I. Introduction

Athletic stadiums and college campuses are plagued by the issue of trash after tailgating parties, after which there is often an assortment of glass, plastic, and aluminum beverage containers. This is both unsightly and time consuming to clean up, and represents a potentially significant source of untapped recyclable materials. By developing an autonomous robot that can locate, sort, and separately store the different containers, the manpower needed for cleaning can be reduced.

II. Objective

Robots must locate, obtain, sort, and store used beverage products. All sorting and storage is to be done on the robot. Points are awarded for the collected objects at the end of the round. Some points will be awarded for unsorted items; however, more points will be awarded for correctly sorted items. The winners will be judged on points with run time being the tiebreaker.
III. Playing Field

1. The playing field is a 10’x10’ square made of green Astroturf, with an “invisible dog fence” perimeter, placed underneath which acts as the boundary. The dog fence transmitter kit will be provided upon registration. See the appendix for construction details.

2. A 1-foot square grid of small spray-painted green dots will indicate potential locations for recyclables. Each recyclable will be placed on a green dot. The integrity or visibility of the dots will not be guaranteed and is not intended as a navigational aid.

3. There will be a hard boundary 12” away from the invisible fence to prevent interaction with other robots on adjacent fields. The height and material of the boundary will not be specified and is not intended as a navigational aid. It will be painted green. See the appendix for construction details.

4. The objects in play consist of Coca-Cola Classic products: 12-ounce aluminum cans, 0.5-liter plastic bottles with the tops still on (yes, this violates recycling standards), and 8-ounce glass bottles. The red labels will not be removed. None will contain liquid, but they may feature minor deformations due to previous usage.

5. There will be 10 total recyclables in play; 5 aluminum cans, 3 plastic bottles, 2 glass bottles.

6. The containers will be placed on their side in any orientation on the playing field.

IV. Robot

1. The robot must have a single button labeled “START”.

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1/5/2009 rev. 3.0
2. The robot must be able to fit in a 12x12x18 inch (LxWxH) box at the start of each match.

3. After the beginning of the round, expansion is unrestricted, but nothing can touch the playing field outside the 12”x12” footprint. The robot does not have to return to its original size.

4. There is no weight or material restriction. But the robot must be powered by non-dangerous means (no combustible or hazardous substances).

5. Gas canisters will be allowed, however the maximum operating pressure is 100 PSI. We kindly request that all canisters be easily inspected and that the participants allow extra inspection for safety. This may include external checks or other acts of verification. It is advisable to keep any high-pressure system in an enclosed compartment.

6. Any robot deemed dangerous by competition officials will be subject to disqualification. This includes any robots using admissible levels of compressed gas implemented in a dangerous way.

7. One (1) to three (3) plastic bags may be placed on the robot to collect recyclables. Each bag must be removable and replaceable at the end of the round for judging.

8. Prior to the beginning of each round, each bag must be labeled as to which object type will be stored inside. The team will gain the extra points for correctly sorted objects only if they are in the corresponding bag.

9. The bags may not drag on the playing surface

10. See section “Scoring” for additional information on scoring and point distribution
V. Rules of Play

1. On cue from an official, a team member must press the start button. The robot must operate autonomously thereafter with no interaction from people or electronic sources.

2. A team may not take any action that purposely interferes with the course of play or causes damage to the playing field or competing robots. The penalty for destructive interference is disqualification for that match.

3. A robot may start in any orientation at the discretion of the team, provided that some part of the robot is within 1 foot of the hard boundary on the interior side. The team is responsible for placement, but may not step onto the field.

4. The robot must traverse the play field and gather cans and bottles. Points will be awarded for everything picked up with additional points for correct sorting. This is detailed under the Scoring section.

5. The playing time will be four (4) minutes.

6. The robot is not required to return to any specific zone by the end of the time period.

7. At the end of the time period the robot may stop autonomously or a team member may stop the robot. However, regardless of when the robot is actually deactivated, no additional points may be accumulated. Any objects obtained after the time limit will not be scored.

8. In addition to the time constraint, a team member may call time at any point, ending the round with no penalty. This will be recorded as the runtime for that round in case of a tie-breaker.
9. The robot does not have to return to its original size at the end of the round (but must do so before the next round).

