MEMO

To: High School Science/Technology Teachers

From: Melvin Roberts, Professor, Computer Integrated Manufacturing Engineering Technology

Date: October 17, 2006

Re: Engineers Week 2007 Trebuchet Competition - Specifications

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Well, it's that time again—time to prepare for the Camden County College National Engineers Week Competition. Next year, National Engineers Week will be officially observed during the week on February 18th. However, Camden County College will be celebrating National Engineers Week a week earlier, on **February 12, 2007**.

Once again, the College's Engineers Week Competition will be the Trebuchet Bean Bag Toss Competition. In the past, many of your schools have participated in the competition and we are looking forward to seeing you all here again. The rules have pretty much stayed the same, however, the target has been modified such that the "bull's-eye" has been cut out to prevent bean bags from skidding/bouncing out of the center ring of the target.

You are probably aware that a Trebuchet is medieval siege machine used to knock down or overthrow fortified walls by hurling projectiles: large rocks, burning debris, and rotting corpses. No rotting corpses will be tossed for Engineers Week, instead, in our case, the siege machine will be made of PVC and the projectile will be 8-ounces bean bags.

The trebuchet uses gravity (a counterweight) to propel the projectile. There shall be no elastic stored energy devices such as bungee cords or rubber bands. We have been able to locate a number of excellent historical and design resources on the Web including a PBS special (NOVA Builds a Trebuchet). We'll leave the Web searches to you. By the way, several metric units are intentionally used in this specification as a teaching point.

Group Organization and Restrictions

- Competing trebuchets shall be constructed by groups of students. We anticipate that each student design team will consist of three (3) to five (5) students. Smaller group sizes are permissible, if absolutely necessary. If a group cannot be formed, then individual entries are also welcome.

- A group is limited to entering one (1) trebuchet in the contest. Participating schools may enter multiple groups.
- No group member shall have received a high school diploma or its equivalent prior to the contest date.
- Parents, teachers, college students, professionals, and anyone else beyond high school age shall not assist directly in the construction of the trebuchet.
- If so inclined, adults may construct and submit *their own* trebuchet to be tested, but it shall not be judged in the contest.

Machine Design

Note: Due to facility constraints (once again, we will be competing indoors, in the College's theater) this is an accuracy competition, not a distance competition. There is no benefit to creating a trebuchet that launches the projectile a great distance if it is uncontrollable and misses the target zone. The decisive factor is to accurately hit the bull's-eye in the target zone.

Design and construct a trebuchet that meets the restrictions and specifications listed below:

1. The trebuchets shall be fabricated of any combination of one inch (1") and/or three-quarters of an inch (3/4") white schedule 40 PVC plumbing piping available from any home center. Contestants may use any combination of schedule 40 white PVC fittings including couplings, Y's, T's, L's, 45 degrees, reducer/expanders, etc. that they deem appropriate for their design. The PVC piping can be cut, split, channeled, chamfered, sanded, beveled, drilled, or notched in any way that the design team deems appropriate. All trebuchet joints shall be glued together using the appropriate PVC glue (also available at the home center). Painting and/or otherwise *cosmetically* decorating the Trebuchets is permitted and encouraged. Be sure to exercise caution, read, and understand all warnings before using PVC glues; use safety glasses and ensure plenty of fresh air. No metallic fasteners are allowed on the machines at all, nowhere.

2. In all cases, the design that the student brings in for the competition is the design that must compete; no design changes are allowed during the competition (except those notes in item 3 which follows below). The machines shall fit into a cube measuring point six (.60) meters per side maximum not including the beam. The beam (also constructed of the same previously described PVC piping) can be of any length deemed appropriate by the machine design but it **shall be of fixed length and non-adjustable during the competition**.

3. In order to allow teams to make adjustments to their trebuchets for distance, all trebuchet beams will be allowed to have multiple pivot points by drilling several holes though the beam. These holes will allow a means of adjusting the relative length of the beam on the counterweight side of the beam relative to the projectile side of the beam. **However, all booms must be of fixed length and non-telescoping, but the**

pivot point about the fulcrum axis can be made adjustable via multiple pivot points as described above. Therefore, teams will be allowed to make fulcrum point adjustments during the competition.

4. The machines may be wheeled or fixed; however, contestants will not be able to change from wheeled to fixed or vice versa during the actual competition. Contestants can use wheels from any source such as old toys, or even PVC pipe caps glued together (preferable). Wheel axels can be wooden, metal, or plastic as deemed appropriate by the design team.

5. No metallic machine bearings or bushings are allowed anywhere on the machine, however clever use of PVC plumbing fittings may serve these purposes if so desired. The only lubricant, if any, shall be wood paste wax such as Minwax or Johnson's (both available at most home centers).

