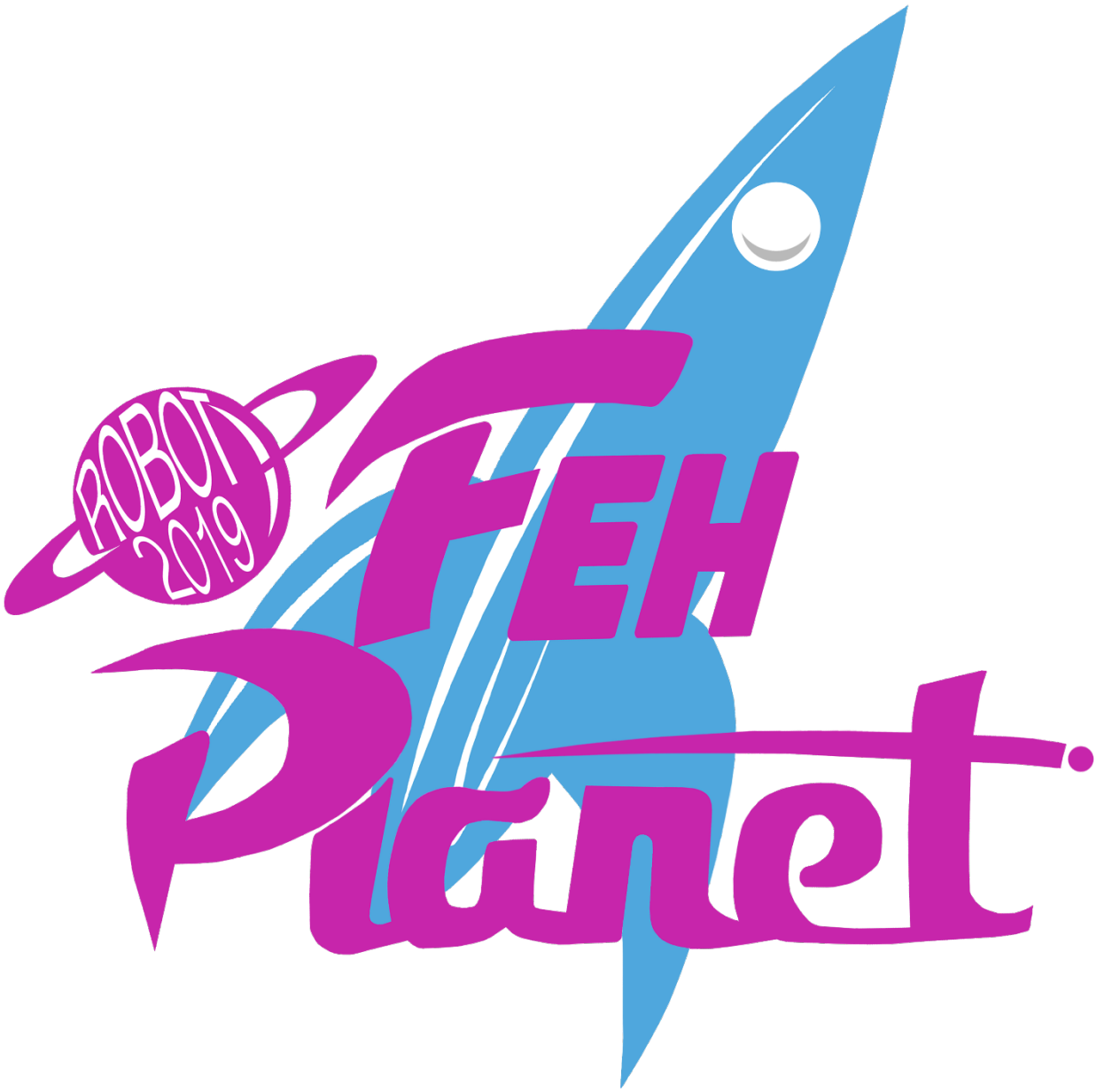
ENGINEERING 1282.01H Design Problem Statement and Specifications
Spring Semester 2019



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This document contains the design problem statement, rules, and specifications for ENGR 1282.01H in spring 2019. It is the responsibility of each student in ENGR 1282.01H to read and understand this document. Students should contact their course instructor for official clarifications, as all rules will be strictly enforced. Points needing further interpretation, explanation, or clarification will be discussed by the instructional faculty before a change is issued. Any rule change will be communicated during the regular class periods and through Carmen announcements. When necessary, clarifications or changes will be reflected in revisions to this document. This document is up to date as of this release, dated as shown in the footer. If changes to this document are necessary, a new version will be released with changes indicated, and students will be notified.

