Engineering Design Challenge I

Who Leads on Water?

Detailed Description

Short Description

The challenge is to design and build small autonomous boats that can complete specified tasks. Boats compete with each other in terms of speed, accuracy, and ability to carry along additional cargo units. To win the game, boats are expected to use sensors and control concepts to be able to operate reliably without human interaction

Time & Location

The challenge will take place on Saturday, April 16, 2016 at Charles Hostler Center, in the American University of Beirut. Teams will have several months to work on their designs.

Eligibility

Teams of 2 to 5 members of students can be part of the challenge. To qualify for winning monetary awards, all team members should be enrolled in a university or a high school as of the day of the competition. Hobbyists, including engineers or any non-students, are welcome to participate in the competition, but will not qualify for winning monetary awards.

Guidance and Advising

Teams are recommended, but not required, to have an advisor. An advisor has to align with the following:

1) An advisor can be anybody; a professor, an engineer in the field, or even a regular university student, who is willing to provide consultancy when needed.
2) An advisor can guide more than one team.
3) Advisors should only guide teams throughout the competition, not do their work. They may suggest ideas and provide feedback for teams, however they must not help with any hardware or software implementation.

Rules

1) A boat is any floating object that aligns with the rules, and the safety regulations specified below. No specific shape or material is required. Creativity is encouraged!
2) All teams must use only one boat to play the three games, however, minor changes and modifications can be made between matches.
3) The boat must pass a safety inspection before competing. Please refer to the safety regulations for more information.
4) The boat should operate autonomously, except when human interaction within special areas is allowed, as specified in the game description.
5) The longest dimension of the boat must be strictly less than 60 cm. This also include any parts that will be submerged underwater.
6) The boat must stay in contact with the water of the pool at all times during the game.
7) The boat should stay as one unit. Anything not permanently attached to the boat is not allowed.
8) Judges take the final decisions in rule matters.
9) Any team that violates these rules will be disqualified.

Safety regulations

1) The boat may not use any fuel/combustion based propulsion methods.
2) The batteries of the boat should be completely waterproofed, so that even in the (hopefully nonexistent) event that a boat sinks, the batteries themselves will not be in contact with water. Wrapping the batteries in nylon bags or sheets is recommended.
3) The boat may not otherwise pollute or contaminate the pool water.
4) Team members who get to the pool level should be either barefoot or wear flip flops.
5) Team members getting into the pool is strictly prohibited, and so is horseplay near the pool. Pool personnel will be available to assist in retrieving any lost items, as well as ensure the safety of participants.

Field description

All dimensions are given in meters, with a tolerance of ±5% except for the second game, for which the tolerance is ±10%.

There are three games that boats compete on; King of speed, Obstacle Course, and Water Tanker.

