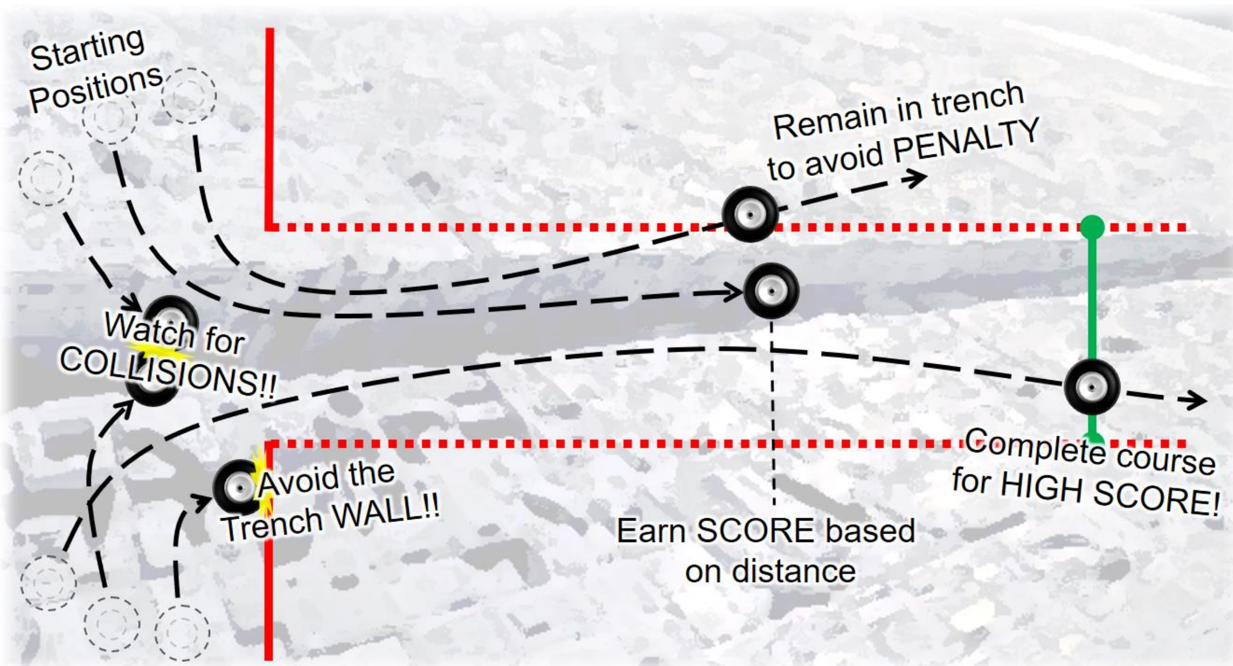
Episode VII
ATTACK ON THE DROID ANTHILL

It is again a period of civil war. Hungry anteaters, striking from dry tropical forests are attempting to win the last victory against the evil Empire.

Anteater spies have obtained secret plans to the Empire's ultimate weapon, the Droid Anthill, an armored subterranean colony with droid ants designed to destroy anteaters.

The ingenious anteaters have designed their own robotic vehicles which must navigate the tunnel leading to the center of the Droid Anthill and destroy the Queen Ant Droid.



Summary. You will work in teams of three to construct an autonomous robot to compete in the free-for-all ATTACK ON THE DROID ANTHILL competition. Your robot will employ a single pneumatic cylinder for propulsion, a servo motor for steering and an Arduino microcontroller. Your robot will navigate the course using a magnetometer to measure its bearing and a reed switch to measure wheel rotations. Team members will take one of three roles: Mechanical Fabrication, Electric and Pneumatic Connections, and Arduino programming. Power from the pneumatic cylinder can be harnessed in any way, although no other actuator can be utilized for propulsion. A tire fixed on top of the robot will store pressurized air for the cylinder and serve as a bumper during collisions. Points will be awarded based on distance travelled down the trench.

