MECH 202 Spring 2014 Competition Project : Turning on a Light Switch (Updated 21 April 2014)
(See appendix F for revision history)

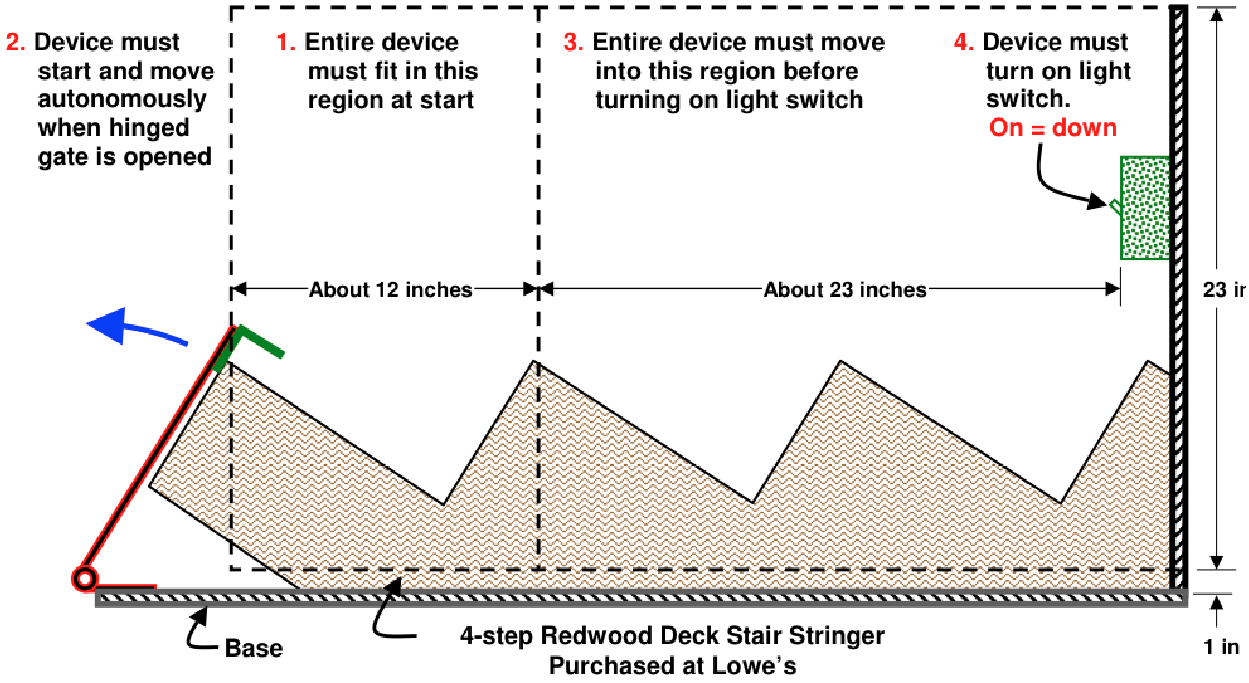
Your team is to design, fabricate, and compete with a working device that safely turns on a light switch. Your team must also submit a report detailing your device and the process used to develop your design. The competition will be on **Saturday, April 26, in Behavioral Sciences Room 131**.

- Your project report must be submitted as a single PDF to the drop-box folder by 7am that day.
- Registration starts at 8:15am per the schedule in Appendix E. Competition starts at 9am.
- The competition takes most of the day. The finals are expected to occur between 2pm and 3pm.

Competition Overview

1. Your team is competing to design and build a safe, most reliable, and lightest weight device that autonomously turns on a light switch in the test environment as described in this document.

2. Below is a conceptual (not to scale) drawing of the competition fixture. Appendix B provides additional detail. Each group should measure the fixture and design their device to handle all potential variability they may encounter. We reserve the right to replace any stringer with other similar stringers bought at Lowe's. You should plan for any additional variability in these stringers and other components.



3. The sketch above shows one lane of a 5-lane fixture. The lanes are spaced at about 18 inch intervals. Each stringer is approximately 1.5 inches wide.

4. Devices must stay 1 inch above the base and cannot extend more than 6 inches from the sides of the stringers, meaning your device cannot be wider than 13.5 inches. Maximum device weight: 3 pounds. No part of any device can go more than 24 inches above the base at any time in a round.