I. SCENARIO

A popular national arcade chain, FEH Planet, is looking to open several new locations and wants to use the new openings to gain a competitive edge in the market. In order to improve employee morale while enhancing the experience of its guests, FEH Planet is looking to employ a series of unmanned vehicles to automate the tasks involved in opening the arcade each day. In order to do this, the company has contacted the Ohio State Research and Development (OSURED) team to help select a prototype from those being offered by several competing companies, including yours. The chosen prototype will be used as the design of the FEH Planet clean-up assistant in the new locations and, if successful, will be implemented in existing FEH Planet locations.

To choose the best robot, a research team at The Ohio State University has constructed a scale model of the FEH Planet Arcade, hereafter referred to as "the course," for the testing of each robot prototype. An overhead view of the course can be seen in Figure 1 below. This simulation involves various tasks that would likely be required of the robot.

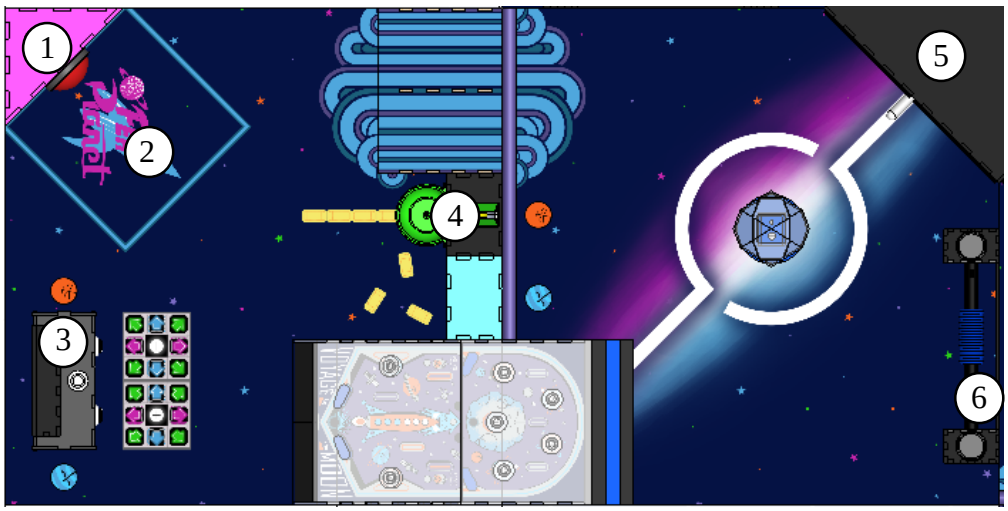

Figure 1: Overhead view of one section of the course.

The robot chosen by OSURED must be able to repeatedly complete specified tasks with precision in a timely manner. These tasks are described below, with additional details in the Notes and Clarifications section of this document.

Part of the arcade is slightly elevated due to the land the arcade was built on. Due to this, the robot must be able to climb a ramp in order to reach the upper section. Two ramps are present, with one located on either side of the coin slot machine. One ramp is made of vinyl, but there is a power cord running across the top that is covered with a cable protector. The other ramp is made of an acrylic material, but has an elevated level at the top and stairs at the far end.

- Once the arcade staff have cleaned the arcade and left the building, the robot must begin to prepare the arcade for opening the next day. A signal light will be used to alert the robot that all staff have departed and that preparations can begin. This light is at Location 2 in Figure 1. To avoid interfering with the clean-up crew, the robot may not start before the light is activated.

- Before the arcade can open, all materials must be put back into their proper places. When closing, an extra token was found and given to the robot to return to the appropriate location. This coin must be dropped back into the coin slot or placed into the lower coin return holder (Location 4) to ensure the dispensing machine is not short on tokens to give out the next day. If the coin is dropped through the top slot it will be able to be automatically counted, while if placed in the lower level it will need to be manually counted. The token must remain in the holder for complete success.

