**Attributes:**	
	Advantages:	
	Disadvantages:	
Redesign 1	**Attributes:**	
	Advantages:	
	Disadvantages:	
Redesign 2	**Attributes:**	
	Advantages:	
	Disadvantages:	
Redesign 3	**Attributes:**	
	Advantages:	
	Disadvantages:	
Redesign 4	**Attributes:**	
	Advantages:	
	Disadvantages:	

Step 5–Analysis of the Baseline versus the Redesigned Simple Machines

a. Complete thedecision matrix or Pugh's selection method to select the bestdesign option, see Table 3.

   Selected Design Option:*Show Decision Matrix*

Submitted by: Todd Easton
Kansas State University
teaston@ksu.edu

Industrial and Manufacturing Systems Engineering
Kansas State University

Lab 3: Edible Engineering Lab - 100 pts

The purpose of this lab is to practice creative problem solving. Since the problem is well defined, the teams should generate relevant alternatives though brainstorming; decide on an alternative, implement and evaluate their solution.

Your assignment is to create a scale that can accurately weigh in grams small items which are less than 60 grams (about 2 oz.). The only catch is that the scale must be entirely edible (20 pts given for eating your scale). Next lab, 10-15 items weighing between 5 and 60 grams will be distributed. Each team will provide their estimate weight of each item. The professor will also build an edible scale, which he must eat.

The accuracy of a scale is determined as the sum of the absolute difference between the estimate and the actual weight of the item. Any group earning achieving a better estimate than the professor earns 80/80 points on the accuracy portion. Any group earning less is given a score based upon how close the group is to the professor's score.

Submitted by: Keith Gardiner
Lehigh University
kg03@Lehigh.EDU

Group Research Study

Group Research Assignment/Executive Report: Students will be randomly assigned into study groups for a group research project. Each group will be given a study topic with the objective of undertaking collaborative research to produce a **two-page *executive report*** that, when finished, must be posted and shared with the whole class to inform them on the status of the topic. This summary should provide appropriate conclusions and recommendations developed and endorsed by the group.

Groups must organize themselves to manage this project, agree on a 'Mission Statement,' communicate and collaborate. Group members named on the final document all receive the same grade. The maximum possible score is 10 pts. *Due date tbd.* Review Chapter 8 in the text and pay particular attention to page 187 and on.

"Executive Report" – a **brief document** ready for rapid reading by an executive **BUT** also containing references to sources clearly showing origins of data and providing sufficient information to convey an understanding and appreciation for the topic and affording recommendations or conclusions that may have been requested. Executive, or Technical Reports, may be accompanied by an **Addenda** with complementary or supplementary materials that are potentially of interest or value but are not absolutely essential to the main narrative.

Confidential Assessment: As a corollary to this group research activity each member of the group must submit a brief (hard copy) confidential assessment evaluating the contributions and performance of each of their colleagues (listed alphabetically with full names including yourself using template provided), recommending and justifying suitable bonus awards sharing $10,000 (virtual) among the group. The template will be posted in Coursesite. The assessment assignment is to be submitted in hardcopy, in class. It will not be accepted via email. *Due date tbd.*
Keith Gardiner, x85070, kg03 – Mohler Labs. Room 323 File: C/Engr98/2012 Fall August, 2012

Ratings: Every student must review and evaluate all of the Executive Reports posted – students' ratings will be used in conjunction with faculty input to determine grades. The rating assignment will be posted in Coursesite.

Project Presentation Evaluation. Hardcopy paper forms will be handed out for assessing 'Content and Delivery' of student project presentations at mid- and end-semester; there will also be digital surveys to evaluate Monday sessions and the lab projects to be dealt with anonymously on Coursesite.

The 56 Group Research Project topics utilized in fall, 2011

Coal Energy	Solar-Photovoltaic	Congestion Charges	"Soft Skills" Training
Liquefied Nat. Gas	Solar-Thermal	Traffic Management	Sustainability
Methane Hydrates	Ultra capacitors	Rail Transportation	Conservation at Lehigh
Oil	New Batteries	Buses	Going "Paperless"
Shale and "Fracking"	Ocean Energy	Feeding the World	Automation vs. Human
Tar Sands	Hydro Resources	Hunger-National, Global	Communication & edia
Hydrogen	Wind Energy	Genetic Engineering-Animals	Agricultural Wastes
Algae-As Future Fuel	Electric Vehicles	Genetic Engineering-Crops	Hybrid Technology
Biomass Energy	Diesel vs. Gasoline	Fish Farming	Harnessing Tides
Butanol, Ethanol	Nuclear Waste	Diet & Legislation(FDA)	Bridge Infrastructure
Carbon Sequestration	Nitrogen Cycle	Poverty-Local, National	Levee Infrastructure
Climate Change	Clean Water	Conservation	"Buy a Volt?"
Fuel Cells	Water Supplies	Rare Earth Materials	Natural Gas
Geothermal Energy	Collision Avoidance	Recycling	Monorails

Submitted by: Melinda Holtzman
Portland State University
holtzman@pdx.edu

Rube Goldberg Project

Engineering is all about doing projects – brainstorming ideas, researching and experimenting, managing your time and resources, working in teams, communicating your results. The main part of this class is a quarter-long, hands-on team project. In the first week you will divide into teams of four or five people and choose one of the following two projects.

1. **Build a Rube Goldberg contraption** to accomplish a simple task of your choosing by the most complicated means possible. Projects will be judged on creativity, clever use of simple materials and the maximum number of steps to reach the goal. The constraint is that at least three electrical engineering elements must be included. For example, these could be using the dc motor to turn or move something, using a sensor to trigger a switch, using a digital logic circuit, an electromagnet, a timer, etc. If you are not familiar with Rube Goldberg machines, here are some (more elaborate) examples:

http://www.youtube.com/watch?v=lCYg_gz4fDo from the Mythbusters TV show

http://www.youtube.com/watch?v=8zN0J_JFFi0 a high school class project

http://www.youtube.com/watch?v=1kvdq8cRNBM an elaborate one from a Japanese competition

Many more can be found online. For information on Rube Goldberg and the history of the competition, see http://en.wikipedia.org/wiki/Rube_Goldberg .

2. **Take engineering to middle school**. Create: (i) a short lively presentation on EE for a middle school class and (ii) a hands-on activity to do with the class. This would be an experiment that the students would, in theory, do themselves, but for the purposes of this project your team will demonstrate it to the class. These projects will also be judged on creativity and use of materials, but also on how they engage the attention of middle-schoolers and inspire them to stay in school, take math and science courses and pursue engineering, particularly electrical engineering, as a career.

For either project, some materials will need to be purchased. Each team will have the free use of a lab kit for the quarter, and those components can also be used in the project. I would estimate roughly that about $10 per person should cover additional materials.

For either project, a written report as well as a presentation/demonstration are required. To make things more interesting, we will make this a friendly competition. The class will vote for the best project and the winning team will win a small prize.

Submitted by: Hailey Queen
North Carolina State University
haqueen@ncsu.edu

NC STATE UNIVERSITY

Bubble Machine Design Project

Objective: Design and build a machine that automatically produces bubbles and launches those bubbles from the machine to float through the air.

Requirement & Constraints:

1. The design must operate automatically. **No** hand cranks.
2. The design may **not** incorporate any parts of commercial bubble-blowing machines. Commercially available bubble wands are acceptable.
3. The team must develop a bubble solution; commercial bubble solution may **not** be used. The recipe for the bubble solution must be submitted during competition.
4. The design may be either line-powered or battery-powered. However, designs are restricted to small battery power – no more than 6 source volts (battery voltage can vary, but a 1.5 volt battery will be considered as such even if it measures 1.6 or 1.4 volts.). Also, consider that batteries generate heat and plan for this element in your design.
5. The design must produce a continuous stream of bubbles for at least one (1) minute.
6. The bubbles must detach from the machine.
7. Electrical safety is a primary concern. Incorporation of electrical components must be reviewed by the guru or your E101 instructor for safety if line-current is being used.
8. Portability – The design must be portable from the team table to the competition area.
9. Points will be awarded for changing bubble size and bubble frequency. This change may be accomplished either automatically or by a team member making a discrete adjustment to the machine in less than 10 seconds. More points will be given to those designs incorporating automatic adjustments.
10. Supplemental Information - Each team should use and read the Wiki message board to keep current on supplemental information relating to this project. All teams will be held responsible for the posted information and any alterations to the competition criteria. Be sure to read ALL messages for this project before posting a specific question (it may have already been answered).
11. Power outlets will be available at Design Day; however, your team must supply an extension cord and power strip for the competition.

12. As with all FEDD projects, this project must be completed within a $40 budget. Found, borrowed or previously owned materials are not considered part of the project budget.

Guru Contact Info:

Competition Judging & Winning: The team that is assessed the most points based on the following competition rubric will win the competition. Judges can assess up to the maximum number of points listed per category, based on how well the individual design performs in that category. In the event of a tie, competition judges will make the final decision on place. On Design Day, the judges must be able to verify that the design meets the above criteria; otherwise the team will be disqualified.

Bubble Blowing Machine Judging Rubric

FRESHMAN ENGINEERING DESIGN DAY

Team Name: ______________________

Team Members: ______________________

____

Section/Instructor: ______________________

Competition Criteria	Points
Meets basic competition requirements:	
No commercial bubble-blowing parts	☐
Recipe submitted	☐
6 V maximum battery-power or line-power	☐
Continuously and automatically operates for 1 minute	☐
Bubbles detach from the machine	☐
Alters Bubble Size	/5
Alters Bubble Frequency	/5
Bubble Volume (number of bubbles)	/5
Creativity in Concept	/5
Craftsmanship (professional appearance and presentation)	/5
Total Points	________

NC STATE UNIVERSITY

Submitted by: Hailey Queen
North Carolina State University
haqueen@ncsu.edu

E 101: Introduction to Engineering & Problem Solving

CONCRETE CANOE

Competition Criteria

Objective: Design, construct, and test a concrete canoe limited by requirements (below).

Requirements, Constraints & Resources

1. Canoe length can be no more than 18 inches.
2. Width can be no more than 1/3 the length.
3. Depth can be no greater than width.
4. Canoe should be constructed of reinforced concrete.

   Reinforced Concrete = Water + Cement + Aggregate + Reinforcements
5. There are no restrictions on the water to concrete ratios that may be used.
6. Aggregate cannot show in the final design.
7. Reinforcements cannot show in the final design.
8. For further ideas see the American Concrete Institute's (ACI) website on admixtures: http://www.concrete.org/general/home.asp
9. As with all FEDD projects, this project must be completed within a $40 budget. Found, borrowed or previously owned materials are not considered part of the project budget.