COMPETITION TIMES:

Section Competitions (June 4-7, during scheduled lab sections): All teams will compete against the other teams from their lab section. The first and second place teams by score will receive 10 points of extra credit and be invited to participate to the Final Competition. In the event of ties, more than two teams may receive extra credit and be invited to the Final Competition (e.g. if the three highest scores were 800, 800, 800 or 800, 750, 750).

Wildcard Competition (June 10, 1-3 p.m.): Any team not invited to the Final Competition following their Section Competition may participate in the Wildcard Competition for a chance of earning one of the remaining spots in the Final Competition. We estimate a most four teams will be selected from the Wildcard. If necessary, ties will be resolved by a single, head-to-head race with randomly assigned Starting Position selection order. No extra credit will be awarded for the Wildcard Competition.

Final Competition (June 10, 4-6 p.m.): The ultimate test of Anthill busting prowess, invited teams will compete for extra credit and podium positions. If necessary, ties will be resolved for medal position, as described for the Wildcard Competition. Extra credit will be awarded to teams scoring in the top eight positions:

Gold: 30 points; **Silver**: 20 points; **Bronze**: 15 points; Forth through Eighth: 10 points.

COMPETITION RULES:

Summary: A maximum of 8 robots will compete in each round, and **each robot will compete in a total of 8 rounds**. We expect these numbers to be 10 and 10 for the final. (These numbers are subject to change if deemed necessary).

Course: Competitions will take place in the Engineering Gateway courtyard, using the sidewalk geometry to define the course (see diagram below; the course will take place in the precise location pictured, note that the course strategically avoids the storm drains). Physical walls will be placed in the locations marked “Trench Wall”, likely 2x4s braced against collision. These **walls may rise as little as 1” above the ground**.

Weather: In the event of rain during the scheduled competition time, teams will be provided with a 3-gallon trash bag to protect their robot against water damage. Teams will also be permitted to claim their Starting Position using a placeholder and prepare their robot under the shelter of the EG sky bridge (rules relating to the “Clear!” signal will remain in effect). At the TAs discretion a short rain delay may be taken to wait out heavy rain. Teams are advised that **robots may behave differently in the rain**, especially those reliant on friction.