- Before the claw machine is ready for use, the lever must be returned to the lowered position (Location 5). The switch must remain in the proper, lowered, position in order to be considered fully ready for the next day's operations.

- One of the robot's most important functions is to reset the software or hardware on the arcade games if necessary. Specifically, the robot must reset the Dance-Dance Robot (DDR) machines (Location 3) as they constantly malfunction. To determine what needs to be reset, two lights corresponding to one of the reset buttons on the machine will light up a specific color (either red or blue) in front of the DDR machine. To assure that the correct type of reset is done, the robot must determine to color of the light and use that knowledge to properly reset the machine. A red light means that the red software button needs to be pressed and a blue light means the blue hardware button needs to be pressed. To complete a hard reset the button must be held down for 5 seconds.

- Foosball is a popular table game at FEH Planet. The score is kept by sliding a scoring counter each time a goal is scored. The last game before the arcade closes is typically rather intense, and winning teams often forget to reset their score counter amidst their victory celebrations. To prepare for the next day's games, the score counter (Location 4) must be reset to zero by sliding the counter, as a unit, back into its original position.

- Once preparations are complete, the robot must exit the arcade to avoid interfering with the daily operations and return to the charging station (Location 1). In order to activate the

charging station, the button located behind the starting position must be pushed. This will put the robot into sleep mode. Once completed, timing on the course will stop and the run will be completed.

Due to low-quality internet service, the WiFi signal in the upper level of the arcade has a tendency to cut out, making transmission from the Robot Positioning System (RPS) to the robot unreliable. The RPS system will be described in more detail below. Due to the poor signal, when the robot is on the back half of ~~in~~ the top portion of the course, it will not receive RPS data from the WiFi. However, if needed, the robot can extend the WiFi signal temporarily by restarting the router. In order to do this successfully, the robot must press the RPS button that is placed on top of the Dance-Dance Robot machine. The longer the robot holds the button, the longer there will be RPS available on the top of the run. If the robot touches the RPS button there will be 15 seconds of availability on the top of the course. There is a maximum of 60 seconds of availability in the top of the course if the button is held down for 3 seconds, the time scales from 15 to 60 seconds based on the time held. There is a 5-second delay between button pressing and activation of the extender due to the reset.

The main objective is to build a self-controlled, self-contained, and self-propelled robotic vehicle to travel over the course. Each robot must begin its run when the start light turns on, navigate the course, and complete the required tasks. Teams will be scored based on how well their robot performs in both individual and head-to-head competition runs. Design specifications and construction details are found in the following section, Robot Design; information on the competitions is provided in the Contest Rules section; and a breakdown of tasks and points is provided in the Robot Performance Grading section.

Your company has been contracted on the basis that it is among the best in the field. Ethical behavior is expected at all times and the collaborative reserves the right to deny contracts to companies that violate this trust. All rules set forth in this document, along with any additions or addendums to this document, are to be followed. It should be noted that successful design teams use the rules to their advantage. This is a competition between many independent companies, and proprietary information should therefore be kept within your own company. Finally, have fun!

II. ROBOT DESIGN

A. Specifications

The robot must meet the specifications below. No exceptions will be allowed. If any question exists, the decision of OSURED will be final. In some cases, the spirit of the contest will be a deciding factor.

1) **Size/Shape:** In its starting configuration, the robot must fit within a footprint no larger than 9” x 9” and must be no taller than 12”. A box for testing the robot’s dimensions will be available at the Company Store throughout the project. In the starting configuration, the robot’s QR code must be completely visible to the RPS system. See item 4 for an explanation of the QR code.

