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Rules for Student Hardware Competition 2001

Original release - September 10, 2000

Last revision date - December 01, 2000

Check revisions at the bottom of this page.

I)

Introduction

The hardware competition will be held on a 4'x10' playing surface (not including the 1'x1' wings). There will be a 4" wall, relative to the upper playing surfaces, surrounding the perimeter of the course. The track will consist of two identical flat areas (excluding paint colors for the balls and bins and the frequency of infrared LED's) separated by a middle section of lower height. The two flat areas will have a ramp sloped down connecting them to the center section. Each flat end will have one starting/ "Cash Out" area, one bin, six balls, navigation lines, and infrared LED's for additional navigation. The center section will have three balls as well as navigation lines. There will be two vehicles on the track competing to see who can collect the most balls in the most efficient manner.

The navigation lines will consist of white lines with black as a background. The distances between the white lines are given on the drawings and are measured from the center of the lines specified. The balls to be collected will be located at the intersection of chosen lines, as given in the track drawings.

One infrared LED located in the center of both starting bins will be used to start the competition. There will be additional infrared LED's used to designate the location of the scoring bin and the starting bin as noted on the drawings. The starting-infrared LED's will be turned off at the same time to indicate the start of a match. All other infrared LED's will be on throughout the entire competition to allow for navigation reference. The match ends when the time limit is up or both vehicles have been removed from the track.

II)

Game Play Rules

- A) Each vehicle starts inside the designated starting area with desired orientation.

- B) A random number generator will determine the side each vehicle starts on for each match.
- C) The infrared LED located inside the starting area will turn off at a calculated wait time on the range of 15 to 30 seconds after hands off is called.
- 1) A random number generator will generate the wait time for each match.
 - 2) Once the starting-infrared LED turns off, the vehicle is free to move without being penalized.
 - 3) A vehicle is not allowed to start the competition before hands off is called. The violating vehicle will be disqualified.
- D) There is a time limit of 5 minutes after the starting-infrared LED's turn off for each match.
- E) There are 15 balls located on the track.
- 1) Six balls are positioned on each end of the track, and three balls are positioned in the center section.
 - 2) The balls always start in these designated positions.
- F) Each vehicle's goal is to collect all 15 balls (up to two at a time), place them in the designated bin, and perform a "Cash Out".
- 1) If a vehicle possesses more than two balls at a time while the vehicle as a whole is moving relative to the track, it will be penalized.
 - 2) A ball must be touching the Masonite (bin flooring) or touching another ball, recursively, that is touching the Masonite in order to be considered inside the bin.
- G) "Cash Out"
- 1) To perform a "Cash Out", a vehicle must break a trip sensor located inside the start bin. The sensor will be activated 30 seconds after the starting-infrared LED is turned off, allowing the vehicle to exit the starting bin.
 - 2) A vehicle cannot "Cash Out" during the 30 seconds after the starting-infrared LED's turn off.
 - 3) Upon a successful "Cash Out", the current contents of the vehicle's bin are recorded, and these contents will be used to determine the team's score even if balls are removed from the bin by the opponent's vehicle after the "Cash Out" occurs.
 - 4) Once a vehicle "Cashes Out", it must be removed from the track.
 - 5) A "Cash Out" performed on the wrong side of the track will result in a failed "Cash Out" and a penalty. The offending vehicle must be removed from the track immediately. The trip sensor will then be reset. Only the balls remaining in the offending vehicle's bin at the end of the match will be recorded. The remaining vehicle is free to finish the course.
- H) The vehicle may only move within the 4" wall boundary. No part of the vehicle can extend horizontally beyond the wall. It will be penalized.

III)