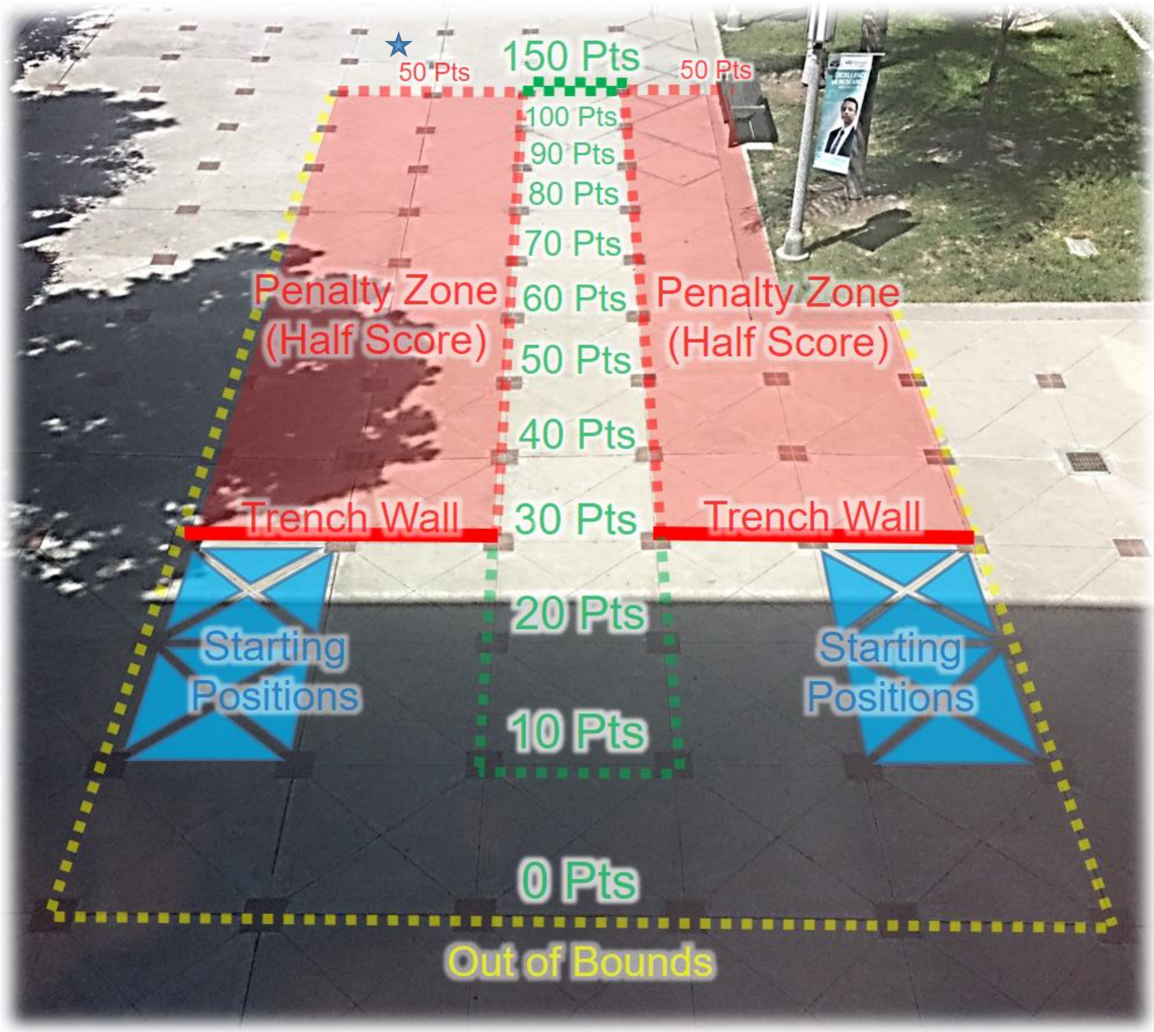
Position Selection: On each round, teams will select from Starting Positions according to a predetermined order (balanced for fairness over each team’s rounds of participation). Teams may select from any of the available Starting Positions (see the 16 blue triangles in diagram below). Starting Positions are defined by sidewalk geometry, a robot must be placed such that no part of its Air Tank tire rests over the dividing line between triangular sidewalk sections. A team may move their robot within their triangular Starting Position up until the “Clear!” signal is given, but **may not move their robot in a way that directly blocks another team’s robot during the last 15 seconds before the “Clear!” signal**.

Race Preparation: Following Starting Position selection, teams will have 3 minutes before the start of the race during which to inflate their Air Tank Tires, upload new Arduino sketches and perform other minor services to their robot. All contact with the robot must cease within one second following the “Clear!” signal, and all team members must step outside the course boundary before the “Go!” signal. The “Clear!” signal may therefore be used to time the press of a button to initiate an Arduino program that begins with a 15 second countdown. If using a 15 second countdown, it is advised to **press this button slightly AFTER the “Clear!” signal,** so as not to violate the actuation rules. It would then be a good idea to halt actuation **no more than 59 seconds later** to ensure compliance.

Race: The race will begin with the “Go!” signal 15 seconds following the “Clear!” signal, and last for 60 seconds until the “Stop!” signal. Only during the 60 seconds of the race may robots actuate their Pneumatic Cylinders or Servo Motors. Arduino programs should therefore halt actuation before this 60 seconds are up. **Strict compliance with these actuation rules is expected, robots will score 0 points on any round they violate them. Robots should begin actuation AFTER the “Go!” signal and cease actuation BEFORE the “Stop!” signal.**