2) **Controller:** Each team will be loaned a programmable Proteus microcontroller. The specifics of the controller, programming language, and environment will be addressed in class and can be found at https://u.osu.edu/fehproteus/. Any physical modification to the controller is strictly prohibited. Teams must not attempt any repair work on their controller. If a team believes their controller is in need of repairs, they are to notify their GTA or instructor. Teams may be charged for Proteus repairs at the discretion of the instructional staff. The list below details other constraints when using the Proteus. A team found in violation of any of these constraints will be subject to penalty or disqualification at the instructors' discretion.

   a. **Adhesives on Proteus:** No adhesives may be used on the Proteus, with the exception of Velcro. Velcro may be attached to the sides or bottom of the Proteus case, but may NOT be attached anywhere on the face containing the screen.
   b. **Proteus as Sensor:** The Proteus screen or button board may not be used as a touch sensor or any other type of sensor. However, use of the accelerometer is permitted.
   c. **Proteus as Structure/Mechanism:** The Proteus may never be used as part of the structure of the robot and may never be used as a mechanical element of the robot.

3) **Signals and Automation:** The robot must be self-propelled. The robot may not receive or transmit any wireless signals, with the exception of communication with the RPS system. (See item 4.) Any intentional violation of this rule may result in immediate disqualification. Robots may not perform any action that could potentially harm another robot or the viewing audience. Contest officials and instructors will have the final say settling any disputes over automation.

4) **QR Code:** To insure proper communication with the course control systems, each team is responsible for providing a QR code. It must be mounted at 9" above the course's surface during all practice runs, performance tests, and competitions following Performance Test 2. Specifications will be provided at a later date.

5) **Adhesives and Paint:** Adhesives, such as hot glue or duct tape, are not intended as primary structural materials and should be used sparingly. Since unanticipated design modifications may require some disassembly, standard removable fasteners should be used to facilitate assembly and disassembly. An example of an allowable use of adhesives is the mounting of some sensors. No adhesive materials may intentionally contact any course surface at any time. A team in violation of this rule must remove the adhesive materials in question. Repeat violators will be subject to penalty at the discretion of OSURED. At a minimum, the team will be charged for repairing any damage that has been done to the course. The Company Store will usually have hot glue, wood glue, PVC adhesive, and common white glue available for use at no cost. Adhesives available for purchase include lengths of solder and small packets of epoxy. These items and any other adhesives or paint may be independently obtained by a team as it deems appropriate. If adhesives or paint are independently obtained, the cost will not be charged to the team budget but must be shown in the robot's parts list. If it is deemed that an adhesive material has been used as a structural element, the team's budget will be charged accordingly.

6) **Budget:** Each team has a budget of $160 to spend at the FEH Company Store in HI 208. Details on how to acquire parts are below and in the store policy document.

a. **Cost–Performance Bonus/Penalty:** Any robot that exceeds the $160 budget will lose 1 point for each $0.50 increment over budget. Following the final competition, bonuses will be awarded to teams that have remaining funds in their budgets. The bonus amount will be determined by multiplying their best final competition score by 0.005 point for each dollar remaining in their budget, up to a maximum of $40. This means the maximum number of cost-performance bonus points is 20 (0.005 * 40(max dollars remaining) * 100(max score) = 20).

B. Construction

This section details robot construction criteria and guidelines. Team members must perform all robot construction. No outside help is allowed, except for approved consultation or direction. Consult with the FEH Program staff before soliciting outside help. Use of unauthorized outside help may result in team disqualification.

1) **Acquisition of Parts:** Each team will be issued a set of basic sensors, in addition to the Proteus. All other parts must be obtained through the online purchasing system set up by the Company Store, which will automatically charge the cost to the team's budget. Certain items will be in stock and available for immediate purchase, while others may have to be obtained by special order. When parts are ordered through the Company Store, only the cost of the parts (not the shipping) will be charged to the team budget. The Company Store is not responsible for shipping delays for specially-ordered parts, so teams should take this into consideration. If the team feels it is necessary to obtain parts from an external source, prior approval from a GTA or instructor is required. If approval is not granted, these parts may be prohibited. All externally acquired parts must be reported to the Company Store before the part is installed on the robot. Please refer to the store policy document for more details. The FEH Program staff will not spend time troubleshooting problems caused by external parts.

   Special note: Due to a previous robot designed by UMBLUE that nearly destroyed the entire arcade, the owners of FEH Planet have specified that no robot may use more than three omnidirectional wheels.

2) **DC Motors:** Several reliable DC motors are available through the Company Store. These motors are verified to be compatible with the Proteus. Other DC motors may be used, but prior faculty approval must be obtained, and motor maintenance will be the responsibility of the team choosing such motors.