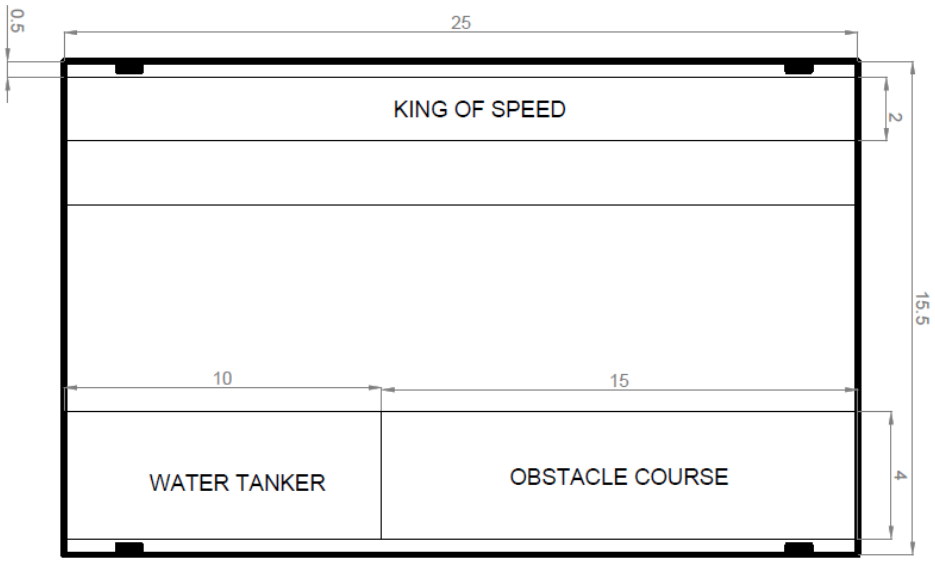

Figure 1: Pool division between the games

In the game descriptions, reference would be made to curtains that boats may use for navigation. Those curtains would be made of a material that reflects ultrasonic waves reasonably well, with a minimum height of 30 cm.

GAME 1 – KING OF SPEED

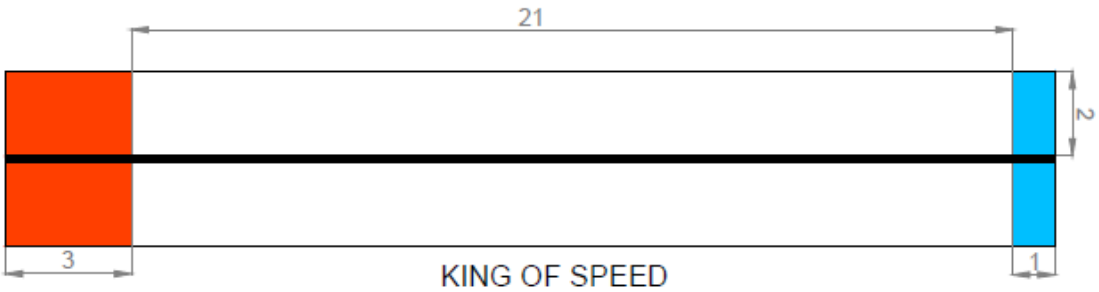

Figure 2: King of Speed field

The cyan area would be the start zone, while the orange area would be the end zone. The start and finish lines are at the edges of the start and end zones, respectively. The end zone would be filled with balloons and other objects to slow boats down and avoid crashing at the end of the race. The thick black line in the middle represents the middle curtain.

GAME 2 – OBSTACLE COURSE

Note that all dimensions in this game have tolerances of ±10%.

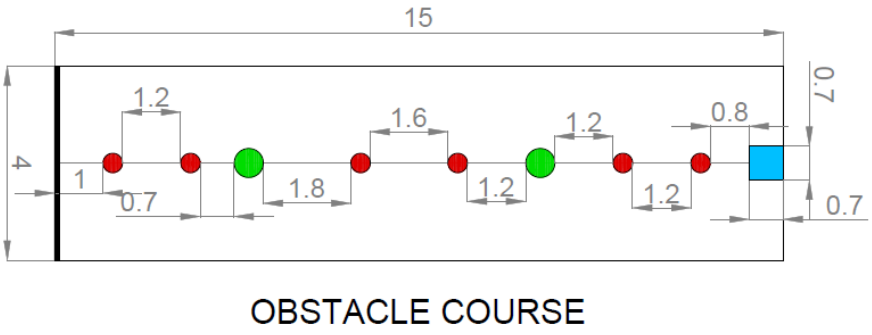

Figure 2: Obstacle Course field

The cyan region is the starting area for the boat. The thick line at the end represents a curtain. Objects are aligned in the middle of the field, with a tolerance of ±10% of the field width. Obstacles will be colored red, while roundabouts will be colored green, with dimensions (above water) as follows:

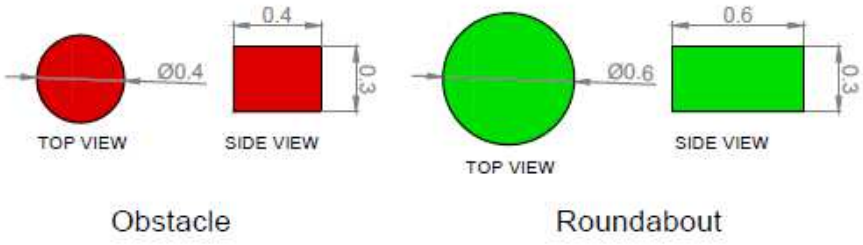

Figure 3: Obstacles and Roundabouts dimensions

The objects will be made of a solid material that reflects ultrasonic waves well.