Specifications

A) Vehicle

- 1) Vehicle must be autonomous and self contained (no external devices used).
- 2) Vehicle must not intentionally cause harm to the opponent (it will be disqualified).
- 3) Vehicle must not harm spectators.
- 4) Minimum height of 2.5" at ALL times – no tolerance.
- 5) BEFORE starting-infrared LED turns off:
 - Maximum width of 10" – no tolerance.
 - Maximum length of 10" – no tolerance.
 - Maximum height of 1' – no tolerance.
- 6) AFTER starting-infrared LED turns off:
 - Maximum width of 2' – no tolerance.
 - Maximum length of 2' – no tolerance.
 - Maximum height of 2' – no tolerance.
- 7) Maximum wheel diameter of 2 inches.
- 8) Maximum weight of vehicle is 20lbs.
- 9) Bumper:
 - Bumper must surround the perimeter of the vehicle only when the vehicle as a whole is moving relative to the track.
 - Bumper must have a minimum curvature radius in the horizontal plane of $\frac{1}{2}$ " with a $\frac{1}{16}$ " tolerance.
 - Bumper must exist on the vehicle over the vertical distance of 1- $\frac{1}{2}$ " to 2- $\frac{1}{2}$ " above the playing surface with a $\frac{1}{8}$ " tolerance.
 - Bumper must be continuous around all sides of the vehicle only when the vehicle as a whole is moving relative to the track.
 - A portion of the vehicle may extend horizontally beyond the bumper only if the vehicle as a whole is not moving relative to the track.
- 10) Vehicle must not expel any harmful gases or liquids.

B) Course

- 1) The floor of the scoring bins and the balls on each end of the track will be painted.
 - The scoring bin and balls on one end will be orange (Safety Orange: RUST-OLEUM #7555).
 - The scoring bin and balls on the other end will be purple (Dark Purple: RUST-OLEUM #7796).
- 2) The balls in the center section of the track will not be painted.
- 3) Infrared LED's:
 - All LED's on the orange side of the course will be driven by a 15kHz square wave generator with a 50% duty cycle. The peak current will be 20mA.
 - All LED's on the purple side of the course will be driven by a 10kHz square wave generator with a 50% duty cycle. The peak current will be 20mA.
- 4) The starting-infrared LED will be countersunk so that the top of the infrared LED is level with the playing surface.
- 5) All infrared LED's mounted on the walls will be countersunk so that the top of the infrared LED is flush with the wall.
 - The LED's located on the wall will be mounted at a vertical distance of 3" from the playing surface.
- 6) The playing surface will be painted black (Flat Black : RUST-OLEUM #7776).
- 7) The navigation lines will be painted white (Gloss White: RUST-OLEUM #7792).
- 8) Each hole beneath the balls will be drilled to a depth of $\frac{1}{2}$ " with a diameter of $\frac{7}{16}$ ".
- 9) The hole beneath the balls will be painted white (Gloss White: RUST-OLEUM #7792).
- 10) The walls of the scoring bins will be made of 1x2 strips so that the bin wall height will be 1.5".
- 11) The floor of the scoring bins will be made of Masonite.
 - The Masonite will be tilted.
 - The Masonite will be 1/8" thick.
 - The corner where the two 1x2 scoring bin walls meet will touch the track flooring so that it is the lowest point.
 - The corner where the 4" exterior walls meet will be raised 1/2" so that it is the highest point.
 - The other two corners will be raised 1/4".

- 12) The white navigation lines will be 3/4" wide plus or minus 1/8".

C) Part numbers and Tolerances

- 1) Paint Numbers - See specifications in section III B.
- 2) Infrared LED's: All infrared LED's will be Radio Shack Catalog Number 276-143c (High-Output Infrared LED).
- 3) Balls will be 1/2" steel balls (McMaster-Carr's Catalog # 96455K56)

D) Tolerances

- 1) All course dimensions are plus or minus 1/4" unless otherwise stated.
- 2) All vehicle restrictions are plus or minus 1/8" unless otherwise stated.

IV)

Scoring

A) Scoring will be determined by the following formula:

- 1) $\text{Score} = (\text{Time remaining (seconds) after vehicle performs a "Cash Out"})/60 + (\text{Balls Scored from bin}) - (\text{Penalties})$.
- 2) Time will be recorded to the nearest tenth of a second.

B) Points for each ball

Points are awarded only to balls remaining in the bin after time expires or if your vehicle "Cashes Out".

- 1) A value of 10 points will be awarded for each ball of the vehicle's sector color.
- 2) A value of 30 points will be awarded for each neutral ball.
- 3) A value of 60 points will be awarded for each ball of the opponent's sector color.

C) Penalties

- 1) If a ball leaves the playing area, the vehicle that expelled the ball will be disqualified from the round. The opposing vehicle wins the match.
- 2) If any portion of the vehicle leaves the starting bin before the starting infrared LED turns off, the violator will receive a -50 point penalty.
- 3) If a vehicle possesses more than two balls while the vehicle as a whole moves relative to the track, the vehicle will receive a penalty of -100 for each ball beyond the second ball.
- 4) If the vehicle "Cashes Out" on the wrong side, it will receive a -10 point penalty. The "Cash Out" will be considered a failure. The vehicle must be removed from the track without locking his bin or time scores.