5. The TAs will keep this fixture locked from now until competition day, except during viewing times. Your team should schedule with the TAs to see and measure the fixture and use your measurements and analysis to ensure that your device will work correctly and reliably. You are not allowed to visit the fixture or place your device on the competition fixture until the first time you compete on April 26. Your group is encouraged to make its own test fixture to develop and test your device.

More detailed competition rules

6. Each round consists of 2-5 devices autonomously competing against each other. The winner in each round is determined based on (i) the correct sequence of tasks safely completed during the 30 seconds from the time the starting gate is lifted and (ii) device weight.

7. The correct sequence of tasks to be safely completed is as follows:

1.	Entire device must fit into the starting area and weigh less than 3 pounds. The starting area is defined as having a depth (from first stinger peak to second stinger peak) of 12 inches, a width of 13.5 inches which is the width of the stringer (1.5 inches) plus six inches per side, and a height of 23 inches, which is measured from 1 inch above the base to 24 inches above the base.
2.	The entire device must start autonomously when the hinged staring gate is opened and no part of the device can move any further back than the back line of the 12-inch starting region at any time during the competition. The device also cannot move below the bottom of the regions or above the tops of the regions, or behind the back region shown in the diagram on page 1. At no time can the device extend more than 6 inches out from either side of the stringer it is traveling on.
3.	The entire device must move to the region shown in step 3 of page 1. During no time can the device move outside of the boundaries described in task 2 above or illustrated in the sketch on page 1.
4.	Once the entire device is in the region shown on step 3 of page 1, the device must turn on the light switch by moving the switch down.

8. The winner of a round will be determined as follows:

a.	If only one device in the round safely completed all four tasks in the allocated 30 seconds and stayed in bounds until the end of the 30-second round, this device will be the winner.
b.	If more than one device in a round safely completed all four tasks in the allocated 30 seconds, and stayed in bounds until the end of the 30-second round, the lightest device that safely completed the four tasks and stayed in bounds will be the winner.
If no devices safely completed all four tasks in the allocated 30 seconds and stayed in bounds until the end of a round, the winner of the round will be determined as described in the next section	
c.	If only one device in the round safely completed the first three tasks in the allocated 30 seconds and stayed in bounds until the end of the 30-second round, this device will be the winner.
d.	If more than one device in the round safely completed the first three tasks in the allocated 30 seconds and stayed in bounds until the end of the 30-second round, the lightest device that safely completed the first three tasks in the allocated thirty seconds and stayed in bounds until the end of the round will be the winner.
If no devices safely completed all four tasks and no devices completed all three tasks as described in the sections a, b, c, and d above, we will do the steps described below.	
e.	The round will be re-run with the same participants. However, if there had been a gross safety violation (see below), that device will be removed from the competition and from this round. If there had been a device damaged, up to 30 minutes will be provided during all rounds except the final rounds for this group to repair their device. The rerun round will then be judged based on the criteria in a, b, c, and d above.
f.	If during the rerun no devices safely completed all four tasks and no devices completed all three tasks as described in the sections a, b, c, and d above, but at least one device safely moved and stayed on the fixture until the end of the round, the lightest device that safely moved and stayed on the fixture will be declared the winner.
g.	If during the rerun, no devices safely moved and stayed on the fixture until the end of the round, the round will be rerun one last time and judged based on the criteria in a-d and f above. If no devices moved during this final rerun, all devices will be deemed to have lost the round. If this occurred in the first set of rounds when devices are run, the devices will get one last chance to run as part of the “elimination brackets”. If this occurred after the first set of rounds when devices are run the first time, all devices will be out of the competition.

9. The safety requirements and their impact on competition results are as follows:

a.	Each device must pass a safety audit prior to noon on Friday, April 25. This audit will be conducted by the TAs and your team should schedule a time with the TAs during the Monday-Friday before the competition to conduct this audit. Bring your device to the audit so they can identify anything that is hazardous or might be considered hazardous. If you have concerns or questions prior to the week before the competition, please contact the TAs to discuss this.
b.	Gross violations of the safety rules will result in your group's device being eliminated from the competition. Examples of gross violations include damaging the fixture (which includes the light bulbs that will be on the final version of the fixture) or any part of your device wandering so far out of bounds or causing a disturbance so significant that another device is damaged or touched. Note that minor vibrations or air disturbances caused by your device on the fixture do not count. All devices must be tolerant of minor vibrations and still stay on the fixture. If you have any questions about your device and any potential areas of risk, check with the TAs. When judging whether a safety violation is a gross violation, we will also look at your design intent and what you did to ensure that a safety violation could not occur.
c.	Your device cannot win a round if it has a minor safety violation. Minor safety violations are things such as: - Moving out of bounds during any time in a round. - Any part of your device falling off. Your device must stay as a single unit during the entire round.