The cargo units that would be used on the competition day would be as follows:

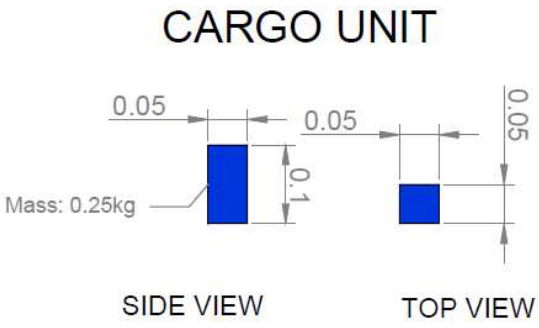

Figure 4: Cargo Unit dimensions

GAME 3 – WATER TANKER

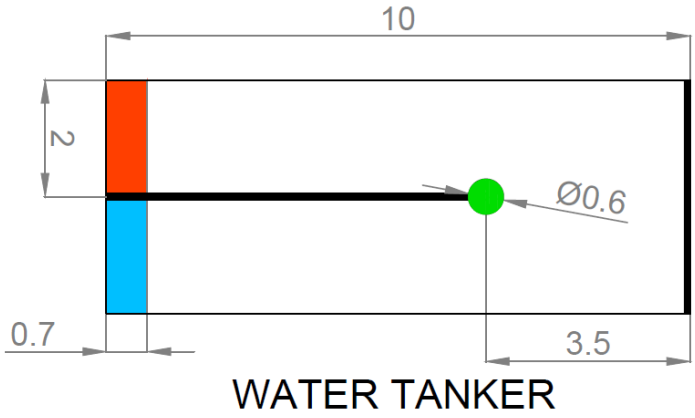

Figure 5: Water Tanker field

The cyan area would represent the loading area, while the orange is the unloading area. The green circle is a roundabout with the same dimensions as described in Figure 3. The middle dark line and the edge are curtains as described. The cup which the boat has to carry would look as follows:

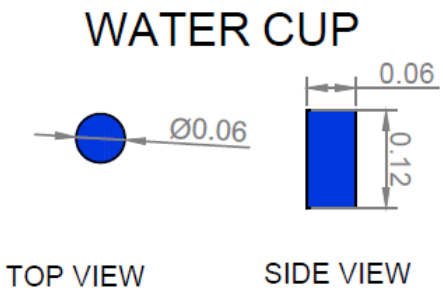

Figure 6: Water cup dimensions

Note that the 5% range of error applies to the top and bottom of the cup separately – the cup might not be a perfect cylinder, so steps must be taken to accommodate that.

Game Description

Refer to the field description as you read the outlined rules below.

GAME 1 – KING OF SPEED

In this game, boats race against the clock in a 21-meter sprint across the pool. Boats get scored according to the time it takes them to complete the track run.

- Boats start at 1 meter from the edge of the pool, and finish 3 meters from the opposite edge.
- Each boat gets 3 trials, and only the best trial gets considered for the game score.
- Two boats complete the track side-by-side in each trial, however they get timed independently.
- The round begins when the judge removes a cloth flag from in front of the boats. Boats have to be prepared to automatically sense the removal of the cloth and start moving accordingly.
- The timer stops when the boat first touches the finish line at the opposite edge of the pool.
- If a boat takes longer than 90 seconds to complete the track, the round is stopped and the boat gets a time of 90 seconds.
- A boat that leaves its lane, partially or completely, immediately gets a score of 0 for the round.
- The boat may not, in any way, intentionally influence the other boat playing in the same round. A violation of this rule gets a score of 0 for the round, and the other boat gets to repeat the trial.
- A tournament will be held for the boats that got the fastest timings, with the winner receiving the King of Speed title.
- Only the best time amongst the 3 main trials will be considered for the final score; results of the tournament will not affect the total score. Details of the tournament will be announced later.