Potential Pitfalls

1. Paint dissolving.
2. Concrete disintegrating.
3. Concrete expansion.
4. Others... (you may talk about these in your presentation)

Guru Contact Info:

Competition Judging & Winning: The team that is assessed the most points based on the following competition rubric will win the competition. Judges can assess up to the maximum number of points listed per category, based on how well the individual design performs in that category. In the event of a tie, competition judges will make the final decision on place. On Design Day, the judges must be able to verify that the design meets the above criteria; otherwise the team will be disqualified.

Canoe Testing Judging Rubric

FRESHMAN ENGINEERING DESIGN DAY

Team Name: ______________________________

Team Members: ______________________________

____

Section/Instructor: ______________________________

Competition Criteria		Points
Meets basic competition requirements:		
Length not more than 18 inches	☐	
Width not more than 1/3 the length	☐	
Depth not greater than width	☐	
Aggregate does not show	☐	
Reinforcement does not show	☐	
Flotation (amount of weight held before sinking)		____
Craftsmanship (professional in appearance & resembles an actual canoe)		_____ /10
Total Points		____________

Submitted by: Hailey Queen
North Carolina State University
haqueen@ncsu.edu

E 101: Introduction to Engineering & Problem Solving

FOUNTAIN PROJECT

Competition Criteria

Objective: Engineers are often challenged with designing and building products that not only meet technical specifications for operation, but also satisfy 'fuzzy' customer requirements that are not always easy to define. The objective of this project is to build a liquid fountain (think garden or foyer, not hallway drinking fountain) that requires investigation and mastery of mechanical and electrical engineering concepts, but also incorporates various aesthetic and customer-focused elements.

Requirement & Constraints:

1. The fountain must continuously and automatically circulate liquid (using discrete bursts of liquid will satisfy the continuous requirement). Plan to operate the design for several hours at Design Day.
2. The design may incorporate either line-powered or battery-powered pumps, as well as line and/or battery powered components. However, consider that batteries generate heat and plan for this element in your design.
3. Space Constraint – the footprint of the design is restricted to 2'x2'. Height is not restricted, although keep in mind that the design must be transported to and from the Design Day site.
4. Electrical safety is a primary concern. Incorporation of electrical components outside of off-the-shelf water pumps must be reviewed by the guru for safety. Pump casings may not be modified in any way, they must remain sealed.
5. Power outlets will be available at Design Day; however, your team must supply an extension cord for the competition.
6. Supplemental Information - Each team should use and read the Wiki message board to keep current on supplemental information relating to this project. All teams will be held responsible for the posted information and any alterations to the competition criteria. Be sure to read ALL messages for this project before posting a specific question (it may have already been answered).
7. A significant number of points will be awarded to designs that incorporate free-flowing movement of liquid against gravity.

For instance, a design in which the liquid flows down a landscape will meet the basic requirements, but will not receive the points that a design which allows the liquid to 'catch air', so to speak.

8. Seek to minimize splashing – imagine that your design must sit in the foyer of a company on an expensive mahogany table. Up to 5 points may be deducted for splashing.
9. Other things to consider – In previous years, the winners of this competition have developed very creative and unique solutions to this design challenge. Think outside of the box!
10. NO live animals are permitted. Use of fish, turtles, frogs or any other living creature will result in disqualification of completion.
11. **Competition Judging & Winning:** The team that is assessed the most points based on the following competition rubric will win the competition. Judges can assess up to the maximum number of points listed per category, based on how well the individual design performs in that category. In the event of a tie, competition judges will make the final decision on place. On Design Day, the judges must be able to verify that the design meets the above criteria; otherwise the team will be disqualified.
12.

Fountain Judging Rubric
FRESHMAN ENGINEERING DESIGN DAY

Team Name: ______________________________

Team Members: ______________________________

____

Section/Instructor:

Competition Criteria	Points
Meets basic competition requirements:	
Continuously fountains water	☐
2'x2' footprint	☐
Craftsmanship (professional appearance and presentation)	/7.5
Incorporates free-flowing liquid movement against gravity	/7.5
Creativity in operation	/5
Creativity in concept	/5

Creativity in:	
Sound	/2.5
Light/Illumination	/2.5
Color	/2.5
Movement	/2.5
Other	/2.5
Deductions for Splashing	**/5**
Total Points	**/37.5**

Guru Contact Info:

NC STATE UNIVERSITY

Submitted by: Hailey Queen
North Carolina State University
haqueen@ncsu.edu

E 101: Introduction to Engineering & Problem Solving

RUBE GOLDBERG MACHINE

Competition Criteria

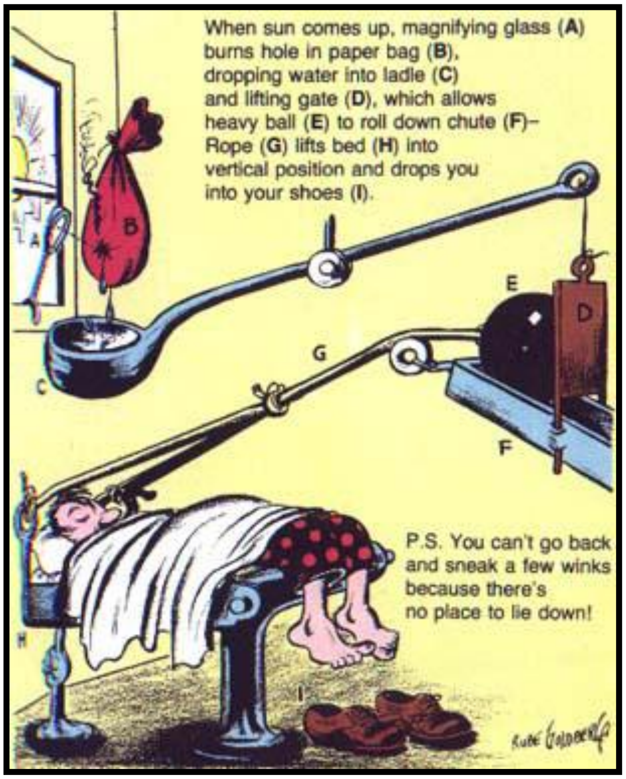
Objective: Design and build a series of elaborate machines designed to perform the simple task of depositing a quarter into a coffee cup, similar to cartoons drawn by engineer and artists Rube Goldberg. Once started this machine should be able to run continuously creating the idea a of perpetual motion, Rube Goldberg machine.

Requirement & Constraints:

1. The machine must contain a minimum of ***3 simple machines***.
    a. Simple Machines include: the level, the wheel & axle, the pulley, the inclined plane, the wedge and the screw.
    b. Simple machines of the same type that are used in series only count as one machine. For example three levers in a row only count as a single simple machine.
2. All simple machines must operate sequentially such that the output of one simple machine activates the next simple machine.
3. Don’t get too complicated! You have to build a machine that works.
4. Once the machine is started it should be able to run continuously without human intervention. There should be little to no setup time between machine “runs.”
5. Safety is the most important element in design. Designs may **not** include dangerous projectiles, fire, explosives, sharp objects, chemical reactions, heat, high voltage, etc.
6. All designs must be approved by the class instructor prior to construction.
7. The machine must be portable so that it can be set up for competition on Freshman Engineering Design Day.
8. The machine must not be more than 2 feet wide, 3 feet long and 3 feet high.
9. Potential power sources include (but are not limited to): springs, elastic, gravity, air, magnets, water, and small 3-volt DC motors. Other power sources should be discussed with the project guru.
10. The Rube Goldberg machine should be built from easy to find materials: wood, metal, rubber, plastic, paper, string, tape, glue, etc. Other materials should be discussed with the project guru.

11. As with all FEDD projects, this project must be completed within a $40 budget. Found, borrowed or previously owned materials are not considered part of the project budget.

Guru Contact Info:



See the Honda "Cog" commercial for some inspiration at http://www.honda.co.uk/

Competition Judging & Winning: The team that is assessed the most points (between 0 & 100) based on the following competition rubric will win the competition. Judges can assess up to the maximum number of points listed per category, based on how well the individual design performs in that category. In the event of a tie, competition judges will make the final decision on place. On Design Day, the judges must be able to verify that the design meets the above criteria; otherwise the team will be disqualified.

Judges may subjectively award bonus points for extraordinary achievement in any judging category.

Rube Goldberg Judging Rubric

FRESHMAN ENGINEERING DESIGN DAY

Team Name: ______________________________

Team Members: ______________________________

____

Section/Instructor: ______________________________

Competition Criteria	Points
Meets basic competition requirements:	
Within required dimensions	☐
Contains at least 3 different simple machines	☐
Simple machines operate in sequence	☐
Successfully Completes Task	/25
Runs Continuously (less than 30 seconds between runs)	/25
Creativity	/25
Craftsmanship & Materials used	/25
Extraordinary Achievement	/bonus
Total	________

Submitted by: Hailey Queen
North Carolina State University
haqueen@ncsu.edu

E 101: Introduction to Engineering & Problem Solving

ARCADE GAME

Competition Criteria

Objective: Design and build a mechanical vintage table top arcade game that is creative, fun to play, and utilizes both luck and skill.

Requirement & Constraints:

1. The game must entail at least four ***different*** actions using a power source against a moving object such as a ball.
2. At least one action must involve the skill of the player. For example using flippers to keep a ball in play.
3. Potential power sources include (but are not limited to): springs, elastic, gravity, air, magnets, water, small 3-volt DC motors, and human intervention (ex. flippers). Other power sources should be discussed with the project guru.
4. Passive actions, such as guides for a ball, may be used as desired.
5. There must be a mechanism to calculate a game score. This can be a simple manual process.
6. The arcade game should be built from easy to find materials: wood, metal, rubber, plastic, paper, string, tape, glue, etc. Other materials should be discussed with the project guru.
7. The entire game must be portable so that it can be set up on Freshman Engineering Design Day.
8. The entire game must have dimensions no more than 2 feet wide, 3 feet long and 3 feet high.
9. All designs must be safe. Games may **not** include projectiles, fire, explosives, sharp objects, chemical reactions, heat, high voltage, etc.
10. All designs requiring approval must be approved by the class instructor prior to construction.
11. As with all FEDD projects, this project must be completed within a $40 budget. Found, borrowed or previously owned materials are not considered part of the project budget.

It should be considered that this project may require construction skills, access to tools and a workplace, as these will be needed to successfully complete the project.