The Trigger Mechanism

The trebuchets shall be actuated via a "remote" triggering mechanism attached to a string that you will provide which has a length of at least six (6) feet. The string material shall be any available natural, or synthetic, or combination thereof fabric string or rope. No cable, chain, or wire rope shall be used with the trigger. The contestant will pull the string while **standing to the left side of the machine** (as viewed when facing the front of your trebuchet as if the projectile were being launched directly at you). The trebuchet may not be held down or steadied by hand during launching. However, up to ten pounds of solid, red brick (also available at the home center) ballast weight may be added to the base of the machine for stabilization during the competition if necessary. No messy powdered or palletized ballast such as sand, beans, or flour is allowed: red brick only.

The trigger pin shall be a length of can be a ¼-inch or ½-inch diameter wooden dowel also available at any home center. Attach the dowel to the trigger string in a safe and secure manner. We recommend a hole drilled through the diameter of the dowel, and the string secured through that hole with a knot. The dowel can be cut, split, channeled, chamfered, sanded, beveled, drilled, or notched in any way that the design team deems appropriate.

The Sling and Counterweight Basket

If your design calls for a sling (not all designs will), contestants may use any available natural, or synthetic, or combination thereof fabric string or rope. No cable, chain, or wire rope shall be allowed. The counterweight basket, of your own design, shall be appropriately sized to secure the counterweight at all times. The basket can consist of either a fabric or plastic container or a combination thereof. The counterweight shall quickly fit into the basket with minimal fuss due to time constraints.

Safety Inspection and Test Shooting

Safety glasses will be provided for each contestant.

The safety of the contestants, the audience and of the site property is our primary concern. The judges prior to the competition will disqualify any catapult that appears unsafe or uncontrollable. No launch will be made from an unsafe device.

The catapult must appear and be demonstrably safe to our judges in an on-stage **test launch** prior to the contest. Any misfire or failure must not be capable of hitting the bystanders or the operator in any way.

Some things that will be on the unsafe list: compressed air, motors, loose parts, sharp or pointy parts, explosives, elastomer storage, operators without safety goggles, or parts of the catapult that will be damaging to the stage floor.

The Projectile

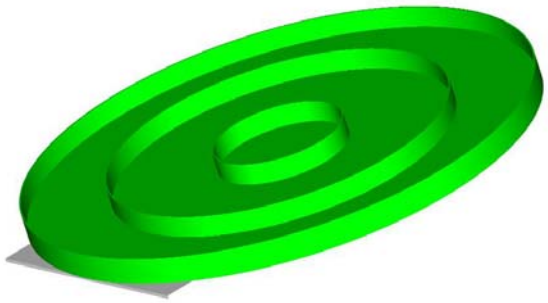
The projectile shall be a flattened ½ lb. bag (8 ounces) of dried small white navy beans wrapped in the original plastic bag. These beans are available at every supermarket. The half-pound bag of beans will be reinforced with standard gray duct tape (available at any home center) such that the bag does not easily burst. The final dimensions of the bag shall be approximately 10cm wide by 10cm long by 6cm thick (at the thickest point). Of course these dimensions are approximate as we are dealing with beans. The College will provide a selection of 5 (five) projectiles for the actual competition. Teams can pick whichever projectile they wish to use during the competition. It is expected that schools will fabricate their own projectiles for testing purposes at their schools.