10. Except in any special cases that might have been mentioned above, the competition is double elimination. Details of how the heats and how the winners and losers move from round to round will be available prior to the day of the competition. Only the first place winners will advance to the next round. We will try to record which devices came in second, third, and fourth place and all tasks that each device accomplished, but will not use this for determining competition results.

11. Any device that has run less than three rounds prior to lunchtime and has not ever safely completed the first three tasks in the allocated 30 seconds and stayed in bounds until the end of the 30-second round will be retested one more time during lunch. During that test we provide one more chance to demonstrate that the device can safely complete the first three tasks in the allocated 30 seconds and stay in bounds until the end of the 30-second round. If the device again fails to complete all tasks, two points will be deducted from the score on the final report.

Further Clarification

12. As mentioned previously, you are encouraged to build your own test fixture. We deliberately made our fixture from standard low cost parts to facilitate duplication of the key elements for our testing. Some of the key parts used for the competition fixture are described in Appendix B.

13. The components used to make the competition fixture will not be perfect or exactly like a test fixture that you might fabricate from the same parts. It is important that your device can tolerate these types of differences. This is and important aspect of having a robust design. Also note that you cannot place your device on the test fixture prior to the competition. You can take measurements. Every year there are many devices that fail to operate due to dimensional differences between the competition fixture and the test fixtures built by students. This is your warning to ensure this doesn't happen to your device.

14. Your device can be made from any materials that you would like to use. However, you cannot use any energy storage method or device that might be deemed hazardous. Examples of hazardous energy storage devices include, but are not limited to:
    - Explosives, combustion processes, or highly exothermic reactions (such as model rockets).
    - A compressed fluid that might release too quickly
    - Anything deemed to be unnecessarily harmful to either the fixture or another competitor's device. This includes having motors that overheat, generate sparks, etc or wheels that leave a residue.

15. If your team is not willing to stand next to your device without protective clothing or safety glasses, your device will be considered hazardous! However, since some individuals are braver than others. The judges reserve the right to deem a device hazardous.

16. No human contact with the device is allowed at any time during the time from the start of a round until that round has finished.

17. The device cannot contain any biological components. For example, you are not allowed to employ a trained squirrel as part of your device.

18. In each round your team will have a maximum of 45 seconds for you to place your device onto the fixture and move away prior to the start. You should design a device that does not need to be calibrated to the lane it will be running in.

19. Your team must check into the registration table at the designated time given in Appendix E. If your team is more than 5 minutes late, and this is deemed to hold up the competition, your team will lose its first round.

20. Damaging the fixture. Your team will be disqualified if your device intentionally or unintentionally damages the fixture in any manner including but not limited to: breaking any part of the fixture, generating noticeable nixes or notches that will impact the integrity of the competition, adding foreign substances such as oil or lubricants onto the fixture.

21. Judging. The TAs (Amit and Brent) will determine which device accomplished which tasks during each round. They are also the primary referees to observe any safety violations. Device weights will be recorded at checkin and may be rechecked later if devices have been modified.

22. Protests. All protests must be registered immediately after the competing round. You must qualify your protests based on the ground rules and the project definition. Keep good engineering records (engineering book) of your development process to use to defend your positions. If you have no supporting documentation at the day of the competition, your protest will be disallowed. Bert Vermeulen will be the final judge on all protests.

23. And keep in mind. This competition is a lot of fun and an opportunity to cheer and encourage everyone. Feel free to invite your friends and family as well. You can see elements of the last five year's competitions at www.mech202.com.

24. Can we use a spring? There's no problem in using a spring, rubber band, or other means of propulsion as long as it does not generate so much force as to be dangerous. Using a crossbow, for example would be considered dangerous because we don't think any of your team members would feel safe standing in front of it.

25. Can we grab our device after it completes the task? Not until the round has been declared completed. Please ensure that your device cannot fall of the table, damage itself, or spin its wheels in a way that will damage the table or generate excessive heating.

26. Will there be any changes made to the competition fixture prior to April 26? We may make minor improvements to ensure that the fixture is stable and race worthy. These changes may slightly affect the geometry of the fixture and the starting gate, but not alter any of the fundamental functionality.

