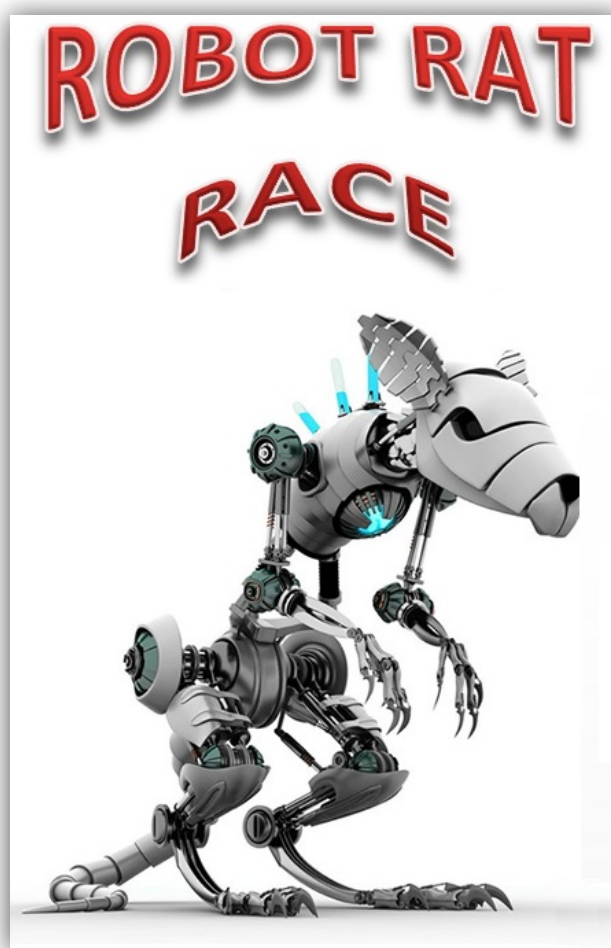




ECE 160

Product Design Specification (PDS)

Fall 2013- 2014



Version 2.0



Design Project Overview:

Rodents, Ltd., a division of Rose Enterprises, has oversight of the **ROBOT RAT RACE (RRR) Tournament**. Rodents, Ltd. would like to solicit your team's professional expertise to design and construct a *system* for entry into the Tournament.

Your team is required to design and construct a *system* also referred to as *robot* that will execute the requirements for the **RRR Tournament** in a superior manner. The tournament playing field consists of a planar surface with a complex maze and several secure cheese vaults (CV). Your robot must retrieve valuable cheese balls (CB) from the cheese holes (CH) in the maze and deliver them to the vaults. The robot rat can earn a significant amount of points by delivering the higher point cheese balls to the more secure vaults. The robot can earn additional points by also returning cheese balls back to the cheese holes at the end of the match.

The product design specifications and contest rules have been sent out to many well-qualified and motivated teams. Therefore, your team must be deliberative and diligent in order to work hard to come up with the most creative and effective solution.

Project Competition:

The final project competition, **ROBOT RAT RACE Tournament**, will be held at **17:30 on Thursday, November 7, 2013 in the Kahn Arena** (aka, the Kahn Rooms of the Hulman Memorial Union). Each team will show off their design to the amazement of their peers. Attendance at the competition is mandatory, any conflicts must be discussed with, and approved by, your instructor before the dry run. Due to the competition, the 18th day of class (9-2) will be cancelled.

Project Awards:

There will be four awards presented based upon the competition results as well as design and team spirit. The four award categories are listed below:

- "The Big Cheese" - Overall Tournament Winner;
- "Havarti Hoarder" - Overall Tournament Runner Up;
- "Colby Creator" - Most creative, unique and elegant solution;
- "Swiss Swagger" – Most "spirited" team with an identifiable non-offensive theme;

The first two awards will be determined by the competition scoring. The last two awards are voted on by ballot during the final project competition. Instructors and students in the course are not allowed to vote. Teams that earn an award will earn bonus points on the final project of 10, 7, 5, and 3 points for The Big Cheese, Havarti Hoarder, Colby Creator, and Swiss Swagger, respectively. Some these teams will also receive certificates and trophies during the competition or final presentations.



