Call for Prototypes – Water Testing and Remediating Robots

Spring 2015 - KNW 2300 - Introduction to Engineering Design

I. Introduction

CleanWater4All.org is a well-financed, philanthropic organization interested in monitoring and preserving the quality of global water resources. They are funding a major initiative in Africa over the next 12 months in conjunction with various research centers on different parts of the continent. As part of this initiative, they will be hiring a team of engineers to develop prototypes of robotics systems that can aid in the testing and remediation of potentially unsafe water sources. CleanWater4All.org will sponsor a competition of the prototype robots on November 21, 2014 to determine which team it will invest in[i].

Estimates are that 780 million people in the world today do not have access to clean drinking water[ii] – more than twice the population of the US. More than 3 million people die each year; one child dies from a water related disease every 21 seconds[iii]. Clearly, any efforts to provide greater access to clean water can have a drastically positive effect on a substantial population[iv].

While there is a range of things that can cause water to be unsafe for consumption, the three of interest for this challenge are turbidity, salinity, and temperature. Turbidity is the cloudiness of a solution due to particles that are suspended in it, and salinity is the concentration of dissolved salts in a solution. The temperature of the water can influence the measurement of the salinity of the water, as well as the general levels of bacteria found in the water. Once the turbidity and salinity of a solution are known, a plan can be devised and executed using appropriate remediation materials. Often the place to dispense the remediation material is different than testing location.

You can never know the terrain of a particular water-testing site. For instance, a robot may have to traverse through areas of low hanging branches or through maze-like geography. Sometimes, getting to a water well means traveling across canyons. All in all, robots that are deployed in the areas of interest must be robust in their construction and control.

II. The Challenge

CleanWater4All.org is sponsoring a competition to determine which team it will invest in. The potential locations in which an autonomous robot could be deployed vary widely in terrain and obstacles. So the challenges that have been designed incorporate a number of tasks to simulate these different environments. While the robotics system itself is very important, CleanWater4All.org is also concerned with the aesthetic qualities of the robot as well as the overall reputation of the teams participating in the challenge. CleanWater4All.org will indicate its view of the aesthetic qualities of the robot and team reputation through a metric known as the Coefficient of Confidence.

The competition will be take place on a 12’ x 16’ arena split down the center to make two 12’ x 8’ playing fields. Each playing field will be identical for each match with the exception of the teeter-totter challenge location. Each match of the competition consists of two teams’ robots competing simultaneously, one on each playing field. The goal for each match is to accrue the highest number of match points based on the point schedule in Table 1. The winning team for each match will earn two (2) ranking points, and the losing team will earn zero (0) ranking points. In the case of a tie, each team will earn one (1) ranking points.

The competition will be in three rounds:

- Qualifying: Teams from each section of KNW 2300 compete in a double-elimination style tournament, and the highest earner of competition tokens will be the section representative to the Semi Finals. The actual tournament bracket will be announced closer to the competition
- Semi Finals: Tuesday’s (L01) and Thursday’s (L03) section winners will go head-to-head as will Wednesday’s sections (L02 and L04) in a best 2-out-of-3 competition.
- Finals: A winner from each group (L01/L03 group and L02/L04 group) will compete in a best 2-out-of-3 competition. The winning team will be crowned the Grand Prize Winner! The Professorial Staff will treat the Grand Prize Winning Team to a special dinner.

III. The Field

Each playing field (for graphical representation of the field, see Figure 1 and Figure 2) will have the following (note that your robot should take into account minor variances/error rates with every dimension listed below):

- The dimensions of the playing field will be 12’ x 8’ with 12” high walls,
- The floor of the playing field will be a dark blue carpet. A grid of tape will be laid down as guiding lines. The tape will be 1” wide white tape. The lines of tape will be laid in an on-center grid, with lines spaced 24” inches apart. The lines will start 12” from the wall. Refer to Figure 3 for clarification.
- The field will contain a water well of an unknown temperature, turbidity, and salinity centered along one shorter wall of the field. The water well will be a rectangular container, with dimensions 4”H x 10”W x 6.75”D,