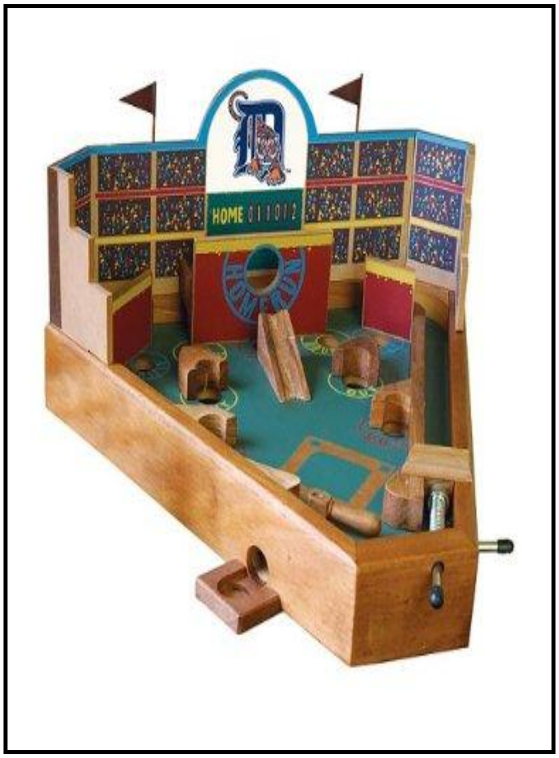
Guru Contact Info:

For questions contact or look to Wiki site for frequently asked questions.

Arcade Games – Past And Present

NC STATE UNIVERSITY

Arcade Games – Past And Present



Competition Judging & Winning: The team that is assessed the most points (between 0 & 100) based on the following competition rubric will win the competition. Judges can assess up to the maximum number of points listed per category, based on how well the individual design performs in that category. In the event of a tie, competition judges will make the final decision on place. On Design Day, the judges must be able to verify that the design meets the above criteria; otherwise the team will be disqualified.

Judges may subjectively award bonus points for extraordinary achievement in any judging category. For example, some form of interlock mechanism used to start the game. Commercial arcade games tend to require the player to insert a coin. However, many other options exist, such as requiring a mechanical operation or an electronic code.

Arcade Game Judging Rubric

FRESHMAN ENGINEERING DESIGN DAY

Team Name: ______________________________

Team Members: ______________________________

____

Section/Instructor: ______________________________

Competition Criteria	Points
Meets basic competition requirements: Within required dimensions	☐
Meets Game Action Specifications (4 actions;1 requiring skill)	/25
Entertainment Value (fun, decoration, difficulty, challenge)	/25
Creativity & Artistic Value (originality, cleverness, esthetics)	/25
Craftsmanship & Materials used	/25
Extraordinary Achievement	/bonus
Total	________

NC STATE UNIVERSITY

Submitted by: Hailey Queen
North Carolina State University
haqueen@ncsu.edu

E 101: Introduction to Engineering & Problem Solving

HOVERCRAFT RACE

Competition Criteria

Objective: Design and build a hovercraft that will navigate a course in the shortest time possible.

Requirements, Constraints & Resources:

HOVERCRAFT

1. The hovercraft may be powered by battery or ac power via an extension cord.
2. Gasoline powered craft will **not** be allowed.
3. The design may **not** incorporate any parts of commercially available hovercraft, helicopter or hovercraft kit. Use or suspected use of such parts will result in immediate disqualification.
4. The hovercraft should allow for required movement within the 1.5 foot wide race track without any part of the craft going off the track (see COURSE requirements & constraints).
5. Any decisions regarding disqualification made by judges will be final.
6. Turning the hovercraft must be accomplished by actuating something on the craft itself, either remotely or by active intervention.
7. The hovercraft may **not** be pushed or pulled by team members.
8. The hovercraft must be tested at an official FEDD pre-event, which will take place one week before FEDD (Tuesday, 11/13/2012). Time and location TBA. **This FEDD pre-event is mandatory**. Groups not represented at this event will not be allowed compete at FEDD.
9. The following resources may be of assistance: http://www.rqriley.com/hc-calc.html, http://www.hoverhawk.com/lcalc.html , http://www.hoverhawk.com/propspd.html
10. As with all FEDD projects, this project must be completed within a $40 budget. Found, borrowed or previously owned materials are not considered part of the project budget.

11. The course will be laid out on a floor that will be **carpeted** inside the McKimmon Center ballroom. (Students are cautioned that testing the hovercraft on a tile floor may not yield the same results that carpet would.)
12. The floor surface may not be perfectly flat (this should be considered during design).
13. The course will be less than fifty linear feet in length and will be 1.5 feet in width.
14. The course will contain multiple turns of up to 90 degrees.

Guru Contact Info:

Competition Judging & Winning: The team that is assessed the most points based on the following competition rubric will win the competition. Judges can assess up to the maximum number of points listed per category, based on how well the individual design performs in that category. In the event of a tie, competition judges will make the final decision on place. On Design Day, the judges must be able to verify that the design meets the above criteria; otherwise the team will be disqualified.

Hovercraft Race Judging Rubric
FRESHMAN ENGINEERING DESIGN DAY

Team Name: ____________________

Team Members: ____________________

____

Section/Instructor: ____________________

Competition Criteria	Points
Meets basic competition requirements: Attended FEDD pre-event Battery-power or line-power (no gasoline-power)	 ☐ ☐
The fastest competitor will be awarded 200 points. The second fastest competitor will be awarded 195 points, etc. Course was completed (time in seconds):	________
Number of times craft violated course boundary (penalty):	____X -3
Craftsmanship (professional appearance and presentation)	/5
BONUS: Hovercraft remotely navigated.	+ 5

BONUS: On board power source.	+5
Total Points	____________

CALIFORNIA STATE POLYTECHNIC UNIVERSITY, POMONA
EGR 100L -Winter Quarter, 2012

Submitted by: Milton Randle
Cal Poly Pomona
mrandle@csupomona.edu

Mini Rose Parade Float Project

The EGR 100L students shall undertake a class project to design and build a functional model of a parade float similar to those constructed for the annual Rose Parade in Pasadena, CA on New Years Day. This effort shall be implemented by teams of students responsible for one or several aspects of the float, with continued overall class meetings to coordinate the efforts relative to the finished product. Materials shall be both at the discretion of the group and as specified by the instructor. The theme for the float designs shall be ***"Oh, the Places You'll Go!"***

The mini rose float parade route is 30 feet long. There is a speed bump at 10 feet and a bridge at 20 feet.

Mini Rose Float Specifications

1. The overall envelope of the float shall be 24 inches maximum in length, 12 inches maximum in width, and be capable of traveling under a bridge that has a 12 inch clearance. **These dimensions are checked at the beginning but can change once the float is in motion.**
2. The drivetrain shall be constructed using Legos Mindstorms parts. During week 6, each team will be provided a kit that includes 2 motors, 1 programmable brick, 4 wheels, and the necessary parts to fabricate the float's drivetrain. No Lego Mindstorms parts can be used on the float surface. This part of the float must be easily removed afterwards, disassembled, and returned to EGR100 cabinets. Students are responsible for making sure the batteries are charged prior to the parade competition.
3. The model shall utilize wheels and tires from the Lego Mindstorms kit.
4. The float will utilize Lego Mindstorms gears and the proper programming to provide a final speed of four (4) feet per minute.
5. The model should travel in a straight line, and does not need steering capability.
6. The model may have limited suspension to prevent malfunction when passing over a 0.5 inch high speed bump.
7. The float framework shall be constructed of a light weight material. It should be designed to fit over the Lego Mindstorms NXT drivetrain without the use of glue, to allow easy access to the brick.
8. Commercially available building kits are not allowed other than the Lego Mindstorms drive train described above. The float will be built from scratch, including decorations. **Please note mini-figures such as ready-made dolls and models are not allowed.**
9. Any items in question can be submitted to the team of EGR100L instructors for approval.
10. Remote control is not allowed.
11. The float shall contain a minimum of three (3) separate animated displays.
    The float with all animations shall fit within the above envelope. No Lego parts or Lego motors can be used for the animations; they will only be used for the drive train.
12. The animation systems shall utilize a frame work that can be attached to the float frame.
13. The separate animation displays shall be powered by **motors** and 1.5 volt batteries. Each animation will have an on/off switch. The dc motor speed reductions shall be by gear, belt, or chain drives. The display or animation drives may not rely on the float drive system.
14. Subjects for the displays may take the form of:
    a. characters with movements
    b. merry-go-round
    c. slide
    d. parachute drop
    e. train
    f. etc.
15. At least part of the float must be decorated with items found in nature.

16. The float covering and decorating materials shall be approved by the instructor and shall be easily removable for re-use of parts by future classes.

Rose Float Project Assessment Rubric
"Oh, the Places You'll Go!"

Date: March 8, 2012

Evaluator name:

Team name:

	Excellent(3)	**Good(2)**	**Needs Improvement(1)**	**3**	**2**	**1**
Correct Size – length, width, height	Correct dimensions and fits under bridge	Too big or too tall	Too big and too tall			
Speed	4 feet/min	Too slow or too fast	Does not move			
Goes over the bump	Goes over smoothly	Goes over with difficulty	Requires help			
Goes straight	Goes straight	Deviates some	Requires help			
Animation System 1	Performs an interesting motion, creative ideas	Works	Doesn't work			
Animation System 2	Performs an interesting motion, creative ideas	Works	Doesn't work			
Animation System 3	Performs an interesting motion, creative ideas	Works	Doesn't work			
Completes the route	Finishes	Drops out after bridge	Drops out after bump			
Overall Creativity	Very clever	Interesting	Plain			
Overall Look	Beautiful	Looks good	Plain			
Overall Functionality	Works well	Needs help	Does not work			
Total Score						

Comments:

Lego Robot Project

Submitted by: Ruby Mehrubeoglu
Texas A&M Corpus Christi
Ruby.Mehrubeoglu@tamucc.edu

ENTC 1303 Introduction to Engineering Technology
ENTC 1211 Fundamentals of Engineering

Lego Robot Project

Objectives
The objectives of this lab include the following:
1. Use the Course Concept Map to demonstrate the skills necessary to successfully complete the project
    - designing and implementation
    - understanding and use of hardware and software tools
    - effective communication (including understanding and following instructions)
    - problem solving
    - teamwork
    - team learning
    - leadership
    - creativity

2. Use Lego pieces to create a robot
    - Blocks
    - Sensors
    - Motor

3. Use Mindstorms software to program the robot to perform desired tasks
    - Modular programming
    - Motion programming

Deliverables
Deliverables for the project include the following:
1. Prelab that includes
    a. Tasks that go under each of the concepts of the Concept Map
    b. Simulation of the robot activities using Mindstorms (preprogram)
2. Oral presentation of the completed work
3. Written report of the completed work that includes
    a. Design and Development process, with final design
    b. Implementation (hardware used)
    c. Programming (including the working program)
    d. Other components of the report will be handed out separately
4. Demonstration of a working robot

Procedure for Building the Lego Robot
(Please see separate handout for the basic robot)

Equipment/Materials/Software
1. Lego blocks
2. Sensors (e.g. touch, light)
3. Motors
4. Lego microcontroller
5. Mindstorms Software
6. MS Office

The Lego Robot Assignment

Choose one of the four Lego Robot projects below. Your choice should be based on the following factors:

1. Your experience with working with such tools
2. The level of challenge you want to undertake
3. Bonus points you want to collect

The robot must be fully functional for full marks.