27. Note that, although we will do the best we can, we cannot guarantee that the fixture will be absolutely rigid. Please design your device to be as tolerant as possible of any movement that may occur to the fixture as it is used during the competition.

Judges Decisions Disclaimer
In a competition of this nature it is hard to anticipate all the interpretations of the rules and situations that will arise in the competition. Therefore, the judges will decide anything not covered by these rules and the interpretations of these rules. These rules are subject to optimization, and may be altered by the staff to preserve the "spirit" of the contest.

The Rewards
1. The winning team will receive an A for the course and will not have to take the final examination
2. The 2nd place team will receive an A for the project and a 100 for the final
3. The 3rd place team will receive an A for the project

Note that all three winning teams must be present during the lecture on April 30, as we may ask you to help explain to others in the class how you designed your device and some of its more successful features.

We will ask other faculty members to help judge the devices for other areas of merit, which might include:

- Manufacturing craftsmanship.
- The use of mechatronics.
- Design simplicity and elegance
- Low cost

The Lead Up
Your design group may ask any questions whatsoever of Bob Thilmont, Bert Vermeulen or the TAs. This is strongly encouraged to ensure that your device meets the spirit of the competition. We encourage you to use RamCT to ask these questions. If you email questions to us, these questions and their answers will be posted on RAMCT. If you have any of us sign a "non-disclosure agreement" (sample attached), we will then discuss with you confidentially those issues you have, and will not disseminate your questions or the answers to the entire class.

Required Report
If you did not get one of the top three places in the competition, your grade for this project will be based almost entirely on the report that you submit, except for the following:

A. Only 1st, 2nd, or 3rd place groups will be graded based on how the device placed in competition.

B. Your report score will be reduced by 2 points if your device did not at least once safely accomplish the first three tasks and stay in bounds during an entire 30-second round on the day of the competition as described in section 7 on page 2.

C. We reserve the right to further lower your project report grade for the project if we feel that you did not make a serious effort to build a device capable of meeting at least the first three tasks described in section 7 on page 2.

The report must be turned in as a correctly labeled single PDF (GroupXX_Project2.pdf) with any supplemental materials in a zip file or folder that is also correctly labeled (GroupXX_Project2.zip). These items must be turned into the drop folder on the T-Drive by 7am on Saturday, April 26. We encourage you to submit your project the night before and then get a good night's sleep. You cannot compete if we have not received the electronic copy of your report as a single PDF.

The report will consist of:

a. **Page 1** (1 point) is the cover sheet in the exact format shown in Appendix C. It must show:
   - Group number
   - Names and email address for each member of your group
   - Checklist of all report content and page(s) where this content can be found.

b. **Page 2** (2 points) is the title page that needs to show:
   - A title identifying the device
   - A photo of the device to fit in the remainder of the space on this page

Pages 3 and beyond of the report will have all of the other information required as listed below. Note that it is important that each section has page numbers that correspond to the pages listed on the cover sheet and that the first page of each section is labeled so that we can identify which section we are reading as we go through the report. We strongly prefer and recommend that you compile your report in exactly the order below.

c. **Project plan** (5 points). Your project plan should include all of the information that we requested for Project 1. This includes: tasks, milestones, owners, planned completion dates, actual completion dates, the critical path, and weekly status snapshots. For the second project, we also want to see how many hours total for the group that you estimated the project would take and how many total hours the product did take. There would be some kind of analysis of planned versus actual schedule and planned hours versus total actual hours for the group.

d. **Specification development** (10 points). You should show how you developed the specifications for your device and its various systems. This should include identification of customers and requirements, competitive analysis, metrics for your specifications, targets, and tradeoffs. Your specification development should be as clear and easy to follow as possible. There should be a table that clearly shows the specification that you are designing your device to meet, which can then be used for your concept generation, concept selection, etc. Your specification should be in your own words, drawings, charts, equations, etc. Your specification should attempt to quantity as much as possible using measurements that can later be verified. Please include how you prioritized the musts and wants (delighted and disgusted) for functional specifications and list all constraints.

e. **Engineering analysis** (15 points). You should demonstrate how you have used engineering concepts learned in other classes you've taken (such as Statics) to help understand and solve this design problem. You can use any other type of analysis and any other resources as long as you tell us what you used for your analysis. This is an important section and has historically been significant in the report grades, and success in the competition.