10. Some damage to the aluminum cans and plastic bottles is permitted. Damage to the glass bottles, however, is not allowed for safety reasons.

11. The can and bottle placement on the field (location only) will be the same for each heat, but may differ between groups and rounds.

12. All robots in the competing heat will be stored in a staging area for the duration of the round and unavailable to the teams for modification.

13. Teams not in the currently competing heat will have full access to their robots.

VI. Competition Format

1. Qualifying Round:
   a. The robot must move one foot autonomously after the push of the start button.
   
   \textit{b. The time and place of this round to be determined.}

2. Preliminary Rounds:
   a. Qualified teams will be divided evenly into two heats.
   b. There will be three preliminary rounds
d. The average score of each team for the three preliminary rounds will be used to determine which teams advance from the preliminary.

e. Eight teams will advance to the finals.

1. The top three teams from each heat will advance from the preliminary.

2. The two highest of all the remaining teams (wild cards) will advance from the preliminary.

3. Final Rounds:

   a. One group of eight teams will participate.
   
   b. Two final rounds will be held.
   
   c. The average of the two final rounds will determine the final ranking.

VII. Scoring

1. 10 points will be awarded for traveling 1 foot into the playing field from the starting position.

2. Each can or plastic bottle correctly sorted is worth 15 points. Each glass bottle correctly sorted is worth 30 points.

3. Each object incorrectly sorted is worth 5 points.

4. Points will be calculated after the end of the round by the judges by assessing the number of sorted and unsorted objects.

5. A penalty is assessed whenever a team either impacts the hard stop surrounding the playing field, or an extremity of the robot passes beyond the 10’x10’ edge of the board.
6. The degree of the penalty is $2^{n-1}$ points per violation where $n$ is the total number of violations that have taken place during that round.

7. The penalty per violation will not increase past $2^5$ points.

8. A line judge will be present to judge violations.

9. The team is encouraged to observe the point calculation and propose an objection, but only before the score is officially recorded. It is the team’s responsibility to be present at the calculation (which will directly follow the round and will be done off to the side) and the team may not request a delay in the calculation.

10. Other awards will be given out to acknowledge outstanding achievement in the following areas:

    * Most Aesthetically pleasing
    * Most entertaining
    * Best use of recyclable/recycled materials
    * Best mechanical design/implementation
    * Best electrical design/implementation
Appendix A: Recyclables

All dimensions are the maximum outer dimensions in decimal inches with a 0.1 inch tolerance. The weights have a 0.05 oz tolerance.
## Appendix B: Board Construction

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Part Number</th>
<th>Construction note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground “invisible” fence</td>
<td>Custom circuit board and parts kit (including the wire) will be provided upon registration.</td>
<td>N/A</td>
<td>The wire will be attached to the underside of the AstroTurf using duct tape.</td>
</tr>
<tr>
<td>AstroTurf - like Carpet</td>
<td>This is a green plastic carpet-like material that will represent grass.</td>
<td>Lowes #234774</td>
<td>It costs $0.44 per square foot (at our Lowes). It is sold in 12’ widths, so you will need to buy a 12’X10’ piece and cut off 2’ of it. It is easy to roll up and transport in a normal car trunk.</td>
</tr>
<tr>
<td>Hard boundary</td>
<td>This is not intended as a navigational aid and is only there to keep the robot from leaving the field. For testing purposes, a painted green “2x4” on its side can be used but will be different than the boundary used in the competition.</td>
<td>Lowes #98653 for the paint Any wooden 2”x4”x10’ will work</td>
<td>The 2x4s should be painted green and placed on its side (so it is only 2” high) along the 10’ outer boundary. The boards are not connected together at the ends, and thus so that they and the AstroTurf can be rolled up and transported easily.</td>
</tr>
<tr>
<td>Possible beverage location markers</td>
<td>These will consist of green spray painted dots. They indicate the possible location of beverage containers and are not intended for navigational aid.</td>
<td>Lowes #98653</td>
<td>The dots are in a 1’ grid as shown in the board diagram and are no larger then 1” in diameter.</td>
</tr>
</tbody>
</table>
Note 1: The board is symmetric so all dimensions on the top also apply to the side.
Note 2: The hard boundary will be slightly different at the competition to discourage its use as a navigational aid.