You must only provide solutions for ONE of the following Lego Robot Projects:

1. ROBOT BUG (Level: Beginner):

Objective: Build a robot that can recognize and avoid obstacles.
(Use the design instructions for Lego Robot Project provided in a separate manual).

Requirements: The robot must be able to follow the specifications and perform the following tasks

1) Use at least two touch sensors
2) Move forward until an obstacle is found
3) Perform efficient evasive action based on the location of the obstacle
(i.e., move backwards, turn and moving forward again)

2. LINE FOLLOWER ROBOT (Level: Intermediate):

Objective: Build a robot that can follow a black line surrounded by a white background

Requirements: The robot must be able to follow the specifications and perform the following tasks

1) Use two motors
2) Use one light sensor
3) Start on a white surface and move until a black line is detected
4) Once a black line is detected, follow the black line

3. ROBOTIC ARM (Level: Intermediate)

Objective: Build a robotic arm that can lift an object from the ground, turn, and place it at a different location.

Requirements: The robot must be able to follow the specifications and perform the following tasks

1) Use two motors
2) Use one light sensor
3) Detect the presence of a close object, pick it up, and place it on a tray
4) After the object has been relocated, the arm must proceed to look for another object.

4. SORTING MACHINE (Level: Advanced)

Objective: Build a sorting machine that picks up small Lego blocks in a bucket and sorts them by color.

Requirements: The robot must be able to follow the specifications and perform the following tasks

1) Use light sensor to differentiate color
2) Place sorted blocks in designate areas.

Programming the Robot

To program your robot, open "Robotics Invention System." Use the 'student' account for access and proceed to "RCX CODE" (RCX is the microcontroller that you will program.) You are now ready to write your program using the Visual Programming Language.

YOU SHOULD TRY TO DESIGN YOUR PROGRAM FIRST, AND TRY TO WRITE A VERY SIMPLE PROGRAM INITIALLY FOR TESTING, BEFORE ATTEMPTING TO WRITE THE FULL CODE FOR YOUR ROBOT!

When you are finished with your program, save it, and put it on a USB drive or equivalent storage device. You are now ready to download it to the RCX.

Find a computer that has a USB tower. Click on "Robotics Invention System." Then, open your program, and download it to the RCX. To install the firmware,

- Start robotics invention system
- Go to settings
- Click on 'download firmware'
- Click 'O.K.'
- Wait until the program is downloaded

The system should now be ready ('system ready')

Submitted by: Sam Clemence
Syracuse University
spclemen@syr.edu

ECS 101

SHOPPING CENTER LAYOUT DESIGN PROJECT

The attached project is the first design project for the semester. The design project and presentation is due **Tuesday November 8, 2011.**

The project must be clearly labeled with the title of the project, the designer(s) names and the date of submission.

A paper copy of the complete design is due on the date of the presentation.

The design will be completed by a team of up to three (or four) individuals---you must choose your own team members and be ready to start the project on Tuesday October 25, 2011.

Each team will present a preliminary report to us on **Thursday November 3, 2011**.

Final Presentations will be made on **Tuesday November 8, 2011.** Each team can use up to three drawings to present and discuss their design.

Department of Civil & Environmental Engineering

ECS 101 – Introduction to Engineering and Computer Science

Shopping Center Layout

As an engineer and designer, you are hired by a land developer to plan the layout of a shopping mall in Central New York.

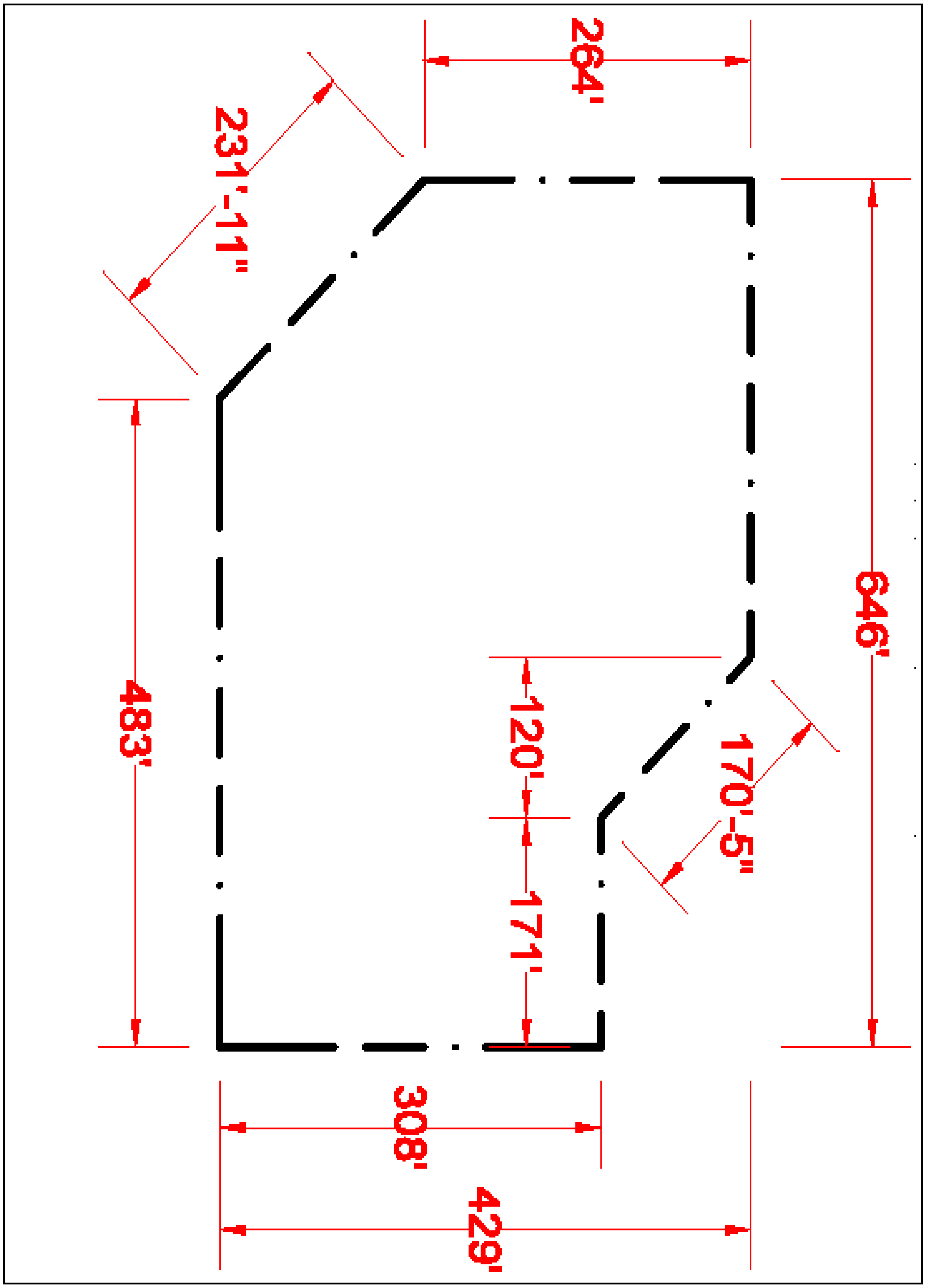
Design restrictions:

- The center must be less than 50 ft. tall
- There must be three large anchor department stores (such as Nordstrom, J.C. Penny, Macy's, etc). Each anchor store must have an area of between 10,000 and 12,000 square feet. The anchor stores should not be located near each other. These stores can be on more than one story.
- In addition to the three anchor stores, there should be approximately 50 other stores ranging from 400 to 1600 sq. ft. There must be a wide variety of stores to accommodate the large diversity of the shoppers.
- The mall must include a food court area of 5,000 sq. ft. and at least one eat-in restaurant.
- **At least 75% of the total space must be leasable space**!

Your packet **MUST** include (but is not limited to):

- Mall floor plans; which show store names, locations, square footages, all entrances and exits to the stores, escalators and elevators, and entrances and exits to the mall. **MUST BE SCALED AND DIMENSIONED, SHOWING PROPERTY LIMITS. (a table can be used to designate store names and square footage)**

- One sample department store floor plan—this should be carefully designed and organized by departments…. Men, women, children, bedding, house wears, perfume. Large department stores also have their own bathrooms. **MUST BE SCALED AND DIMENSIONED.**
- 2 Exterior Elevations: You must have a North or South and an East or West. Remember that mall lobby areas have a lot of windows. **MUST BE SCALED AND DIMENSIONED.**
- One department store-front elevation. This should coordinate with the floor plan --- Think about how department stores draw customers in…. large openings, big signs, separate lobbies. **MUST BE SCALED AND DIMENSIONED.**
- **The design must include some "green" components or sustainable engineering concept(s) and parking facilities!**



Please note that the picture is not shown to scale. Follow the dimensions.

Hints:

Use Architectural Units w/ precision of 0'-0".

Use copyclip (Ctrl + C) to move entire drawings in AutoCAD. If you have more than one floor plan, copyclip the first one and move it to the next drawing. Then, you already have the proper dimensions for the second floor, locations of staircases and elevator shafts, etc. *Use easy geometries* to calculate square footages.

Use the distance command (type in dist (enter)) to determine the exact distances to the exits.

VISIT THE MALL to do some research. Take notes on how many emergency exits (or signs for them) that you see. Take notes on how many escalators there are, if they work with the layout. Evaluate the natural lighting (windows) in the mall and how it is designed. If you want proper store logos, I suggest visiting the website.

*Remember fire cod*es. You don't have to be exact, but remember granny at the mall and think about how long it will take her to get to an emergency exit 1000 ft. away.

Submitted by: Mark Holtzapple
Texas A&M University
m-holtzapple@mail.che.tamu.edu

ENGR 111C Project
Air-Powered Car
Spring 2012

Objective

For the air-powered car shown in Figure 1, your team will do the following:

- design
- build
- test
- evaluate
- report

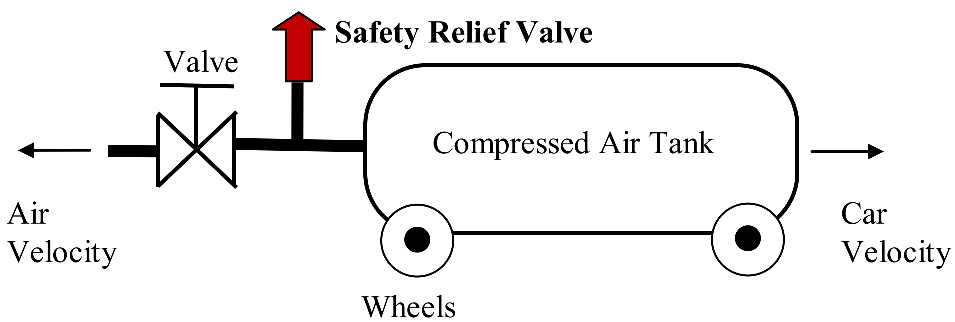


Figure 1. Schematic of air-powered car.