- The field will contain a starting box located in the center from where each robot will begin a match with the robot facing directly towards the water well. The location of the starting box is shown in Figure 3 as a central grid region, and constitutes a space of slightly less than 24” x 24”.
- From the perspective of standing in the well looking towards the opposite side of the field, the right side of the field will contain a set of two salinity remediation material dispensers, dispensing ping pong balls valued at two (2) different values of S/cm . (for example one dispenser will provide 10 S/cm units of remediating material and the other will provide 100 S/cm units of remediating material) Each dispenser will be located on a guiding line. (Refer to Figure 3 for the locations of the dispensers). ,
- From the perspective of standing in the well looking towards the opposite side of the field, the left side of the field will contain a set of two turbidity remediation material dispensers, dispensing ping pong balls valued at two different values in NTU (for example one dispenser will provide 1NTU of remediating material and the other will provide 10NTU of remediating material). Each dispenser will be located on a guiding line. (Refer to Figure 3 for the locations of the dispenser values). The ping pong balls will be contained in a 1½” PVC pipe. The pipes will contain 12 ping pong balls each, for a total of 48 ping pong balls across all 4 dispensers.
- A ping-pong ball will be fully exposed at the bottom of the pipe, and will rest on a circular platform. Your robot will be tasked with either knocking the ball off the platform into a container on the robot, or grabbing it and storing it in the container. The top of the exposed ball will be 10” off of the ground.
- On the opposite half of the field from the water well, there will be a 5” deep, 18” wide canyon. Ramps of length 13.75” will be affixed to both sides.
- On the opposite wall of the field from the water well, the field will contain a specific region for delivery of the remediation materials.
- A teeter-totter device will be perched on a pedestal between the two playing fields. This device represents the only part of the playing field that can be utilized or engaged by a single robot in a match. Therefore, only one team can get points associated with the teeter-totter.