- 5) If a vehicle does not meet the bumper specifications at any time during the match, it will be disqualified.
- 6) If a vehicle extends horizontally beyond the exterior wall, it will receive a -20 point penalty for each violation.

V)

Playoff format

A) Playoff Design Overview

- 1) The playoff format will be double elimination with randomization.
- 2) There competition will consist of rounds where every team plays exactly one match per round unless they receive the bye.
- 3) There will be as many rounds as necessary to complete the competition.
- 4) At the end of each match, the team with more points is declared the winner.
- 5) If a team loses two matches, they are eliminated from the competition.

B) All Rounds

- 1) Teams will be randomly divided into pairs to compete against each other.
- 2) If there is an odd number of teams, the highest scoring team from the previous round will receive the bye (see V C 1 for special case). If two or more teams tied for the highest score, a random team from the set of highest scoring teams will receive the bye.
- 3) A team can receive more than one bye during the competition.
- 4) If a team receives the bye for a round, the team must compete in the next round.
- 5) If a match is declared a tie, both teams advance to the next round (see V E 1 and V E 2 for special cases).

C) First Round

- 1) In Round 1, if there is an odd number of teams, a randomly chosen team will receive the bye.

D) Second Round

- 1) In Round 2, a team will not compete against the same team they competed with in Round 1. After Round 2, rematches may occur.

E) Final Round

- 1) If there is a tie in the last round, there will be a rematch 10 minutes after the end of the first match.
- 2) If there is a tie in the rematch, both teams tie for 1st place.

VI) Miscellaneous

- 1) The lighting conditions where the competition is to be held are unknown.
- 2) IEEE membership is required for all team members.
- 3) All judge's decisions are final.

Rules Revision History

Revision: 1 **Rule: III B 8** **September 12, 2000**

Previous Rule: Each hole beneath the balls will be $3/8$ " and will be drilled to a depth of $1/2$ ".

Revised Rule: Each hole beneath the balls will be drilled to a depth of $1/2$ " with a diameter of $3/8$ ".

Revision: 2 **Rule: III B 10** **September 12, 2000**

Previous Rule: The walls of the scoring bins will be made of 1"x2" strips.

Revised Rule: The walls of the scoring bins will be made of 1x2 strips so that the bin wall height will be 1.5".

Revision: 3 **Rule: III A 8** **September 12, 2000**

Previous Rule: Maximum **mass** of vehicle is 20 lbs.

Revised Rule: Maximum **weight** of vehicle is 20lbs.

Revision: 4 **Rule: III B 12** **September 12, 2000**

Previous Rule: N/A

Revised Rule: The white navigation lines will be 3/4" wide plus or minus 1/8".

Revision: 5

Rule: III B 8

**September 23,
2000**

Previous Rule: Each hole beneath the balls will be drilled to a depth of 1/2" with a diameter of 3/8".

Revised Rule: Each hole beneath the balls will be drilled to a depth of 1/2" with a diameter of 7/16".

Revision: 7

Rule: I ¶3 S1

**September 27,
2000**

Previous Rule: There will be additional infrared LED's used to designate the location of the scoring bin and the starting bin as noted on the drawings (TBU).

Revised Rule: There will be additional infrared LED's used to designate the location of the scoring bin and the starting bin as noted on the drawings.

Revision: 8

Rule: II F 2

**September 27,
2000**

Previous Rule: A ball must be touching the Masonite (bin flooring) or touching another ball that is touching the Masonite in order to be considered inside the bin.

Revised Rule: A ball must be touching the Masonite (bin flooring) or touching another ball, **recursively**, that is touching the Masonite in order to be considered inside the bin.

Revision: 9

Rule: III B 1.1

**September 27,
2000**

Previous Rule: The scoring bin and balls on one end will be orange (paint # TBD).

Revised Rule: The scoring bin and balls on one end will be orange (Safety Orange: RUST-OLEUM #7555).

Revision: 10

Rule: III B 1.2

**September 27,
2000**

Previous Rule: The scoring bin and balls on the other end will be purple (paint # TBD).

Revised Rule: The scoring bin and balls on the other end will be purple (Dark Purple: RUST-OLEUM #7796).

Revision: 11

Rule: III B 3.1

**September 27,
2000**

Previous Rule: A square wave generator with specs TBD will drive each infrared LED on one side of the course.