Constraints

- tank material of construction = polyvinyl chloride (PVC) schedule-40 pipe
- pipe diameter = 3 inches maximum
- pipe length = 12 inches maximum
- end caps = PVC
- all pressurized components must be selected to withstand at least 150 psig

Pressure Vessel Construction

Figure 2 shows a schematic of the pressure vessel, which is constructed from PVC pipe, an end cap, a reducer, and a bushing. A ½ -in × ¼-in National Pipe Thread (NPT) threaded pipe fitting reducer is inserted into the bushing, to which valves, pipe tees, nozzles, etc. are attached.

Safety Issues

- **Pipe:** There are two types of schedule-40 pipe available at home improvement stores. One is sold in 2-ft lengths and is marked "not for pressure." DO NOT

PURCHASE THIS PIPE!! As shown in the accompanying video, this pipe bursts at about 200 psig. Instead, purchase 10-ft sections that are marked "260 psi at 73 F," which is the recommended working pressure at room temperature. The accompanying video shows that this pipe withstands pressures of about 800 psi.

- **End cap containment system:** A properly selected pipe is very safe. The major point of vessel failure is end caps and fittings flying off because of joint failure. To prevent this, a containment system is needed to prevent parts from flying off in case of joint failure. Figure 3 shows a containment system consisting of large washers at each end of the vessel. The washer is selected so that the center hole rests on the shoulder of the pipe fitting reducer. Holes are drilled in the periphery of the washer so that 14-gauge galvanized steel wire joins the two washers.

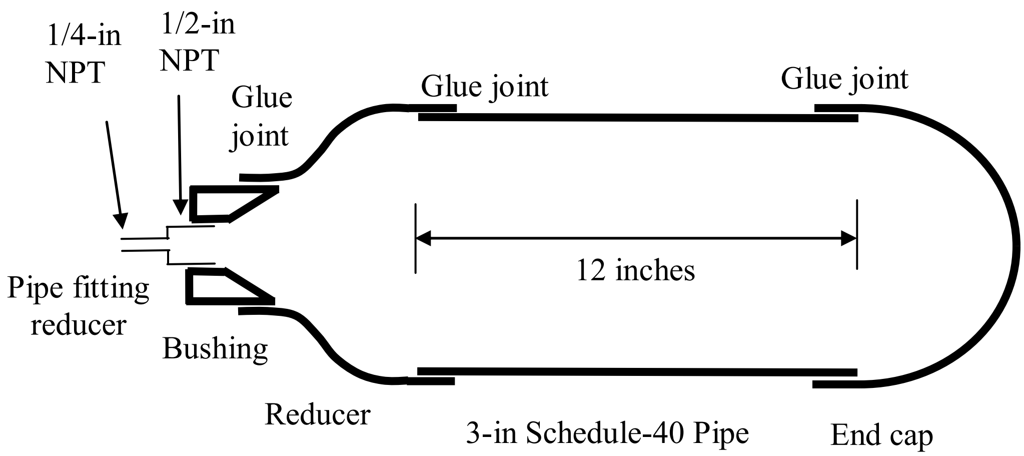


Figure 2. Pressure vessel construction.

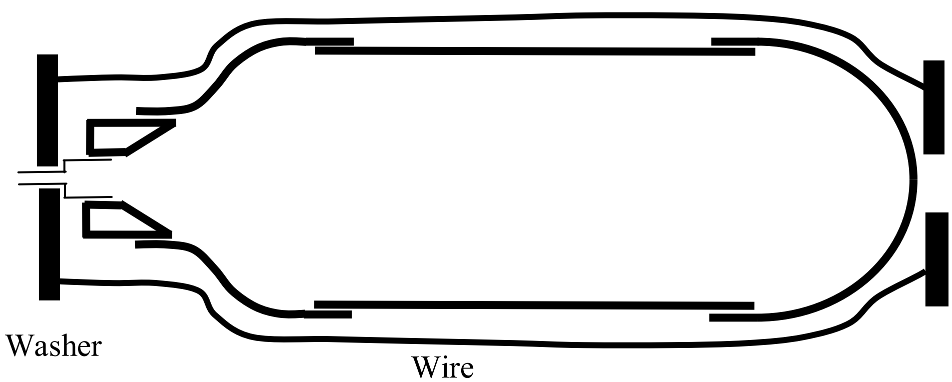


Figure 3. End cap containment system.

Figure 4 shows a detail of how the 14-gauge galvanized steel wires are to be fed through the peripheral holes in the washer. A single strand is fed through holes at each end and then twisted so the washers are snugged tightly against the vessel, thus forming a wire pair. To ensure the twist does not untie, it must be soldered. If the end caps were to fail at a pressure of 800 psi (far above the working pressure), the total force is

$$F = AP = \frac{\pi}{4} D^2 P = \frac{\pi}{4} (3\,\text{in})^2 800 \frac{\text{lb}_\text{f}}{\text{in}^2} = 5660\,\text{lb}_\text{f}$$

The 14-gauge wire has a breaking strength of about 700 lb_f. (http://www.fishock.com/store/electric-fence-wire/wc-141320). A minimum of eight wires (or four wire pairs) is sufficient to resist the force. For added safety, use at least six wire pairs.

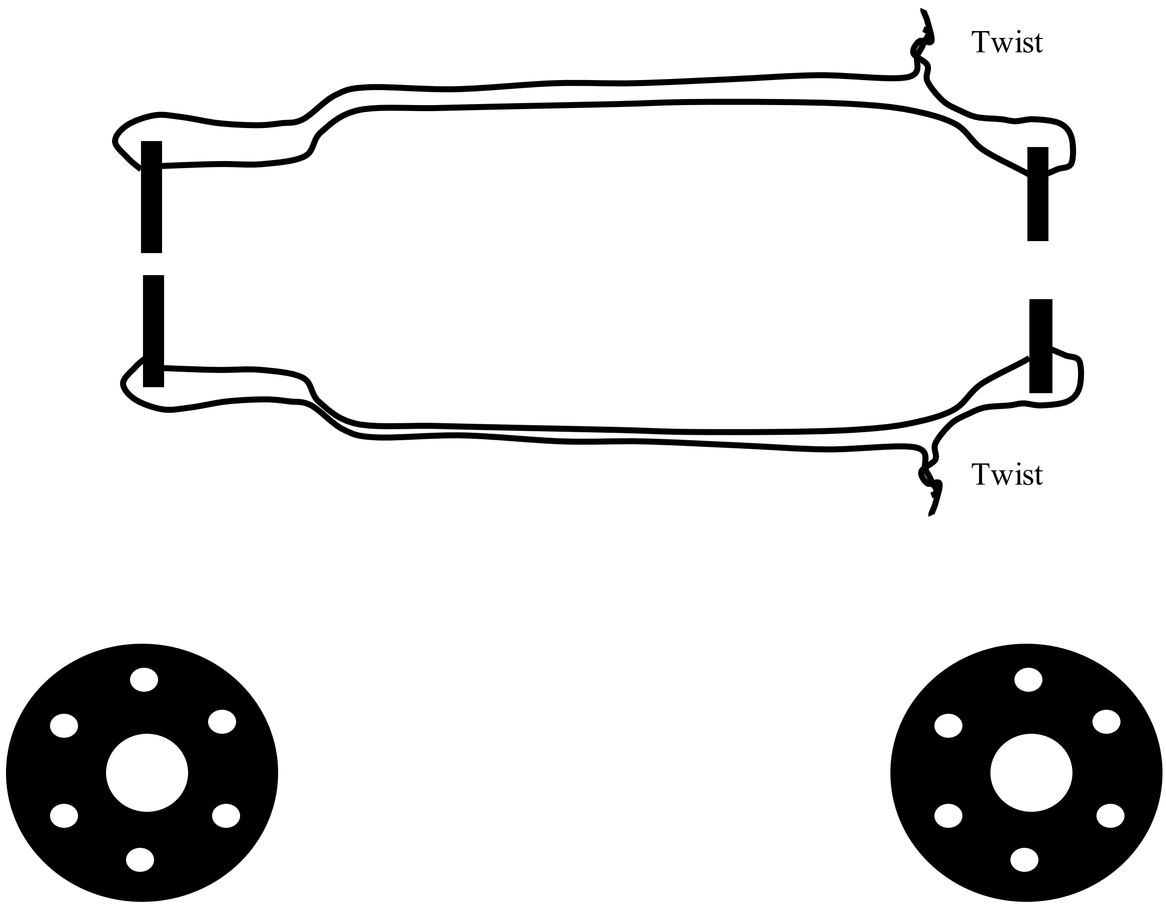


Figure 4. Containment wire detail.

- **Joints:** PVC is joined by applying a purple PVC cleaner and then PVC glue. Allow 24 hours for joints to cure before applying pressure. (Note: The glue is a solvent that bonds PVC to PVC; it cannot bond PVC to other materials, such as metal.) Instructions for using PVC glue are found at the following website:

  http://www.youtube.com/watch?v=IWpH_iJNH34

  Do NOT use any other glue besides PVC cement. Gluing will occur in class after instructions are given.

- **Hydrostatic pressure test:** After the vehicle is assembled, fill it completely with water and then apply 150 psig pressure. Inspect the vessel for integrity and leaks. (Note: High-pressure water does not contain as much energy as high-pressure gas, so a hydrostatic test is a safe way to verify vessel integrity. ***Be very certain that you fill the vessel completely with water—no air at all inside the vessel***.) The hydrostatic test will be done in class.
- **Safety Relieve Valve:** Install a safety relief valve as shown in Figure 1. An appropriate valve is available from Grainger (Item 4TK26) described at the following website:

  http://www.grainger.com/Grainger/items/4TK26?cm_mmc=Google%20Base-_-Pneumatics-_-Air%20Compressor%20Accessories-_-4TK26

- **Safety glasses:** Wear safety glasses when assembling equipment and operating the air-powered car. **During the car demonstration, students not wearing their safety glasses will be asked to leave.**
- **Penetrations:** Do not drill or cut into the pressure vessel as this may disrupt vessel integrity. All connections must be made using standard off-the-shelf fittings.
- **Maximum working pressure:** On the compressed air tank, put the following label:

Maximum gas pressure = 70 psig

Schedule

- **Class 11.1:** Turn in sketches of your design to your graphics instructor
- **Class 12.1:** Glue pressure vessel. Bring to class the following items:
  - 12-inch section of 3-in-diameter Schedule-40 PVC pipe rated for 260 psi at 73°F
  - end cap
  - reducer
  - bushing
  - purple PVC cleaner
  - PVC cement
- **Class 13.1:** Pressure test. Bring to class the following items:
  - glued pressure vessel made in Class 12.2
  - installed containment system on the pressure vessel
  - ½ -in × ¼-in National Pipe Thread (NPT) threaded pipe fitting reducer installed
  - Schrader valve installed
  - valve shown in Figure 1 installed
  - safety relief valve NOT installed (it will not allow us to go to the full test pressure)

   - vessel completely filled with water up to Schrader valve
- **Class 14.2:** Demonstrate your air-powered car in class
- **Class 15.1:** Submit your team report

Sketch

The sketch should identify all components in detail. Be sure to address detailed issues such as how the vessel will be charged with compressed air, how the wheels will be mounted, and how the car will be steered. Determine sources of off-the-shelf equipment, such as fittings, wheels, valves, pipe, etc.