Product Design Specification

The requirements for the *system* are as follows:

General Requirements:

1. The *system* shall be designed to perform on the competition surface shown in Figures 1 and 2.
2. Each cheese ball is the shape, size and weight of a ping pong ball.
3. The *system* shall be constructed only from LEGO® pieces included in the provided kit as listed in the kit inventory. The team may also request no more than one (1) light sensor from the ECE parts room if they have a need. In order to organize the robot cables, the team may also request two (2) meters of orange kite string from the ECE parts room or use their own tie wraps. Tie wraps may only be used to organized cables and for no other use.
4. The laptop of one team member will be allowed to be used as control device for the *system* but it is not considered a part of the *system*. This laptop may only be used during the remote control period of the match.
5. The *system* shall operate without damaging the competition surface or any of the game pieces.
6. The *system* shall be designed to operate for the entire match without any reconstruction or reconfiguration.
7. The *system* shall be designed to operate without any physical contact (this includes wired connections to the laptop) during each match of the tournament. During the remote control period, the laptop of one team member may be used to control the *system* as long as there is no physical contact during the match. All controlling devices must be operated by the same team member during the entire match.
8. The system shall collect CBs from any of the four (4) CHs within the maze. The system shall deliver CBs to any of three (3) CVs.
9. The system shall not damage the competition surface, CB, CH, CV or any other system.

Materials:

1. Student teams shall use only the parts provided in their LEGO® kit as listed on their kit inventory, parts provided by the ECE Parts Room to complete their kit inventory or as listed in this document including string and one additional light sensor, if required. One team member laptop will be allowed to be used as control device for the *system* but it is not considered a part of the *system*.
2. No additional parts shall be added to the inventory received from the ECE Stockroom without prior written approval by the ECE160 faculty.



3. Parts shall not be traded between teams.
4. Students shall not modify the kit or parts provided.

Students shall return the LEGO® NXT kit as listed in the kit inventory and all additional parts supplied with all items accounted for one day before the final presentation session held during Finals Week.

Communication/Programming requirements:

1. The *system* shall be programmed in NXT-G (the drag and drop language supplied by LEGO®) or any other appropriate programming language selected by each team. Any programming language/operating system software used must be available to all students at no cost, freeware, or available through existing Rose-Hulman licenses. All teams using any software other than NXT-G must provide information for acquiring the software to the instructor (who will publicize this to all teams).
2. During the autonomous period, the system must move to the CH, acquire CBs, move to the CVs and release CBs with no human intervention or communication with the laptop.
3. During the teleoperation (remote control) period, the laptop may be used to communicate with/control only your team's NXT within the wireless capabilities of the control devices. This will typically be done via Bluetooth. The control devices may not be positioned within, over, or under the competition surface during the match. The laptop may be placed on the surface adjacent to the competition surface during the team's competition.
4. The *system* may communicate with the control devices via wireless or wired connection during the set up period before each match, but only via wireless communication channels during the match.

Competition Surface:

- The competition will be held on a table that is 6' x 6'. The competition surface will be flat black and is shown in Figures 1 and 2. There will also be a white line on the surface for line following as shown in Figure 2. The walls of the competition table will be wood color. Figures 1 and 2 include the dimensions of the table and the locations of the CBs, CHs and CVs.
- The CH consists of 2 dimples that are $\frac{3}{4}$ " deep in the table to keep the balls from rolling. Each CH will contain two (2) CBs located in dimples on the playing surface that touch the back wall of the CH. There will be a 2" center to center separation between the CB with a $\frac{1}{2}$ " gap between them. The ping pong balls are approximately 1 $\frac{1}{2}$ " in diameter.
- The CV consists of dimples in the table that are $\frac{3}{4}$ " deep to keep the balls from rolling and there will be two $\frac{1}{8}$ " high rails along each side of the vault to confine the CBs. The front of the vault will be open to accommodate the robot driving in and out.



- The competition surface and CBs will be provided for practice during the project design and construction phase. The competition surface shall not be modified or damage in any way during practice or competition.

Competition Rules:

1. The *system* shall be defined to be that device constructed by the team to perform the designated tasks.
 - a. The *system* shall not include a computer, infrared port or external wires, or any part of the competition surface.
 - b. The *system* shall include the constructed device and any software loaded into the NXT.
 - c. All components of the system must remain connected to all other parts of the system during the match. If parts become detached from the system during the match they may not be removed from the competition surface until the conclusion of the match. Detached part(s) may be reattached during subsequent setup periods or between matches.
2. The *system* may be started from any point on the competition surface. No part of the *system* may extend over the outer walls of the competition surface.
3. The tournament is comprised of a seeding round and several elimination rounds. Round 1 is used to determine seeding for the second round of the tournament and it will be based upon the **dry run** conducted on day 17 (9-1) of class. During the dry run each team will complete their first match of round 1 and earn a score. Since this also serves as the practice day, if a team so chooses, they may elect to run twice and keep the higher of the two scores. Since the dry run is also the **design freeze**, once the team completes their first run, they are not allowed to make any changes to the physical hardware design of their system although the program may still be modified.
4. During the second day of the competition (Thursday night), there will be paired matches or heats consisting of two competition tables with one team per table in the elimination rounds. The pairings will be based upon the seeding determined from the maximum of the dry run scores.
5. Each match will consist of a 1 minute setup period followed by a cheese retrieval period lasting up to 3 minutes. At the beginning of the setup period, a die will be rolled for each table to determine the point values for the CBs at each CH. During the 1 minute setup period the *system* may be programmed or reprogrammed. By the completion of the setup period, the system should be turned on but must not move before the 180 second competition clock is started by the officials.
6. The cheese retrieval period will consist of a 30 second autonomous period and a 2 ½ minute teleoperation period. The match will end 3 minutes after the setup period, or when both systems have stopped moving, whichever comes first. Teams have the



option of designing the system to be fully autonomous for the 3 minutes and this will be addressed in more detail later in this document.