f. **Concept generation and concept selection** (10 points). There should be a description of the concepts your group considered, the methods used to generate concepts, and the process used to make the choices that lead to the design (or designs) your group decided to build and test as prototypes. The conclusion of this section needs to tie back to the specifications, constraints, and analysis performed in steps d and e above.

g. **Device description** (15 points). There should be annotated drawings or annotated photos that explain the following in a way that we can understand:
   - How to make a device similar to yours. This could be photos of all of your parts and how they are to be assembled, an exploded view, or any other method you think conveys all of the information.
   - The process (movement steps and sequence) of how your device has been designed to accomplish the tasks given in section 7 on page 2.
   - Any critical elements or features that making your device work and work reliably.
   - Any clever ideas that you think make your device unique.

   We do not require Creo drawings or solid models, but you can use Creo or another CAD package to help you generate your design prior to fabrication. CAD software can also be useful for you to generate the images that explain how to build your device and how it works. If you do create any models, include the important images in the main body of the report and put all source files into a ZIP file.

h. **Bill of materials** (5 points). The bill or materials (BOM) for this project is different than the one for the first project Appendix D provides a sample. The BOM for this project must include:
   - The cost of each item required to fabricate your device
   - Where each item can be obtained (where you got it)
   - There should be a total cost so we see how much it would cost to buy the components to build a device similar to yours.

   Also please tell us how much in total you spent (including spares, parts you didn't end up using, things that broke, etc)

i. **Reliability and design margin analysis** (4 points). This analysis should show the places where you believe your device is most likely to fail and what you have done to build design margin into those areas. This should also identify how much variability in the dimensions of the competition fixture your device can tolerate and an assessment of the impact of vibration during storage and usage that your device can tolerate.

j. **Testing** (10 points). A description of the testing that you did to verify that your device would perform well in the competition. This should include a description of things you learned during these tests and improvements that you made as a result of testing. It also needs to compare your actual device to the specification targets and constraints you developed in part d above.

k. **Safety** (4 points). A safety analysis of your design or design choices showing risks and what your team did to minimize the most critical hazards.

l. **Service and support plan** (4 points). This should show what you plan to do in case any part of your device should fail and you need to make emergency repairs during competition day. What spares will you have?

m. **Teamwork analysis** (4 points). This requirement is the same as it was for the first project. We encourage you to use team contracts, health assessments, meeting minutes, and other tools that

allow you to work effectively as a team and include this information. We recommend that you have a summary of lessons learned in preparing the device and the report for the competition.

To summarize, the grading of this report is done using the same approach as for Project 1, but we do not need CREO models and we expect significantly better technical analysis and grade to a higher standard based on the things that you've learned in this class. Just like for Project 1, we expect that reports worthy of a grade of 90 or above will demonstrate initiative by including additional relevant material, demonstrate critical thinking in the analysis, and have a "WOW" factor to them.

Post Mortem

By Monday evening April 28 (at 6pm), all groups including those that won first, second, or third place must turn in brief post-mortem listing at least eight things they learned from the project, including competition day. Doing a post-mortem is a good idea for any project. This post mortem is your homework assignment for April 28 and will be described in a homework assignment that will be posted on the T-Drive.

APPENDIX A.

Request for Confidentiality (use if you need to share info with TAs or Instructors)

The undersigned agrees to hold confidential information of a competitive nature with the group members listed here. If the discussion leads to items of general interest (eg. – rules, competition or grading clarification), the design group allows publication of those items of general interest. Otherwise, any discussion of a competitive nature leading to a competitive advantage for the group will be held confidential.