Demonstration

The car performance will be demonstrated in the hallways outside the classrooms. Using a bicycle pump supplied by your team, pressurize the vessel to 70 psig. Release the pressure, which allows the gas to exit the rear and propel the car forward. Your demonstration grade will be based upon distance traveled when it stops. Because the hallways are fairly narrow, it will be important that the car travel in a straight line. If it hits the wall, the location where it finally stops will count as the distance traveled. You will perform three trials. The grade will be based upon the mean of the first three trials. If all three trials are "bad" (i.e., the car hits the wall), your team will be allowed to repeat the runs until you have one "good" run (i.e., the car comes to a stop without hitting the wall). Only "good" runs will be used in your calculations.

During the demonstration, you must measure the mass of your car, which will be used in calculations. Also, you will determine the distance your vehicle travels (without compressed air) when it is placed at multiple heights on a ramp (Figure 5). The higher it starts, the farther it travels.

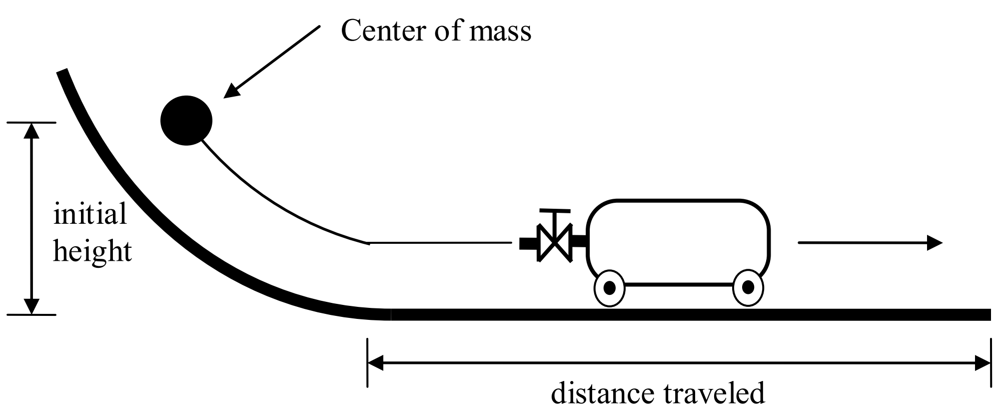


Figure 5. Schematic of ramp system.

Demonstration Grade

Within a class, the team that travels the farthest distance will receive a grade of 100. The team that travels the shortest distance will receive a grade of 60. Other teams will receive an intermediate grade based upon a straight-line fit to these end points.

Report

The report must contain the following information in the following order:

1. Brief description of the technology and problem statement
2. Description of the as-built air-powered car with appropriate AutoCAD drawings
3. Operating procedures for the air-powered car
4. Description of safety measures taken
5. Certification that hydrostatic pressure test was performed (must be signed by all team members)
6. Expenses (Document your expenses. Only account for the portion you used. For example, if the total cost of 8 ft of 3-in PVC pipe is $8, the cost of the 1-ft pipe would be listed as $1. Only list expendables (e.g., pipe, fittings, wheels) and not any special tools. The bicycle pump is not an expendable because it can be used for other purposes.)
7. Description of results from the demonstration. A table must be included that reports the results of the three trials. The mean and standard deviation must be reported in the table.
8. Efficiency calculations
9. Suggested improvements based upon experience gained
10. Summary (what did you learn?)

The report must be printed on white paper and stapled in the upper left corner. Do NOT place the report in a binder or holder. For the report cover sheet, use the last page of this document. Tables and graphs must be appropriately titled and labeled (WITH UNITS). Reference all tables and graphs in the text.

Efficiency Calculations

The efficiency η is the ratio of energy output to energy input.

$$\eta = \frac{\text{Energy out}}{\text{Energy input}}$$

Energy input – The theoretical energy content of the compressed gas can be determined by first measuring or estimating the volume of the compressed air tank. Knowing the absolute pressure and absolute temperature, the number of moles of 70-psig gas in the vessel can be estimated using the ideal gas equation. To determined the theoretical work it requires to compress the gas, envision a large piston/cylinder (Figure 6) that contains all these moles at an initial pressure of 1 atmosphere (absolute) and room temperature. As the piston slowly compresses the gas, assume that the temperature stays constant and the pressure can be obtained from the ideal gas equation. Assuming a cross-sectional area of the piston and knowing this pressure at each instant during the compression, the force required to push the piston can be calculated. (Note: The initial force $F_{initial}$ is zero because the pressure on each side of the piston is identical. Atmospheric pressure always provides a portion of the total force acting on the piston.) Integrating the force over the distance allows the total theoretical work to be calculated. Integrate numerically using an Excel spreadsheet. Confirm the result analytically using calculus.

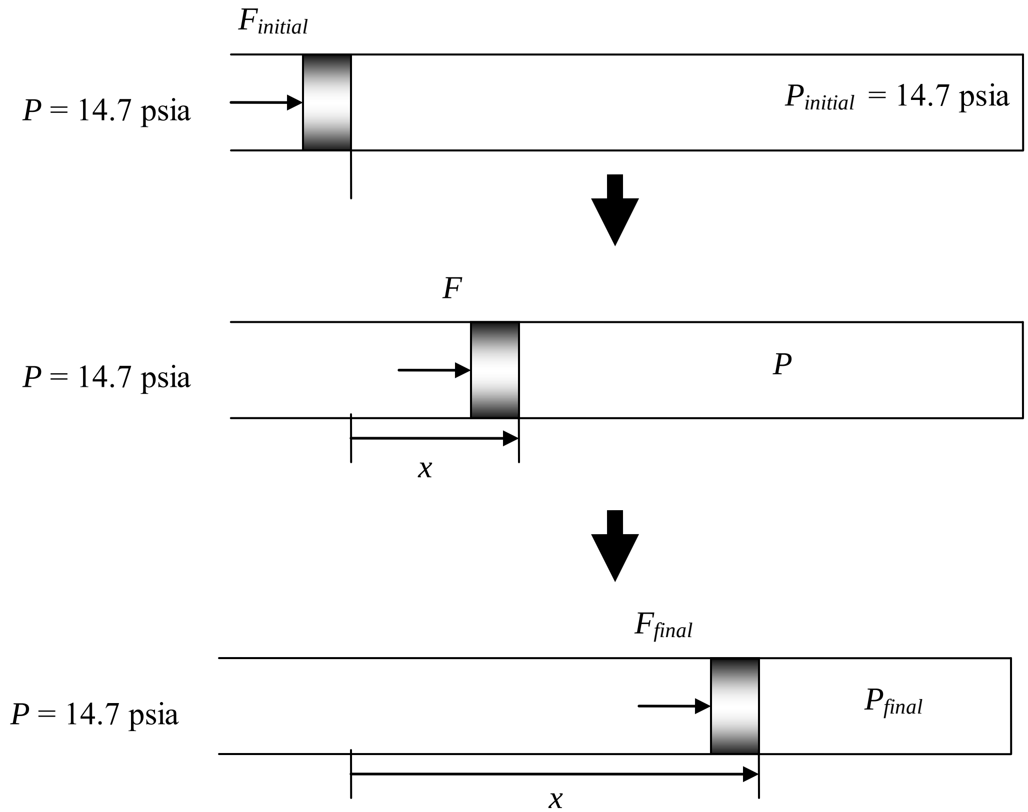


Figure 6. Piston/cylinder used to compress air from the initial pressure to final pressure.

Energy output – The energy output from your car can be estimated by plotting the potential energy of the car on the ramp versus distance traveled (Figure 7). (Note: For illustrative purposes, the figure shows a linear relationship between potential energy and distance traveled. Your curve may differ, or it may be the same. Your experimental data will determine the relationship.) Once you have the plot, show your distance traveled using compressed air. The curve will allow you to estimate the energy delivered from the compressed air.

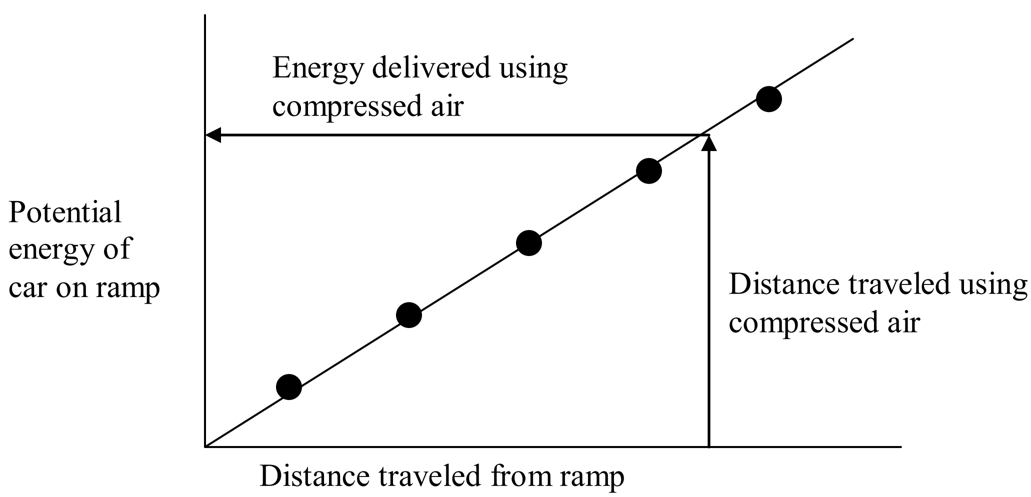


Figure 7. Experimentally determined relationship between the potential energy of the car on the ramp and the distance traveled from the ramp.

Project Grade

The final project grade will be determined as follows:

- sketch = 20%
- demonstration = 30%
- report = 50%

Helpful Hints

Do not procrastinate – There are lots of students in ENGR 111C all of whom will need to purchase 3-in pipe and fittings from Lowes, Home Depot, or plumbing supply houses. If you wait to the last minute to purchase your supplies, it is likely the stores will run out because of the unanticipated demand. Get your supplies early!!