7. A roll of a die at the beginning of the setup period will establish the data set (1-6) to set the points values for the CBs at each CH. The roll of the die indicates the CH for the 7 point, 5 point, 3 point, and 1 point CBs, respectively. If the die reads 6 or blank, the team can choose which data set to use. The coding for the roll is indicated by Table 1. For example if you roll a 4 then CH 4 has 7 pt balls, CH 3 has 5 pt balls, CH 2 has 3 pt balls and CH 1 has 1 pt balls.

Table 1: Die and Cheese Hole Code/Data Set

Roll	Code/CH #
1	1234
2	2413
3	3142
4	4321
5	1432
6	team's choice

8. Immediately following the roll of the die, tournament officials will place the CBs at the proper CH according to the code listed in Table 1. The CBs will be white small ping pong balls with small, dark, numeric symbols indicating their value.
9. The competition time begins once the CBs are placed and tournament officials give the starting signal. The system should immediately autonomously navigate the maze for 30 seconds to retrieve CBs from the CHs and deliver them to the CV.
10. The CV has a security value (SV) that is inversely proportional to the width of the CV. For example, the narrowest CV has a SV = 5, the intermediate CV has a SV = 3 and the widest CV has a SV = 1.
11. The narrowest CV can hold two (2) CBs; the intermediate CV can hold four (4) CBs, the widest CV can hold six (6) CBs. Therefore, there are 12 possible vault locations where the CBs can be delivered.

Scoring Rules:

1. The competition will be a single elimination tournament where the scores reset after every round. After round 1, the teams will be ranked to determine their seeding for round 2. After round 2, the teams will be ranked based upon their round 2 match score. The top half of the teams will move on to round 3. This will continue every round until we have the competition winner.
2. The value of each CB delivered to a SV will be calculated by using the following formula:

$$CB * SV$$



The total score for all of the CBs delivered to the vault will be determined by the following formula:

$$CB_del = \sum CB * SV$$

For example, if a 3 point CB is retrieved from a CH and delivered to a CV with a 5 point SV, then the $CB_del = 3 * 5 = 15$. CBs can only be scored once for placement in the CV.

3. Additional scoring can only occur if all CBs have been successfully moved to a CV. Then a team can score additional points by returning the CBs to a CH. A successful CB return occurs only when the CB is positioned on a CH dimple and remains at rest and not in contact with the system for at least 10 seconds. A CB can only be scored once when placed within the CH.
4. If a CB is returned to the original CH then the score will be double the delivery score as determined by the following formula:

$$CB_retA = 2 * CB * SV$$

For example, if you return a 3 point CB to the original CH from a CV with a 5 point SV, then $CB_retA = 2 * 3 * 5 = 30$.

5. If a CB is returned to a CH other than the original then the score will be the same as the delivery score determined by the following formula:

$$CB_retB = CB * SV$$

For example, if you return a 3 point CB from a 5 point CV to any CH other than the original, then $CB_retA = 3 * 5 = 15$.

6. The total score for all of the CBs returned to the CH from the CV will be determined by the following formula:

$$CB_ret = \sum CB_retA + \sum CB_retB$$

7. All scores are doubled during the 30 second autonomous period. A team may choose to complete the entire match autonomously and scores will be doubled for the entire match.
8. Scoring for a team's match within a round of the competition will be calculated as the sum of the scores of the CBs delivered to the CV and CBs returned to the CH as calculated by the following formula,

$$Match_Score = \sum CB_del + \sum CB_ret$$

9. If there is a tie which prohibits the judges from determining the team that will move on to the next round then there will be a sudden victory playoff match. During the sudden victory round, the first team to score a point moves on. If there is a 3 way tie, the team that moves on will be determined by the flip of a coin.

**Judging:**

1. Judges shall be provided by Rodents, Ltd., and the ECE Department.
2. Judges will serve as announcers, officials and scorekeepers. Therefore, judges will be responsible for insuring that the teams abide by the rules of competition, scoring each round and giving the score sheet to the official scorekeeper. Officials, announcers, score keepers along with team members will be responsible for field reset.
3. The decision of the officials shall be final. Decisions may be challenged for factual or interpretive errors; but, the officials have the final decision on the validity of challenges.
4. Teams shall ask the instructor for rule interpretations in a timely fashion. Requests for rule interpretations made after 5:00 p.m. on November 7, 2013 will be rejected.