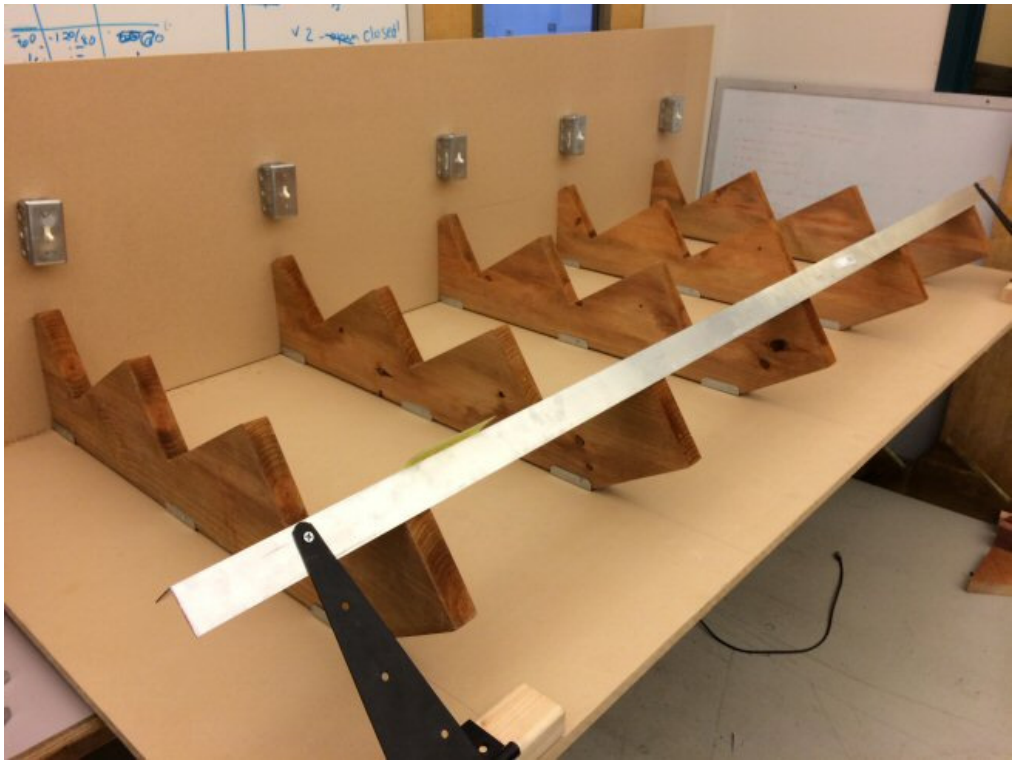
Signed: Dated:

APPENDIX B
Fixture Parts List and Supplementary Fixture Info

Below is a rough bill of materials for what was used to build the main components of the competition fixture. Note that this fixture has 5 lanes. You can build a test fixture just using a stringer and a switch box, with switch and cover plate mounted in the correct location. Also note that the fixture to be used during the competition will be wired and will have light bulbs (located outside of the zone where your device is allowed to operate) that will turn on when when the switch is turned on.

ITEM	DESCRIPTION	MATERIAL	SOURCE	QTY	UNIT PRICE
1	4-step stair stringer. End cut adjacent to back panel, about 40" long.	Redwood	Lowe's	5	About $10
2	2"x4"x1 7/8" deep galvanized steel electrical box with ½ inch knockouts.	Galvanized steel	Lowe's	5	$ 0.91
3	Standard on-off switch for electrical boxes.	Various	Lowe's	5	$ 0.69
4	Galvanized steel switch covers that match the boxes and switches.	Galvanized steel	Lowe's	5	$ 0.64
5	12 inch T-hinge (Item 65699).	Painted steel	Harbor Freight	2	$ 7.99
6	2 inch x 2 inch extruded aluminum angle "iron" 1/16 inch wall thickness 96 inches long.	Aluminum	Lowe's	1	$19.83
7	Base: 15/32 inch x 96 inch x 42.5 inch plywood or equivalent.	Wood	Lowe's	1	About $40
8	Back Panel: 15/32 inch x 96 inch x 24 inch plywood or equivalent	Wood	Lowe's	1	About $40
9	Wood screws	Steel	Lowe's	100	About $0.05
10	Mounting brackets for stringers	Galvanized steel	Lowe's	20	$0.56

Below are photos of the test fixture:



Appendix C
Cover Sheet Template

Group Number ____

Group Members	Email Addresses

Section	Pages where found
a. Cover sheet	1
b. Title and photo of device	2
c. Project plan & hours spent	
d. Specification development	
e. Engineering analysis	
f. Concept development and choice	
g. Illustrated description of device function	
h. Bill of materials	
i. Description of testing	
j. Safety analysis	
k. Reliability and design margin analysis	
l. Service and support plan	
m. Teamwork analysis	

Supplemental Information	Where located

Appendix D
Mandatory Information for Bill of Materials

Item#	Description	Material	Where purchased	Quantity	Cost
				Total cost:	
				Total spent by team (including spares, broken parts, etc):	

Appendix E
Competition Day Schedule (April 26)

To be provided later

Appendix F
Revision History

Date	Revision	Changes made
11-March	Original	Not applicable
28-March	Rev 2	Clarified wood stringer used on competition fixture
21-April	Rev 3	Competition day schedule now added