Share expenses – PVC pipe is purchased in lengths longer than 1 foot. One team could purchase a long length of pipe, cut it into 1-ft sections, and sell the sections to other teams.

Schrader valve – The standard method for coupling a bicycle pump to a tire is called a Schrader valve. A Schrader valve that couples to standard national pipe thread (NPT) is available on the Internet (Google search: Schrader NPT).

http://www.airridefittings.com/store/index.php?main_page=product_info&products_id=24

Be sure to plan ahead to allow time for shipping. Schrader valves are also available at automotive parts stores, such as O'Reilly's.

Calculus Hints:

$$\int \frac{dx}{x} = \ln|x| + C$$

$$\int \frac{dx}{a-x} = -\ln|a-x| + C$$

Air-Powered Car Project

Section Number ______________________ (typed)

Team Number ________________________ (typed)

Student Name (typed)	Percent of Effort*	Student Signature

* Full effort = 100%

Item	Points Earned	Maximum Points	Description
1		5	Brief description of the technology and problem statement
2		10	Description of the as-built air-powered car with appropriate AutoCAD drawings
3		5	Operating procedures for the air-powered car
4		5	Description of safety measures taken
5		5	Certification that hydrostatic pressure test was performed
6		5	Expenses
7		10	Description of results from the demonstration
8a		10	Efficiency analysis (potential energy graph)
8b		20	Efficiency calculations (numerical)
8c		15	Efficiency calculation (analytical)
9		5	Suggested improvements based upon experience gained
10		5	Summary (what did you learn?)
		Bonus for exceptional report appearance and professionalism	
		Penalty for poor report appearance and lack of professionalism	
		Total	

ME176 Freshman Design I
Department of Engineering **Fall 2012**
Western Kentucky University

Submitted by: Kevin Schmaltz
Western Kentucky University
kevin.schmaltz@wku.edu

To: ME176 Students

From: Dr. Kevin Schmaltz

Date: September 11 or 12, 2012

Subject: Final Design-Build-Test Project Handout – Tennis Ball Launcher

INTRODUCTION:

The ME 176 class provides students with an introduction to the engineering design process, professional communications and the use of professional tools. You will perform these activities many times in your future careers as mechanical engineers.

In a typical design project it is necessary to determine the intended design outcomes, create or verify the specifications and performance criteria necessary, perform some analysis and finally build an artifact - often an initial artifact, or prototype, is built to verify the design before a final product is made. This final ME176 project culminates the design prototyping activities of this class, and is an opportunity for each of you in a team of 5 or 6 to demonstrate your ability to develop and apply your engineering design, professional communications and professional tools skills.

ASSIGNMENT:

Your team must design, build, and test a device that accurately and repeatedly launches a tennis ball into a 5-gallon bucket from a distance of 20 to 40 feet. The device must fit within a 2 ft x 2 ft x 2 ft cube in ready to launch state, and must weigh less than 5 kg. Both your device and the bucket will rest on the ground during device operation.

Additionally, your device must be operated by a single team member who will trigger the launching of each ball. Only the trigger mechanism may be touched by the operator, not the tennis ball. The device must sit securely on the ground without being touched. The team (one or more members) may adjust the device between launching balls.

Construction and assembly of your team's tennis ball launcher may take place in the SPF or your team may elect to use other fabrication facilities. Device testing and calibration should take place in the High Bay. Some fabrication components from the EPF will be made available, others your team will have to provide (sharing the cost among the team).

Final testing of your device will take place on Wednesday December 12 at noon in the High Bay in the form of a competition. The device will be verified for size and weight requirements and will be judged for quality of design and construction (worth 25 class points). Your team will then be told a distance (between 20 and 40 feet) to launch the tennis ball. You will have 2 minutes to place your device on the floor and prepare to launch the specified distance. You will get 3 attempts to launch, with 2 minutes between rounds to adjust your device. Scoring will be as follows:

$$\textbf{Score} = (30 - 3 \cdot \text{distance from bucket (ft.)})_{1st\ round} + (20 - 2 \cdot \text{distance from bucket (ft.)})_{2nd\ round} + (10 - 1 \cdot \text{distance from bucket (ft.)})_{3rd\ round}$$

This score will be your team's class points for device performance.

In order to document your design your team must create drawings of your device sufficient to convey your final design. All parts must be **hand sketched** in a professional manner. Similarly you must estimate the cost of your device materials using retail prices, even if you have the materials and they are "free" to your team.

WKU materials and supplies listed below include prices.

PROJECT DELIVERABLES:

The table below summarizes the required activities for the final ME176 project:

Project Schedule/Milestones	Date	Course Points
Assignment Given	Week of September 11^{th}	-
Individual concept ideas	Week of October 2^{nd}	15
In-class concept review and design selection	Week of November 13^{th}	25
ME176 open week (Thanksgiving break)	Week of November 20^{st}	-
Required team meeting/review plans	Week of November 27^{th}	-
ME176 open week	Week of December 3^{rd}	-
Required minimal function demo*	Friday, December 7 noon	25
Project Competition, Device Quality and Design Report	December 12 noon	60/25/100
	TOTAL	**250**

* A functioning device must be demonstrated **before noon Friday December 7, 2012 for full credit** for the Competition Points.

A competition of all ME176 devices will take place on Wednesday December 12, 2012. **NO WORK WILL BE ACCEPTED AFTER THIS TIME!** The device will be yours to keep, but team reports will not be returned, so keep a copy of your report so that you can use it later for internship interviews, etc.

ME176 Freshman Design I
Department of Engineering **Fall 2012**
Western Kentucky University

<u>Final Report Requirements (worth 100 class points):</u>

1. A stapled (**<u>not bound</u>**) report with a professional cover memo.
2. Introduction including project definition and design requirements (criteria).
3. A section showing your early concepts and your selection process to chose the final design.
4. A hand drawing of your final overall device showing all necessary views and individual prints of each part showing all necessary views and dimensions.
5. A budget table listing each component, the cost of each component, and the total device cost.
6. Conclusion with observations about project, discussion of testing done, what you learned from this project and suggested improvements for future students.

APPENDIX

Engineering department provided construction materials*:

Round Aluminum stock

½" dia = $0.20 / inch	1" dia = $0.45 / inch	2" dia = $2.00 / inch

Flat/Square Aluminum stock

¼" x 1" = $0.25 / inch	¼" x 2" = $0.45 / inch	¼" x 3" = $0.67 / inch
⅜" x 1" = $0.43 / inch	⅜" x 2" = $0.60 / inch	⅜" x 3" = $0.85 / inch
½" x 1" = $0.55 / inch	½" x 2" = $0.78 / inch	½" x 3" = $0.96 / inch
1" x 1" = $1.19 / inch		

*All metal stock is priced per inch of length, rounded to the nearest inch. **You do not have to actually purchase any of these materials, but they should be included in your budget in your report.**

Submitted by: Rob Gettens
Western New England University
robert.gettens@wne.edu

Design Project Two - Inventory Robot Design Project

Learning Objective: To experience a formalized engineering design process by creating a prototype device/system that meets the customers‟ specifications

Learning Outcome: The students will demonstrate the ability to work in teams creating a prototype device/system by following a prescribed engineering design process. The students will formally present their results both orally and in written form as well as demonstrate the working prototype.

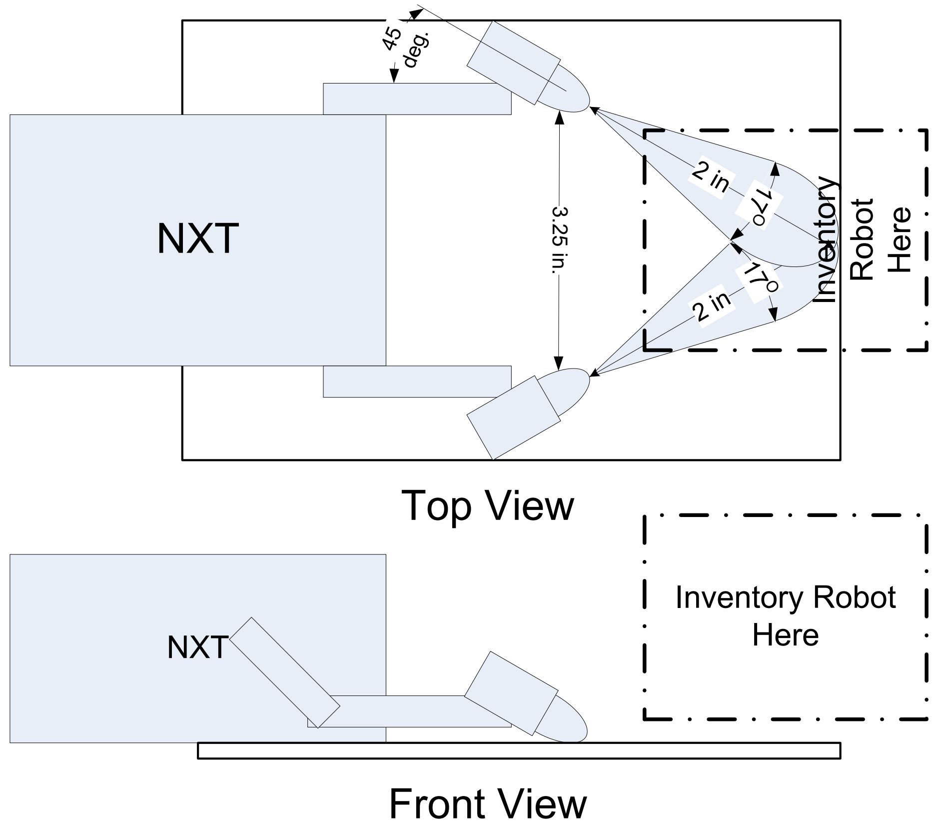
The Situation: Your company, Inventory Management Robotics, is competing for a contract to supply efficient, accurate, and autonomous robots that will stock and manage inventory that may be hazardous to human health and safety. Your design will be a scaled version of the final product.

Performance

- The robot prototype is to be programmed to accurately follow (nominal transit time 20sec $\pm$ 2sec) one of three paths (each has a unique dispatch number). The path is defined by a one-inch wide, meandering dark line down the middle of a light, six-inch wide background (see figure 3). The length and orientation of each path segment is predefined by the customer. The robot is to carry a stock item as it travels and accurately drop that item into a stock bin at the end of the designated path. An open, anchored box (see figure 2) at the end of each path serves as the stock bin. The box is positioned 6 inches (on a straight line) from the end of the travel path. The robot does not know which path it will take until it gets a number flashed to it from a dispatch robot.