3) **Reusability:** Emphasis is placed on the reusability of the robot. Therefore, any loose or disposable parts should be used with prudence. Rules regarding disposable parts are specified below.

4) **Return of Unused Parts:** For in-stock parts purchased through the Company Store, teams can return any unused parts up to the day before the final competition for a credit of 75% of the purchase price to their budget. This does not apply to any parts left over from any kit, such as an Erector Set or tread kit. A complete unused kit may be returned. There is no buyback credit for special-order parts. No electronic parts, sensors, or motors may be returned. All returns must

be approved by the store before credit is issued. Company Store employees have the final say as to whether a part can be returned.

III. TESTING LOGISTICS

A. Testing

Teams will have access to the course for testing, but only during their scheduled class period and regularly scheduled open lab hours. (e.g., if a team is from a class that meets at 8:00, they may not be in the lab room between 10:05 and 5:05 MWF.) Each team must keep a log of the amount testing time used on the course as part of project documentation. Log entries should show date, time, purpose of test, name of engineer(s) conducting the test, and number of minutes used. This log must be summarized in the team's final report and included in detail in the team portfolio.

B. Performance Tests

There are four performance tests scheduled during the project. The tasks and scoring for each test are detailed in a separate document on Carmen. The following are specific details regarding the performance tests.

1) Each team will be allotted up to five official attempts to pass that week's performance test, where "official" indicates that their instructor, GTA, or designated UTA has been requested to score the run.

2) An official performance test may only be attempted during a team's assigned class period. The performance test must begin before the end of the period, (i.e. if the class ends at 5:05 the test cannot be started at 5:06 without special instructor permission.)

3) The team will be awarded the points from their best attempt.

4) There is no limit to the number of practice runs

Additionally, each performance test will have a stretch bonus and an early completion bonus. A performance test must be completed with a perfect score in order to be eligible for bonuses. These bonus points will be added to the team's score on that performance test.

IV. CONTEST RULES

The contest rules, current as of this revision, are below. Teams will be notified of any changes or revisions. Students needing rule clarifications should direct their questions to their course instructor or GTA. Major questions requiring the attention of the OSURED Executive Board may take up to a week to be answered.

A. Contest Course

The course contains four identical sections. It fits within a 12' by 12' footprint and is roughly in the shape of a windmill with an enlarged center. It has relatively smooth horizontal surfaces. A Lexan wall surrounds the course on all sides. Some minor variation from section to section is to be expected, and it is the responsibility of each team to accommodate for these discrepancies. Measurements of important course components are provided in the full CAD model on Carmen. All measurements are accurate to within ¼".

The course is partitioned into four identical regions to accommodate up to four robots operating simultaneously. Each robot will begin in its respective starting area and operate in its own region. If what constitutes a region is unclear, please ask a member of the instructional team. At the start of the simulation, the robot will receive a signal to begin operations. It will then move about the course to complete the given tasks.

The simulation course is largely computer-controlled by the Course Automation System (CAS). The CAS is a hardware and software framework that controls all electronic elements integrated into the course. Examples include the starting light, the Robot Positioning System (RPS) and its signals, and the automatic scoring system. It also senses each robot's interactions with the course tasks. Teams will be given access to the CAS for testing and debugging robots. Any attempt to modify or affect the behavior of the CAS will result in disqualification from the competition. Tampering with course wiring, sensors, or control circuitry is strictly prohibited.

Throughout the simulation, the RPS transmits several pieces of information via radio frequency (RF) to each robot. The transmission starts when the run begins and contains the following data:

1. The robot's position and heading
2. Course stop signal (when activated)

The RPS will transmit a stop indicator to all course electronics at the end of the two minute simulation. This stop indicator will prevent any further interaction between robots and any course sensors or other input and output functionality, ending the run for the robot.

B. Starting a Run

Teams will wait for a go-ahead signal from the course master, who will also direct them where to place their robots. A team member will then have sixty seconds to perform any preparation action(s). The robot can be placed in any orientation at the discretion of the team but must be completely contained within the 12"x12" starting area. Once the robot has been positioned as desired and the start preparation is complete, no further interaction with the robot will be permitted.