GAME 2 – OBSTACLE COURSE

In this game, boats have to navigate a course while crossing in between obstacles and roundabouts. Additional points can be obtained based on the number of units of external weight carried along.

- A team member places the boat in the starting area of the obstacle course.
- Standardized cargo units are provided on the competition day, each weighing 250g (figure 4).
- Team members may pre-load the boat with up to 3kg of external weight by loading cargo units.
- The boat gets a multiplier to their score based on weight carried, as in the scoring document.
- If a cargo unit falls off the boat during the match, the multiplier is removed for the whole round, and a penalty instead is applied equal to double the value of the multiplier for each cargo unit.
- There are two types of objects; two green roundabouts, and six red obstacles. Positions of all obstacles and roundabouts are fixed, with tolerances of ±10% on all dimensions.
- The boat successfully completes a crossing if its whole body passes through the imaginary crossing line between two objects.

- The boat gets points based on the number of crossings between obstacles/roundabouts, or turns around roundabouts.
- A boat can only get points for any given crossing once, and any roundabout twice (once as a 360° turn and the other as a 720° turn).
- The time for each round is 2 minutes, after which the scoring stops.
- The timing starts as soon as the boat starts moving, or 15 seconds after the boat is placed, whichever happens before.
- If a boat leaves the game area, partially or completely, the scoring is immediately stopped.

GAME 3 – WATER TANKER

In this game, boats have to move water from one container to another, moving it with a cup of water across the pool. After a team member loads the boat with a cup of water, the boat has to move to the target area where it will be unloaded, then back to the loading area to get the cup refilled. This repeats until the time limit ends. Final score is based on the final volume of water moved. Note that the boat has to move smoothly so as to not spill water.

- Only two team members, called the operators, are allowed to interact with the boat; one at the loading area and another at the unloading. They cannot switch positions during the game.
- Operators can only interact with the boat when it is completely inside their respective highlighted area.
- Operators load and unload the water from a plastic cup provided on the game day (figure 6).
- The cup has to travel with the boat in both directions, waiting for the operators to finish loading and unloading the cup.
- The design may not block the top of the cup, or go along the sides over the top of the cup. It has to be exposed from above.
- The boat must keep the cup at all times above the level of the pool water, with the top of the cup at least 10 cm from the surface of the water.
- Any mechanism that loads water from the pool to the cup is not allowed. The water reaching the destination must entirely come from the source container.
- The timing starts as soon as the boat starts moving, or 15 seconds after the boat is placed, whichever happens before.
- The game goes on for 2 minutes 30 seconds, after which the water in the target container is measured for scoring. If the game finishes with the boat fully in the unloading area, the team may unload whatever water the cup is carrying before the water is measured.
- In case the cup falls off the boat, or the boat leaves the challenge area, or the boat crosses the curtain, the game stops. The team gets scored and penalized, as outlined in the scoring criteria.

Scoring

Teams will be assessed based on the following two measures:

1) Actual Performance (60%):
   60% of the total points will be given based on the boat's performance on the field on the challenge day, according to the scoring criteria specified in a separate document.
2) Technical Assessment (40%):
   The remaining 40% will be based on design evaluation by a team of judges from different universities, according to the judging rubrics specified in a separate document.

Awards

The team with the highest overall score gets a monetary prize of $1000. The runner up gets a prize of $500. Other awards will be distributed among teams who demonstrate proficiency in certain aspects of the competition.

Appendix: Changelog

- December 2, 2015: Initial release
- December 28, 2015:
    - Changed starting area dimensions in Obstacle Course and Water Tanker
    - Allowing high school students to participate