Dispatcher and Robot Specifications

- The graphic in figure 1 illustrates the dispatch area where the inventory robot will receive its dispatch number via LED flashes.
- The dispatch sequence will consist of a two-second warning flash (light is ON for 2 sec then off), followed by the dispatch path number flash sequence. The sequence of light flashes takes 1 second to complete.
- It is expected that the light sensor LEDs on the inventory robot are off in order to minimize interference with sensing the dispatch flashes. (There is a special modifier that shuts OFF the light sensor red LEDs).
- The inventory robot does not need to signal that it is ready to receive its dispatch number, but it must signal that it has received that number.
- The dispatch procedure is to place the inventory robot appropriately in the dispatch area then activate it.
- Autonomous behavior (detecting the dispatch number and proceeding with inventory delivery) is expected after activation. It is this action that starts the competition clock.
- The transit time of the inventory robot will be determined by elapsed time measured from the time the robot starts moving to a dispatch path to the time the robot signals it is within one foot of the inventory bin. The robot will be judged on how accurately it travels its designated path and delivers the stock item at the end of the path. Also, the robot is expected to be consistent, reliable, and efficient.



The distance between the LED tips is 3.25".
Tilt angle of LEDs relative to support brackets is 45 degrees.
Beam width of LEDs is 17 degrees.
Beam depth is approximately 2 inch.
Illuminated surface is white.

Fig. 1
Dispatch Station

NOTES

- Consistency will be determined by how well transit times are predicted via a statistical analysis of experimental data. As part of design deliverables, documented results of a ***Consistency-time***^{90} statistical analysis must be reported upon. Consistency-time^{90} is defined as the range of times, out of a collection of all run times, where 90% of successful runs occurred. The narrower the time range the more consistent the design.
- Efficiency is based on energy consumed. In this case the energy consumed will be a statistical summary (mean and standard deviation) of energy consumed by the device as it maneuvered a given path and delivered its stock item.
- Accuracy will be determined by where the inventory item is dropped in the stock bin. Each drop location has a point value. See figure 2 for the bin construction and point distribution. Also, accuracy will be determined by how closely the robot"s indication of being one foot from the bin agrees with actual measurements.

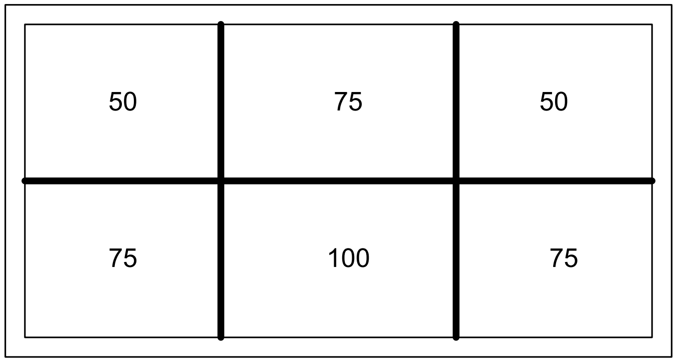


Fig. 2
Stock Bin Structure with Award Points

Competition

- All teams will compete to accurately deliver a stock item (a LEGO ball) into an empty “stock bin” (LEGO box) within the specified transit time. The competition space will be on a stage floor (like S100 or Rivers) marked off with blue painter‟s masking tape on a light masking tape background. Configurations of the masking-tape paths are as follows:

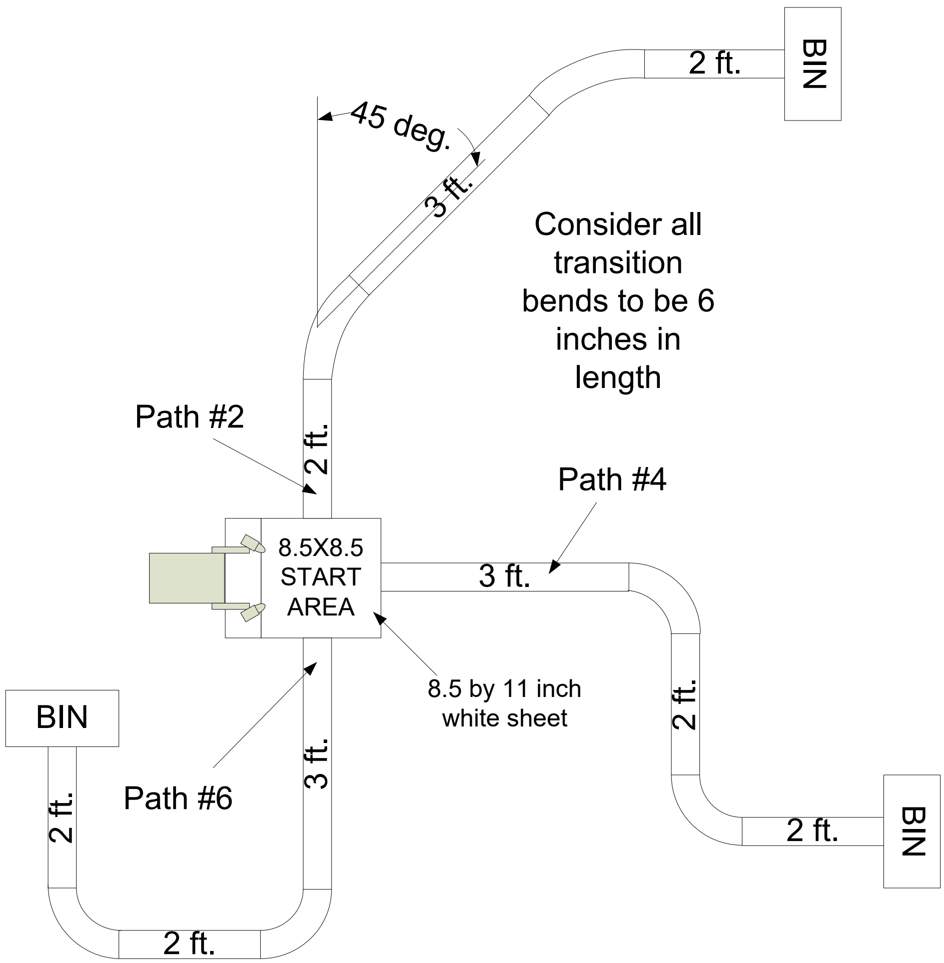


Fig. 3
Dispatch Paths
(Only dark tape shown)

- The above paths may be subject to change up through design week 2.
- The work area of the inventory robot as it travels is assumed to be limited to three inches either side of the designated travel path. It is further assumed that there are floor to ceiling obstacles at the edges of the work area that prevent „short cuts".

A Legal Run

- A run is considered legal if the robot stays on the path designated by the dispatcher.
- During a legal run, the robot will be judged on path tracking, distance sensing, and delivery accuracy.

Mousetrap Powered Vehicle

Submitted by: Jae-Won Choi
University of Akron
jchoi1@uakron.edu

4600:165 DESIGN PROJECT (tools_project.doc)

PROJECT DUE DATE: LAST TUESDAY TOOLS DISCUSSION SESSION FALL 2012

OBJECTIVE:
Design and build a vehicle powered by **one ordinary mousetrap**. The vehicle must travel 10 ft in a straight line and two feet up an incline of approximately 10° (see figure below). The fastest mousetrap vehicle is declared as the best design. The surface of the racetrack is a reasonably cleaned 1/16" thick aluminum plate.

MATERIALS:
One ordinary mousetrap and one ordinary rubber band are allowed. The rubber band is optional. There should be no other source to store potential energy to drive your vehicle.

DESIGN CONDITIONS:
The vehicle must be designed and built by the team. A vehicle which is bought as a kit will be disqualified and the report associated with this vehicle will be returned to team with zero point.
The vehicle must fit **approximately** within one cubic foot of volume and powered by **one regular mousetrap** that contains a torsional spring. An additional **one** ordinary rubber band is also allowed. If a vehicle does not travel the required 12 ″ distance, it is disqualified. You can interact with your vehicle only once at the start. Cost of building the vehicle must be less than $10.00. No starting block or slingshots are permitted. For example, you cannot fly a ping-pong ball using the mousetrap and call it a "vehicle." The vehicle is understood to be a device that is in contact with the ground while it is in motion.

DESIGN REPORT
Each team will submit one detailed written report. The length of the report should not exceed seven pages. The report must contain:
1. The total potential energy stored and the average velocity of your vehicle. The average velocity estimate should be based on energy balance calculations and it should be verified by the experimental data. If you only submit experimental data for the average velocity estimation you receive 50% of the point. What this means is that I need to see the calculated velocity using the energy balance.
2. Material choice and time line
3. Technical Drawing

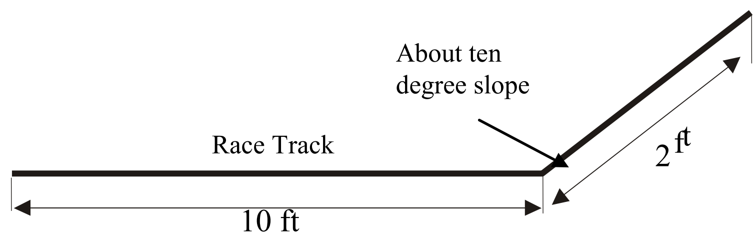
The technical drawing should contain the necessary information for an independent party to be able to manufacture the same vehicle using this drawing. This means that all dimensions and tolerances, including the materials used have to be specified explicitly. Please make sure that the Unit System that you used is stated explicitly. At least two views of the car should be presented in the technical drawing. Hand sketches will not be accepted. Each team will distribute the three tasks stated above to its members as if this is a company project.

5. List of references. If a particular reference that is listed in the list of references is not referred to in the main body of the report then it means it is not really used.

COMPETITION RULES
Two vehicles will be randomly selected to race against each other and each race will be a single elimination. Any vehicle straying across its lane is automatically eliminated. The vehicle that reaches the top of the incline first will be declared as the winner. The course grade for the orientation part will be based on the submitted report, not on how the vehicle has performed during competition.

FREQUENTLY ASKED QUESTIONS

1. One of our team members did not participate at all, what should we do? One solution is not to have his/her name on the technical report you submit. Since there are many groups it will be very difficult for me to intervene.
2. This one cubic foot of volume constraint that you have, does that include the extension arm that we may have ? The answer is no.
3. Can we use a rubber band in addition to the spring? Yes, one additional rubber band is allowed.
4. Can we have a copy of previous technical reports? No.
5. What should be the format of our report? Typical format may include: Title, your names, introduction, determination of spring constant, determination of total stored energy, determination of average velocity of vehicle, comparison with the experimental data, material choice, cost, conclusion, references and technical drawings.



Your check list for the report:

1. Do you have the data and calculations for the spring constant?
2. Do you have (a) numerically calculated velocity, and (b) experimentally measured velocity?
3. Can I reproduce this car from the technical drawings you submitted?
4. Do you have the reference list? Are you referring to the reference list in your report ?