The course master will activate the starting light. This is the indicator a robot must use to begin the run. A robot that does not wait for the start signal will be issued a warning, and all teams on the course will be given another sixty seconds of preparation. Any robot that false starts two times during the same run will be disqualified from that run.

C. Ending a Run

The CAS tracks run times in case of any ties (see Points and Scoring section for details). There are three methods by which a run can end:

1) 2 minutes elapse
2) The robot activates the final button
3) Early termination by the team

In all cases, the CAS will deactivate the robot and calculate the score and run time. If the team wishes to end the run early for any reason, they must lift a panel and flip the termination switch located on the side of the course. Teams may not touch or remove robots from the course until directed to do so by the course master, unless damage to the robot or course is imminent.

D. Competitions

The contest is divided into two distinct sections: the individual competition and the final competition. Individual competition results will be used to seed the teams for the final competition, where the best-performing robots will be determined. Both competitions will contribute points to the overall team score as a component of the ENGR 1282.01H course grade.

Scoring for the competitions will be based on the points earned for starting on command, navigating the course, completing tasks properly, and finishing the course. See the attached point distribution. Note that points are divided into primary and secondary points. Only points earned for primary tasks, and penalties are included in the course grade. Secondary points do not count in the course grade but are counted for purposes of helping determine placement in the competitions.

1) **Rules:**
   a. **Time Limits:** Each team will have one minute to set up their robot before each run. A run will last a maximum of two minutes from the time that the start light is activated. One minute will be allowed to remove the robot and any loose parts after run completion.
   b. **RPS:** All robots will be required to enable communication with the RPS. Instructions for enabling RPS communication are available on Carmen and in the Proteus documentation. Failure to enable RPS communication may be grounds for disqualification from the individual or final competition.
   c. **Robot-to-Robot Interactions:** Robot-to-robot interactions are not allowed during the competition. Additionally, any object that interferes with another robot or is left in an opponent's space at the end of a run will be grounds for a penalty. At no time may a robot engage in an act that seems to either show a flagrant disregard for another robot's safety or to be intentionally damaging. All decisions of the course masters are final.
   d. **Loose or Disposable Parts:** A loose or disposable part is defined as any part that is intentionally or unintentionally dropped or lost during a single run. The contest officials may choose to confiscate any loose or disposable part at the end of a competition round.
      - **NOTE:** It may be assumed that as many as six (6) runs during the final competition will be necessary, so a sufficient quantity of any disposable parts must be included for competition and must be reflected in the cost of the design. Although most robots will make fewer runs in the final competition, six will be used as the basis for determining the cost of disposable parts.
   e. **The Pit:** Between runs, teams have access to this area for performing basic maintenance and battery charging. As there is a limited amount of time between runs, major alterations are generally discouraged.

f. **Technical Inspection:** Twice during the semester, all robots will be inspected by the OSURED staff to insure compliance with specifications. All parts on the robot will be inventoried and compared to the team's budget report. Any parts not listed must be removed from the robots immediately. Absolutely no modification of the hardware is allowed between elimination from the final competition and the final technical inspection. Violation of this stipulation will be cause for disqualification and constitutes academic misconduct.

2) **Individual Competition:**
On **Friday, March 29th, 2019**, the individual competition will be held during regular class periods. This competition is closed, so only ENGR 1282.01H students in the section competing and instructional staff may be present. One robot will compete at a time, and each team will have three opportunities to demonstrate robot performance. Additional details will be provided closer to the competition date.

3) **Final Competition:**
On **Saturday, April 6th, 2019**, the final competition will be held in the lower gym at the Recreation and Physical Activity Center (RPAC). It is open to the public, but judges and officials have the right to remove any spectators or participants if necessary.

Four robots will perform simultaneously. There will be three rounds of round robin play, as well as a single-elimination tournament. For each single-elimination run, the robot that earns the most points will be declared the winner. In the case of a numerical tie, the robot with the faster time will be the winner. If two or more robots are tied in both points and time, the match will be re-run from the beginning with only the tied robots.