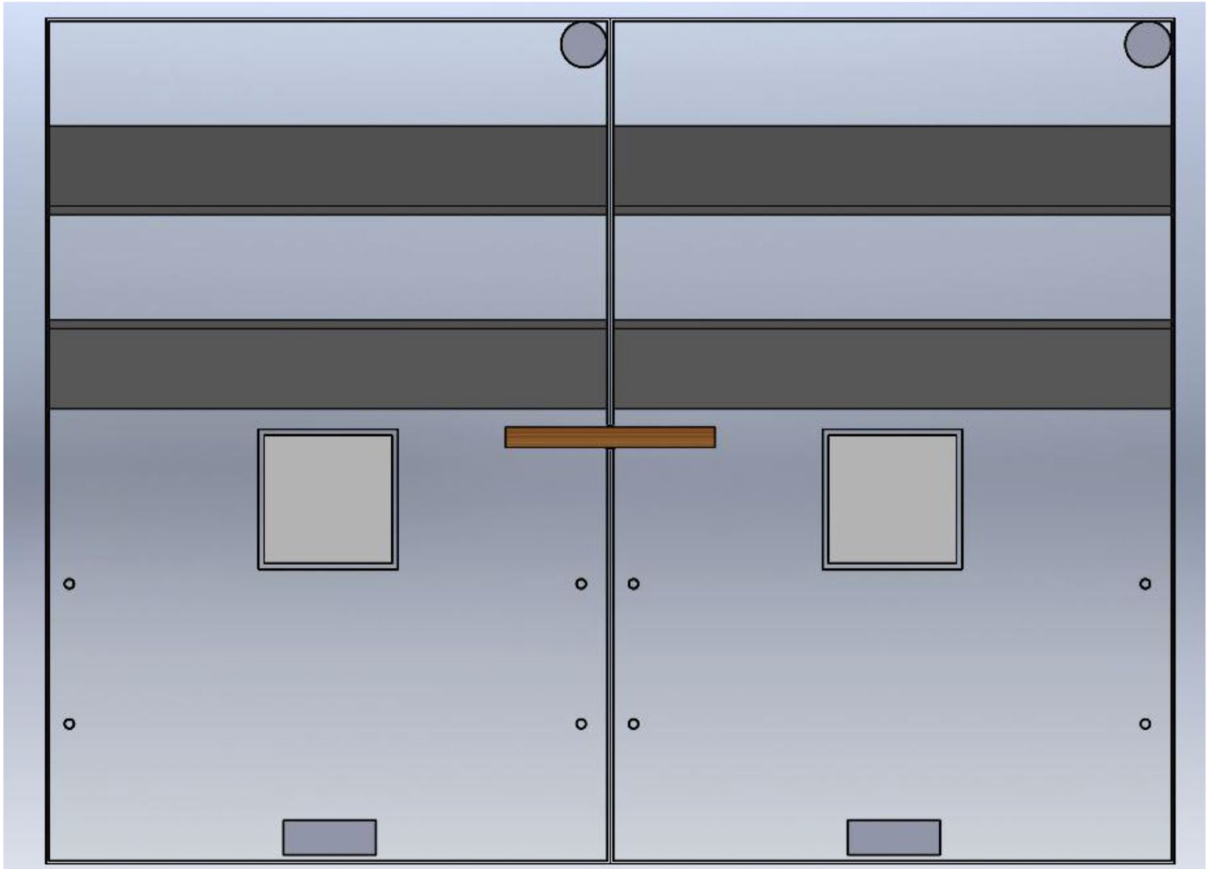

Figure 1: Playing Field Layout

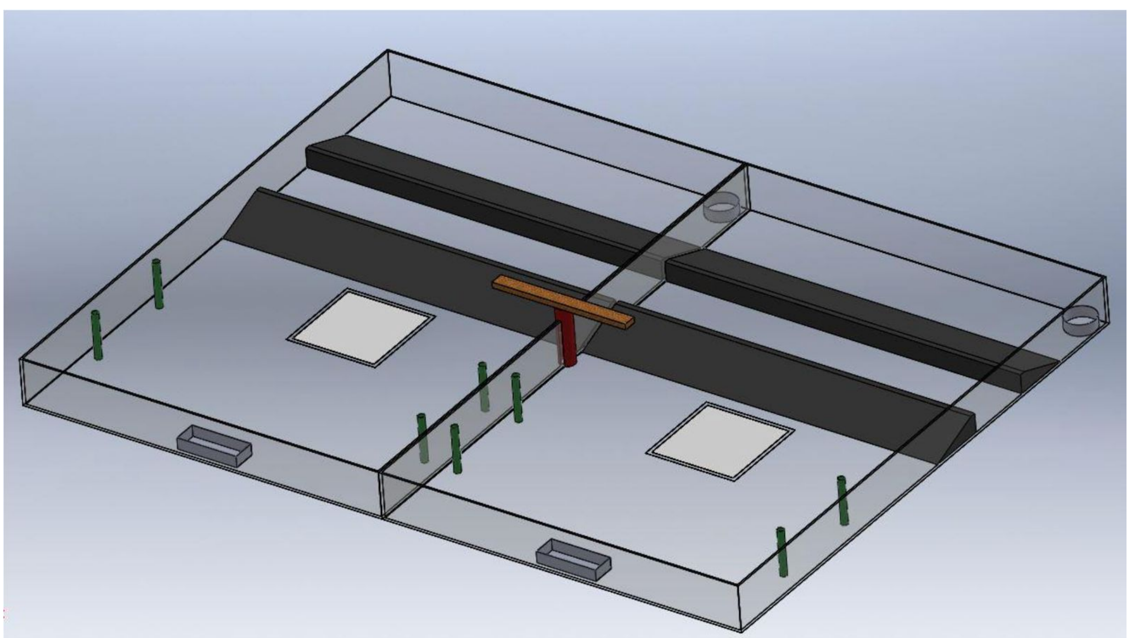

Figure 2: Side angle of playing field

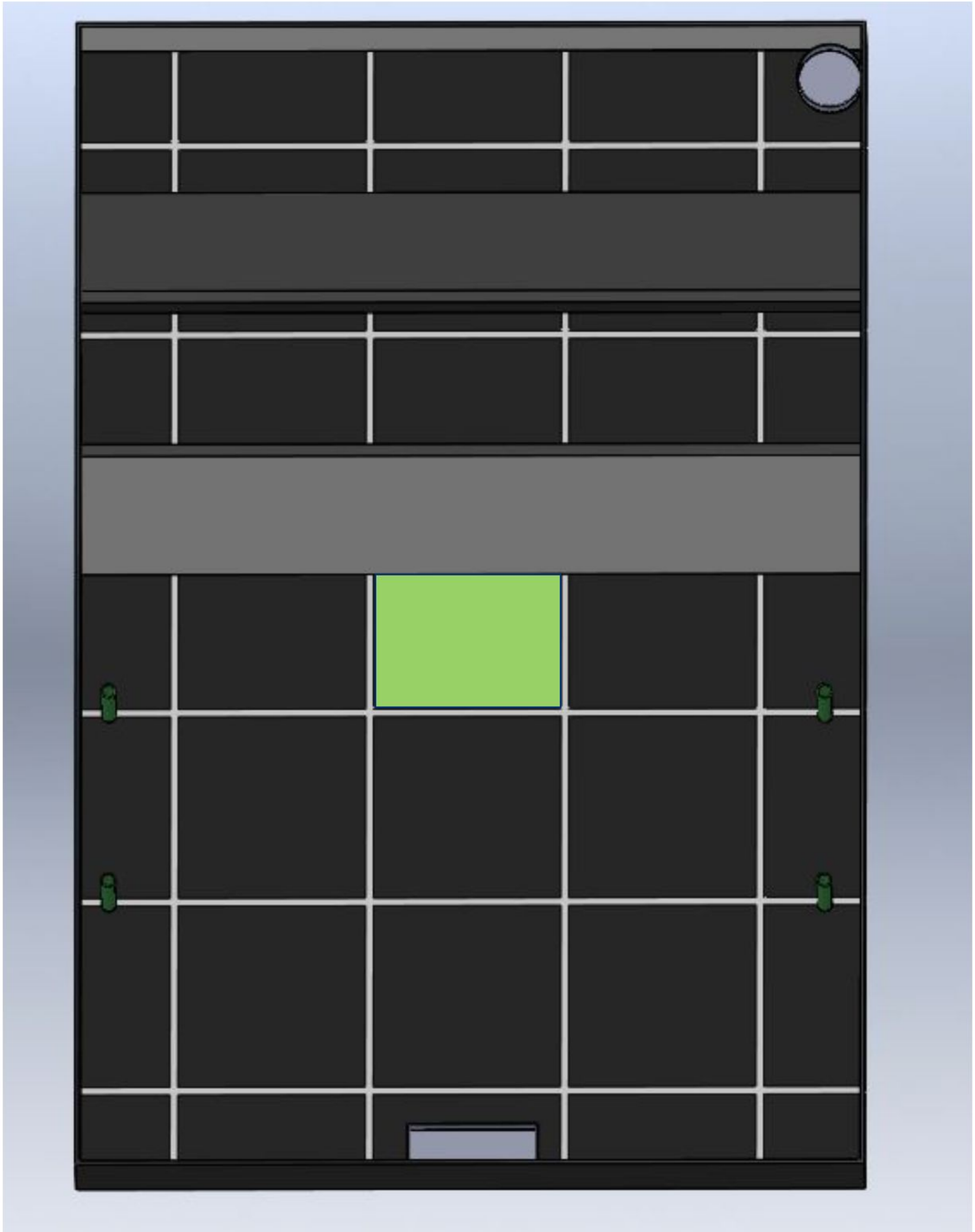

Figure 3: Individual playing field, with guidelines and starting region

IV. Rules of the Competition

1. Match

a. The duration of the match will be 5 minutes
b. During a match, the two competing robots will accumulate as many match points as possible based on the point schedule in Table 1. Not all tasks must be attempted.
c. The winning team from a match will earn two ranking points
d. The losing team from a match will earn zero ranking points
e. In the event of a tie, each team will earn one ranking point
f. Before the competition, the judges will provide each team with a “bucket” of points based upon that team’s Coefficient of Confidence. Before each match, a team will be able to apply any number of points remaining in the “bucket” to their score for a particular match. (The possible range will be communicated at a later date).

2. Canyon Crossing

a. Any bridge built to cross the canyon must only constructed from materials provided by the KNW 2300 staff. The entire bridge must be built from the limited materials supplied (exact dimension and material list to follow).
b. Your team may have more than one bridge, but only one bridge can be used per match.
c. Competition staff will place your bridge at one of three pre-specified locations: Center, Left, or Right. You will not know which of these three locations will be chosen before a particular match; your robot must find the structure.
d. In a given match, both bridges (if both teams construct one) will be placed in the same location across the canyon.
e. The bottom of the canyon will be filled with some amount of unknown materials. As such, the bridge MAY NOT touch the ground.

3. Robot Operation

a. No team member may interact with the robot during a match.
b. In between matches, you can modify your robot, bridge, or control software in any way you see fit. However, matches will start at their scheduled time.
c. If your robot gets stuck somewhere on the playing field during a match, your team will have to make a quick decision if you want to “reset” your robot. If your team chooses a match “reset”, the robot goes back to the starting square and you forfeit any points earned in the match up to the point of reset. The clock does not stop ticking during a reset.
d. If your control program encounters an unrecoverable error during a match, your team has the option to reset (as indicated in section III.3.c) or restart your control program. If you choose to restart your program, no modifications to the code will be allowed but no points will be deducted for the match.