Revised Rule: Each LED on one end of the course will be driven by a 15kHz square wave generator with a 50% duty cycle. The peak current is TBD.

Revision: 12

Rule: III B 3.2

**September 27,
2000**

Previous Rule: A different square wave generator with specs TBD will drive each infrared LED on the other end of the course.

Revised Rule: Each LED on the other end of the course will be driven by a 10kHz square wave generator with a 50% duty cycle. The peak current is TBD.

Revision: 13

Rule: III B 5.1

**September 27,
2000**

Previous Rule: N/A

Revised Rule: The LED's located on the wall will be mounted at a vertical distance of 3" from the playing surface.

Revision: 14

Rule: III B 6

**September 27,
2000**

Previous Rule: The playing surface will be painted black (paint # TBD).

Revised Rule: The playing surface will be painted black (Flat Black : RUST-OLEUM #7776).

Revision: 15 **Rule: III B 7** **September 27,
2000**

Previous Rule: The navigation lines will be painted white (paint # TBD).

Revised Rule: The navigation lines will be painted white (Gloss White: RUST-OLEUM #7792).

Revision: 16 **Rule: III C 1** **September 27,
2000**

Previous Rule: Paint #'s – TBD

Revised Rule: Paint Numbers - See specifications in section III B.

Revision: 17 **Rule: III C 2** **September 27,
2000**

Previous Rule: Infrared LED's – TBD

Revised Rule: Infrared LED's: All infrared LED's will be Radio Shack Catalog Number 276-143c (High-Output Infrared LED's).

Revision: 18 **Rule: IV C 1** **September 27,
2000**

Previous Rule: If a ball leaves the playing area, the last vehicle to touch the ball will receive a score of -200 and the vehicle must be removed from the playing area.

Revised Rule: If a ball leaves the playing area, the vehicle that expelled the ball will be disqualified from the round. The opposing vehicle wins the match.

Revision: 19 **Rule: IV C 2** **September 27,
2000**

Previous Rule: If the vehicle leaves the starting bin prior to the 15 second hands off period, the violator will be penalize 50 points.

Revised Rule: If any portion of the vehicle leaves the starting bin before the starting infrared LED turns off, the violator will receive a -50 point penalty.

Revision: 20 **Rule: IV C 3** **September 27,
2000**

Previous Rule: If a vehicle possesses more than two balls while the vehicle as a whole moves relative to the track, they will receive a penalty of -100 for each ball beyond the second ball.

Revised Rule: If a vehicle possesses more than two balls while the vehicle as a whole moves relative to the track, the vehicle will receive a penalty of -100 for each ball beyond the second ball.

Revision: 21 **Rule: IV C 4** **September 27,
2000**

Previous Rule: If the vehicle "Cashes Out" on the wrong side, it receives a -10 point penalty. The "Cash Out" will be considered a failure. The vehicle must be removed from the track without locking his bin or time scores.

Revised Rule: If the vehicle "Cashes Out" on the wrong side, it will receive a -10 point penalty. The "Cash Out" will be considered a failure. The vehicle must be removed from the track without locking his bin or time scores.

Revision: 22 **Rule: IV C 5** **September 27,
2000**

Previous Rule: N/A

Revised Rule: If a vehicle does not meet the bumper specifications at any time during the match, it will be disqualified.

Revision: 23 **Rule: IV A 1** **October 6, 2000**

Previous Rule: Score = (Time remaining (seconds))/6 + (Balls Scored from bin) – (Penalties).

Revised Rule: Score = (Time remaining (seconds) **after vehicle performs a "Cash Out"**)/60 + (Balls Scored from bin) – (Penalties).

Revision: 24 **Rule: II F 1** **October 7, 2000**

Previous Rule: If a vehicle **carries** more than two balls at a time, it will be penalized.

Revised Rule: If a vehicle **possesses** more than two balls at a time, it will be penalized.

Revision: 25 **Rule: II C 3** **October 7, 2000**

Previous Rule: N/A

Revised Rule: A vehicle is not allowed to start the competition before hands off is called. The violating vehicle will be disqualified.

Revision: 26 **Rule: II F 1** **October 12, 2000**

Previous Rule: If a vehicle possesses more than two balls at a time, it will be penalized.

Revised Rule: If a vehicle possesses more than two balls at a time **while the vehicle as a whole is moving relative to the track**, it will be penalized.

Revision: 27 **Rule: III B 3.1** **October 12, 2000**

Previous Rule: Each LED on one end of the course will be driven by a 15kHz square wave generator with a 50% duty cycle. The peak current is TBD.