Other Requirements:

1. All students shall participate with their team in the competition.
2. All students shall participate with their team in the design process for this project.
3. All team members shall participate equally in the project work.
4. All team members shall receive a grade on the project based upon the entire team's work as well as their individual work.
5. Students shall respect the creativity of others.
6. Students shall in no way interfere with another team's project work or interfere with another team during the competition.

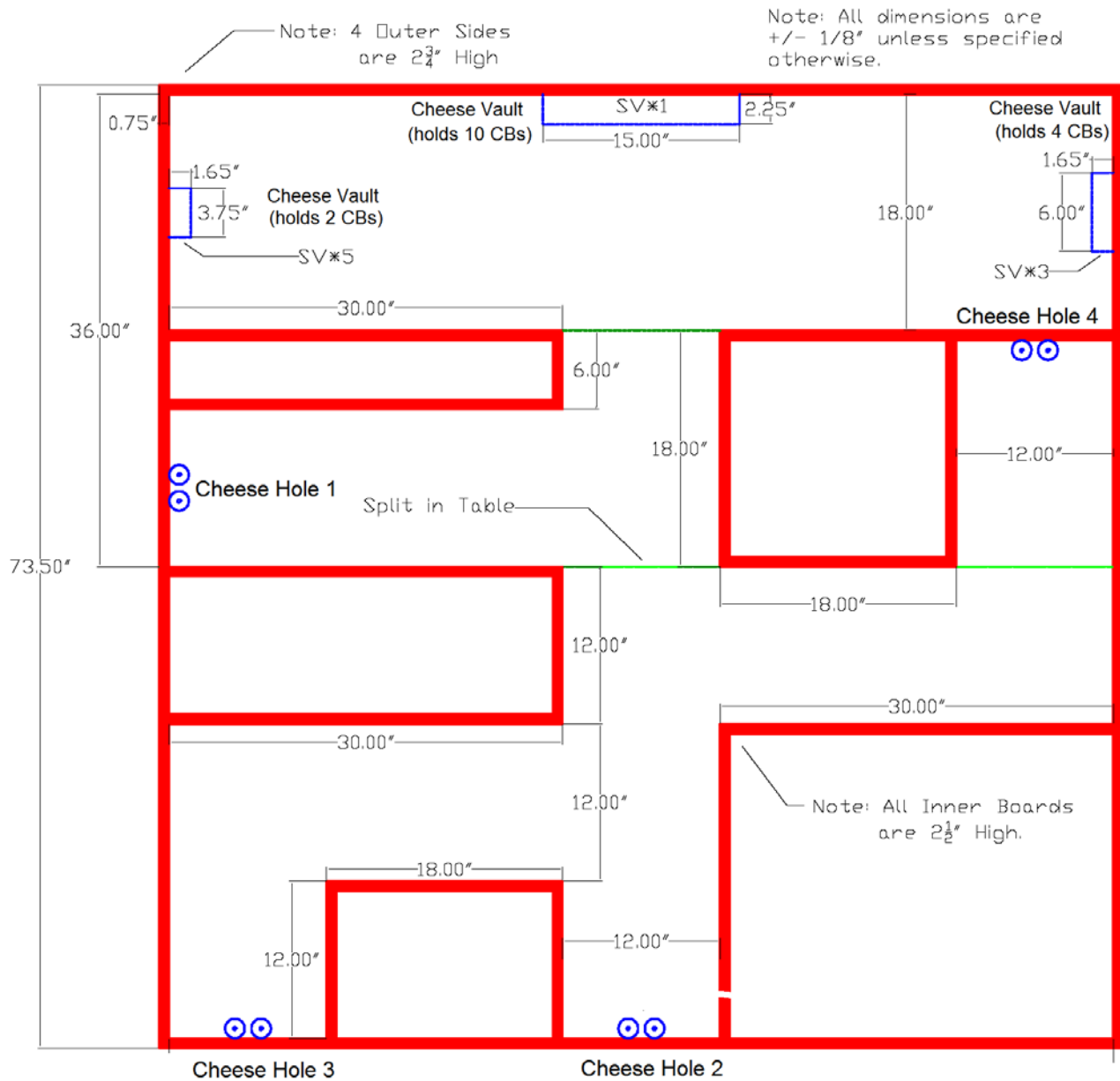


Figure 1: Competition Surface with Dimensions



Acronym Glossary

CB – Cheese Ball
CH – Cheese Hole
CV – Cheese Vault
SV – Security Value
RRR – Robot Rat Race