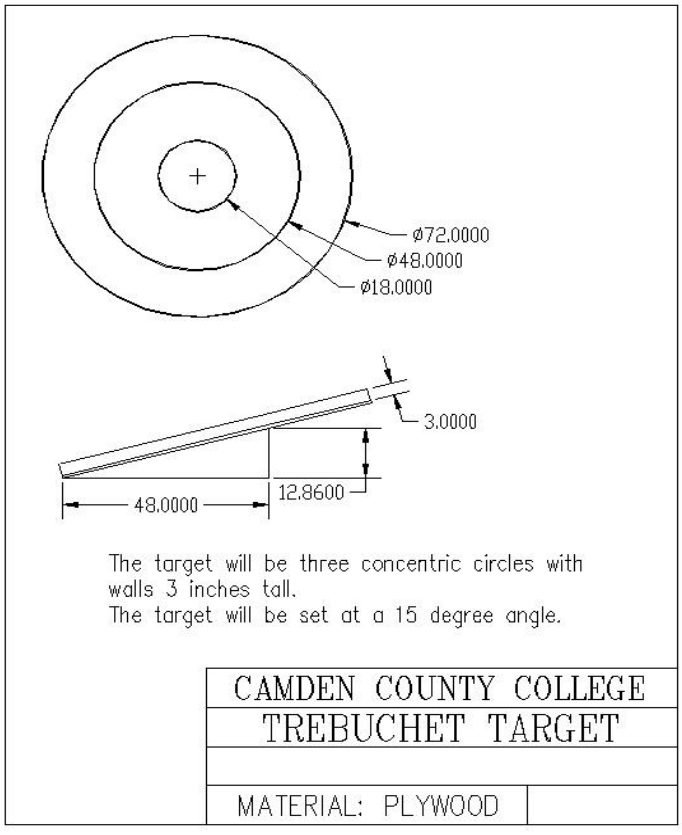
The Target and Scoring

Please note that the trebuchet target has changed from our maiden offering of the competition.

In order to prevent projectiles from "skidding off" of the target, the target has been redesigned to one similar to the "Ski Ball" games found at amusement parks, carnivals, etc. The target will be a still be a 6-foot diameter circle of ¾-inch painted plywood substrate. The target assembly will be tilted at an angle of approximately 15 degrees toward the launch area. A three-ring bull's-eye has been erected on plywood. The innermost ring of one-and-one half (1.5)-foot outside diameter shall be worth five (5) points; the middle ring of 4-foot outside diameter shall be worth three (3) points; the outermost ring of 6-foot outside diameter shall be worth two (2) points. Each ring in the bull's-eye target will be separated from the adjacent ring by a 3-inch high plywood "wall" ala the ski ball game. Shots that result in the beanbag landing atop a plywood wall between two circles on the bull's-eye (incredibly unlikely) will result in the higher point value. See CAD sketches below for an idea of how the new target will appear.

New for 2007, the centermost ring of the bull's-eye will be cut away so as to further prevent bean bags from bouncing and/or skidding off of the innermost section of the target (the five-point ring only). A net will attached to the underside of the target to facilitate removal of the bean bags. Additionally, the target assembly will be stiffened up to account for the material that has been removed.





The Counterweight

The counterweight for the competition shall consist of a single grouping of from one to six (inclusive) 12-ounce cans of soda secured with two (2) wrappings (top half of cans

and bottom half of cans) of standard gray duct wrapped around the perimeter of the cans. There will be several such counterweights available during the competition such that one team can load while another team competes. It is expected that schools will fabricate their own counterweights for testing purposes at their schools

Practice Shots and Staging Area

If so desired, a maximum of two practice shots will be allowed while on the theater stage during the competition. Practice shots do not count toward the final competition score. The College's technical staff is currently discussing the possibility of opening a staging area to be located in the theater lobby. The contestants will use this staging area for final assembly and for making adjustments to their trebuchet. All student contestants must be orderly and accompanied by an instructor/chaperone from their own school whenever they are in the theater lobby. Once the competition actually begins, the staging area will be closed.

The Competition

Teams will compete singly: one machine team at a time.

The competition is actually pretty simple: each team will use its trebuchets to take three (3) tosses at the target bull's-eye that will be placed at distance of twenty (20) feet away. No part of the catapult may project beyond the launch line, which will be twenty feet away from the center of the bull's eye. The launch line shall be scribed in an arc and marked with duct tape. Just like in a game of horseshoes: the final "spot" for the bean bag will be where the bag comes to a complete rest, not where it first hits the ground. The highest three-toss total score wins. Trebuchets may be repositioned after each shot but not within the 20-foot launch line. Repositioning beyond 20 feet is permissible within the confines of the stage (up to approximately 30 feet away from the target).

Note: The lowest point of the ceiling above the theater stage is approximately 17 feet. Be mindful of this during your design process because beanbags that are lobbed too high will hit the theater lights.

Trebuchets that suffer a failure of the launching mechanism during the competition shall be disqualified. In the event of a disqualification, the accumulated score (if any) prior to the point of failure will be used.

No alterations, other than aiming corrections, shall be performed on the trebuchets during the on-stage portion of the competition.

Safety glasses shall be provided and must be used.

Ties will be adjudicated based on weight of the machine. A machine will be weighed if and only if it is involved in a tie for first, second, or third place.

Prizes

There will be first, second, and third place trophies for the highest three total scores. All students who participate in the competition will receive a memento to mark the occasion.

Competition Registration and Contacts

In order to register your high school, please fax your registration form to Karen Gasparro at Camden County College at 856-374-5011.

Registration deadline is December 21, 2006

Technical Questions? Call:

- Professor Melvin Roberts at ext. 4526 or e-mail: mroberts@camdencc.edu
- Professor Lawrence Chatman at ext. 4526 or e-mail: lchatman@camdencc.edu
- Kevin Schmidt at ext. 4517 or e-mail: kschmidt@camdencc.edu