Revised Rule: Each LED on one end of the course will be driven by a 15kHz square wave generator with a 50% duty cycle. The peak current **will be 20mA**.

Revision: 28 **Rule: III B 3.2** **October 12, 2000**

Previous Rule: Each LED on the other end of the course will be driven by a 10kHz square wave generator with a 50% duty cycle. The peak current is TBD.

Revised Rule: Each LED on the other end of the course will be driven by a 10kHz square wave generator with a 50% duty cycle. The peak current will be 20mA.

Revision: 29 **Rule: III B 3.1** **October 17, 2000**

Previous Rule: Each LED on one end of the course will be driven by a 15kHz square wave generator with a 50% duty cycle. The peak current will be 20mA.

Revised Rule: All LED's on the orange side of the course will be driven by a 15kHz square wave generator with a 50% duty cycle. The peak current will be 20mA.

Revision: 30 **Rule: III B 3.2** **October 17, 2000**

Previous Rule: Each LED on the other end of the course will be driven by a 10kHz square wave generator with a 50% duty cycle. The peak current will be 20mA.

Revised Rule: All LED's on the purple side of the course will be driven by a 10kHz square wave generator with a 50% duty cycle. The peak current will be 20mA.

Revision: 31 **Rule: III B 11.1** **October 21, 2000**

Previous Rule: The Masonite will be tilted with specs TBD.

Revised Rule: The Masonite will be tilted.

Revision: 32 **Rule: III B 11.2** **October 21, 2000**

Previous Rule: N/A

Revised Rule: The Masonite will be 1/8" thick.

Revision: 33 **Rule: III B 11.3** **October 21, 2000**

Previous Rule: N/A

Revised Rule: The corner where the two 1x2 scoring bin walls meet will touch the track flooring so that it is the lowest point.

Revision: 34 **Rule: III B 11.4** **October 21, 2000**

Previous Rule: N/A

Revised Rule: The corner where the 4" exterior walls meet will be raised 1/2" so that it is the highest point.

Revision: 35 **Rule: III B 11.5** **October 21, 2000**

Previous Rule: N/A

Revised Rule: The other two corners will be raised 1/4".

Revision: 36 **Rules: V * *** **November 15,
2000**

Previous Rule: A) TBD

Revised Rules:

A) Playoff Design Overview

- 1) The playoff format will be double elimination with randomization.
- 2) There competition will consist of rounds where every team plays exactly one match per round unless they receive the bye.
- 3) There will be as many rounds as necessary to complete the competition.
- 4) At the end of each match, the team with more points is declared the winner.
- 5) If a team loses two matches, they are eliminated from the competition.

B) All Rounds

- 1) Teams will be randomly divided into pairs to compete against each other.
- 2) If there is an odd number of teams, the highest scoring team from the previous round will receive the bye (see V C 1 for special case). If two or more teams tied for the highest score, a random team from the set of highest scoring teams will receive the bye.

- 3) A team can receive more than one bye during the competition.
- 4) If a team receives the bye for a round, the team must compete in the next round.
- 5) If a match is declared a tie, both teams advance to the next round (see V E 1 and V E 2 for special cases).

C) First Round

- 1) In Round 1, if there is an odd number of teams, a randomly chosen team will receive the bye.

D) Second Round

- 1) In Round 2, a team will not compete against the same team they competed with in Round 1. After Round 2, rematches may occur.

E) Final Round

- 1) If there is a tie in the last round, there will be a rematch 10 minutes after the end of the first match.
- 2) If there is a tie in the rematch, both teams tie for 1st place.

Revision: 36

Rule: II H

**November 30,
2000**

Previous Rule: The vehicle may only move within the 4" wall boundary. No part of the vehicle can extend horizontally beyond the wall.

Revised Rule: The vehicle may only move within the 4" wall boundary. No part of the vehicle can extend horizontally beyond the wall. **It will be penalized.**

Revision: 37

Rule: IV C 6

**December 1,
2000**

Previous Rule: N/A

Revised Rule: If a vehicle extends horizontally beyond the exterior wall, it will receive a -20 point penalty for each violation.

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Track Drawings

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A			
	Top View	Top View	Top View
B			
	Side View	Balls - Top view	Balls - Side View
C			
	Starting Bin	Scoring Bin	3D View
D			
	Circuit Schematic	Bonus - Top View	Modulation Waveform

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