4. **Robot Size and Materials**

a. Your robot may not exceed 18” x 18” x 18” in size.

b. You must construct your robot from the materials provided by the KNW 2300 staff.
    i. If you desire additional components, you must send an email to Professor Fontenot with a direct link that can be used to order the component and a brief justification for why you need it
    ii. Any additional components purchased by KNW 2300 for your team or any additional components your team purchases may not exceed $30.00. Any components that you already own still count towards this limit (including materials from the Innovation Gym).
    iii. Any additional requests for materials will be handled on a case-by-case basis by the course staff. All decisions are final.

V. Task Point Values

Table 1: Task Point Values

Task	**Points**
Find water	5
Get across canyon	10
Find bridge	10
Dispense at least one ball (turbidity)	3
Dispense at least one ball (salinity)	3
Leave the starting box	5
Measure turbidity (within range, report value)	10
Measure salinity (within range, report value)	10
Dispense turbidity balls (amount)[vi]	20
Dispense salinity balls (amount)[vi]	20
Deliver remediation materials to specific location	20
Depress the teeter-totter more than 15°	15

VI. Use of the Classroom/Innovation Gym Space and Materials

Being a member of this course affords you certain privileges not available to every undergraduate engineering student at SMU. With these privileges comes responsibilities. The points below are not suggestions; **they are requirements**.

- You are given 24/7 access to Junkins Hall, Junkins 202, and the Deason Innovation Gym (assuming you registered for Gym access). These spaces belong to everyone. It is extremely important that you respect these spaces, and it is your responsibility to clean up after yourselves.
- You are also given a toolkit containing a number of tools, listed below. Your team is responsible for these tools for the semester, and your team will be required to return ALL items during the final exam period. Every team is assigned a numbered kit, and the tools in those kits have been marked with a matching number. Each kit contains the following set of tools:

    - Tape Measure
    - Large Wire Strippers
    - Medium Wire Strippers
    - Wire Cutters
    - Jeweler's Screwdriver kit (with 6 screwdrivers)
    - Slip Joint Pliers
    - Long Nose Pliers
    - Scissors
    - Level
    - Short Screwdriver (¼" x 1½" Flathead)
    - Short Screwdriver (PH2 x 1½" Phillips head)
    - Medium Screwdriver (3/16" x 3" Flathead)
    - Medium Screwdriver (PH1 x 3" Phillips head)
    - Large Screwdriver (¼" x 4" Flathead)
    - Medium Screwdriver (PH2 x 4" Phillips head)
    - 2x 2mm Allen wrenches

If a tool breaks during normal use, notify a KNW2300 staff member, and your tool will be replaced. In the event that you lose a tool, one of several things may occur:

- If your team is aware that a tool is lost during the semester (before the final competition), notify a Professor. We will re-supply the tool, at the expense of your team's $30 budget
    - If your budget has been exhausted, then at least two members of your team will be required to help in the Innovation Gym (i.e. cleaning) for one hour per tool lost. We will re-supply your tool(s).

- If your team returns an incomplete toolkit during the final exam time, then you will be docked 1 point from your semester average per tool lost or incomplete (in the case of the Jeweler's screwdriver kit for example). Each bullet point above constitutes a single tool.

Under no circumstances should you take possession of any tools that belong to the Innovation Gym. You are free to use those tools that you have access to while in the Gym, but you may NOT remove them.

During the semester, your locker may be checked for unnecessary collection of class materials. The definition of "unnecessary collection" is up to the discretion of the KNW2300 staff. Remember, you are sharing the lab with 14 other teams. Storing an unreasonable number of parts and supplies hinders the effectiveness of the other teams. The is a practice we do not tolerate, and if it happens more frequently than we like, it may be considered academic sabotage of the other teams, which is a violation of the SMU Honor Code.

---

i. Note that this is a hypothetical scenario. At no point will SMU or the Professorial staff actually provide monetary incentives for participating in this challenge or class.
ii. For more information, see http://water.org/water-crisis/water-facts/water/.
iii. For more information, see http://water.org/water-crisis/water-facts/children/.
iv. Clean water is a real problem that hundreds of millions of humans deal with on a daily basis. We have chosen this scenario for the KNW 2300 course for a number of reasons. In no way do we mean to make light of the situation facing so many men, women, and children by using it as the scenario associated with this class. If you are interested in ways to get involved in research pertaining to providing clean drinking water, we encourage you to talk to Dr. Andrew Quicksall, a professor in the CEE Department at SMU and one of the faculty members for this course.
v. The robot inserting at least one probe into the liquid in the water well will signify that the water has been found.
vi. The number of points awarded for Dispense turbidity balls and Dispense salinity balls will be based on the difference between the actual value dispensed by a robot and the theoretical value needed to remediate the current solution.