All competition runs are eligible to count for team course grades. Additionally, all performances may contribute to awards and prizes determined by the judges at the competition's conclusion. Prizes will be awarded for the top 3 performing robots in the round robin competition, top 4 robots in the single-elimination tournament, 3 robots for outstanding achievement in engineering (as determined by the judges), 3 robots for most aesthetically pleasing (as determined by the judges), and 3 robots for outstanding achievement in innovation (as determined by the judges). Additional prizes that will be awarded at the end of the semester including the 4 best documentation packages and the gracious professionalism award.

Last year's schedule for the day was as follows. It is anticipated that this year will be very similar. This schedule is tentative and subject to change at any time.

10:00 – 10:30 am: team arrival and check-in
12:00 pm: round robin begins
short break
4:00 pm: head-to-head begins
5:30 pm: prize and award ceremony

V. ROBOT PERFORMANCE SCORING

Only primary tasks and penalties will be factored into the course grade. Primary tasks, secondary tasks, and penalties will count towards competition scores. All scoring is tracked and totaled by the CAS. However, in the event that a penalty must be assessed or if at any point there is a dispute as to the validity of a task completion, the course master and/or instructional staff has the authority to override the system or disqualify the run.

Primary Tasks	**Points**
Initiate on start light (Notes 1 & 2)	8
Press the final charging button (Note 13)	8
Place token in lower container (Notes 3)	8
Token remains in bottom container (Note 3)	6
Move foosball counter (Note 7)	12
Left claw lever in down position (Note 6)	10
Moved claw lever (Note 5)	7
Press a DDR reset button (Note 10)	7
Press the correct DDR reset button (Note 11)	9
Possible Primary Task Points	**75**
Secondary Tasks	
Foosball counter remains in final position (Note 9)	5
Place token in coin slot (Note 4)	8
Fully move foosball counter to final position (Note 8)	7
Hold DDR button for 5 seconds (Note 12)	5
Possible Secondary Task Points	**25**
Total Possible Task Points	**100**
Penalties	
Interfering with a competitor's robot (Note 14)	DQ

VI. NOTES AND CLARIFICATIONS

Successful completion of each task will result in an electrical signal being sent to the CAS. If the CAS does not receive a signal, the task was not successfully completed.

Primary and Secondary Tasks and Notes:

1) **Starting area:** At the start of a run, no part of the robot may extend past the outer-most edge of the blue lines surrounding the starting area.

2) **Initiate on start light:** the robot starts immediately when the light embedded in the floor of the starting area (Location 1) comes on (not before and not more than three seconds after). The robot must perform some action, where an action is defined as moving at least 1" from its starting position or rotating the entire robot at least 10°.

3) **Place token in the lower container:** the token is placed in the green bowl at the base of the token container. The token must remain in the container and cover the CDS cell. (Location 4)

4) **Place token in upper coin slot:** The token must enter and fully pass through the upper token slot in order to be counted (Location 4). If the token passes through the upper coin slot and fails to cover the lower CdS cell, full points will still be awarded.

5) **Move claw machine lever:** successfully toggling the switch from its initial position (Location 5).

6) **Claw lever remains in down position:** Successfully pulling lever and ensuring it remains in the down and reset position (Location 5).

7) **Move foosball counter from starting position:** successfully moving the foosball counter (Location 6) at least one inch from its initial position.

8) **Fully move foosball counter:** At any point in the run the counter comes within half of an inch of the left wall of foosball (Location 6).

9) **Foosball remains in final position:** Foosball must be within half of an inch of the left wall at the conclusion of the run for points to be counted.

10) **Press a DDR reset button:** successfully pressing one of the two reset buttons, which are red and blue (Location 3).

11) **Press the correct DDR reset button:** successfully pressing the reset button indicated by the lights near the DDR. If at any time during the run the incorrect button is pressed, this objective cannot be completed (Location 3).

12) **Hold the correct DDR reset button:** the button must be held for the full 5 seconds in order to earn the points for it (Location 3).

13) **Press the final charging button:** pressing the final red button (Location 1), ending the run. No points can be accumulated for the run after this button is pressed.

14) **Interfering with a Competitor's Robot:** At no time may a robot physically interfere with another robot or cause interference with another robot through a secondary medium. Disqualification will be at the discretion of the GTA or instructor present at the competition.