Scoring: After the race, robots will be scored based on their final position and whether they crossed the finish line or moved out of bounds. A robot’s position is defined as the point on the ground directly underneath the geometric center of its Air Tank tire. This position is used and robots are scored even if they fall over. Any robot that moves out of bounds at any time (crosses a yellow line in the diagram below) will score 0 points. Any robot that crosses the finish line will score 150 points if they crossed inside the Trench or 50 points if they crossed outside the trench. Otherwise robots will score based on the sidewalk square inside which they stop after the race (the corners of these squares are defined by the red tiles). Scores increase in increments of 10 points per square inside the Trench (0 to 100 points). Any position outside the Trench on the near side of the Trench Wall scores 0 points. On the far side of the Trench Wall, a penalty is applied to robots that end the race outside the Trench: robots will score half the points they would have in the Trench square the same distance beyond the Trench Wall (between 15 and 50 points). Although no actuation is allowed after the “Stop!” signal, robots may continue to move from momentum or the slope of the course; scoring begins when all robots stop moving.

Bonus Scoring: If your robot stops in the square marked with a star after having achieved 150 points, you will get an extra 50 points for a total of 200.

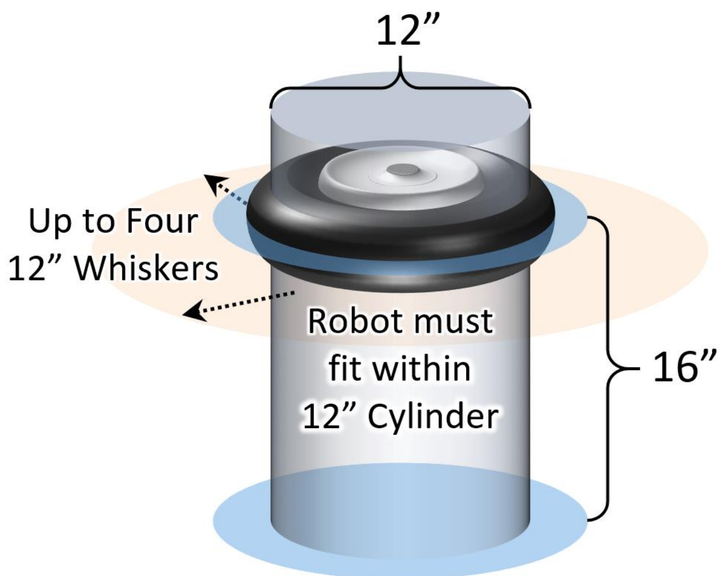


Time	Event	Details
< -3:00	Position Selection	Teams take turns selecting Starting Position according to the round's prescribed order
-3:00 to -0:15	Race Preparation	Teams may interact their robot, but the robot may not leave the Starting Position
-0:15	**"Clear!" Signal**	Teams must stop interacting with robot
-0:15 to 0:00	Clear Course	Teams must step away from their robot and move outside course boundary
0:00	**"Go!" Signal**	Robots must not actuate before this signal
0:00 to 1:00	Race	Actuation is allowed
1:00	**"Stop" Signal**	Robots must not actuate after this signal
1:00 to 3:00	Scoring	TAs will score the robots performance; teams must remain outside the course boundary
~3:00	Retrieve Robots	Teams may enter the course; the next round's Position Selection phase begins immediately

MECHANICAL AND ELECTRICAL CONTRAINTS.

Robots must comply with the following design constraints in order to compete in the Section, Wildcard and Final Competitions. TAs will likely check for compliance at various times during the quarter, but teams are responsible for compliance on competition day.

Dimensions: The Air Tank tire will also serve as the bumper with which the robot contacts other robots. To ensure that most contact takes place between robots' bumpers, the Air Tank tire must be positioned **parallel to the ground** such that it is centered on a plane **16.0±0.25" above the ground** (i.e. the 4" wide tire will fit within the space between 14" to 18" above the ground).



To prevent other parts of the robots from contacting each other, the entire robot must fit **inside a 12.0" diameter cylinder** perpendicular to the ground and concentric with the Air Tank tire, **with two exceptions:**

Up to four light, flexible Whiskers may extend up to **12" outside** the 12" diameter cylinder specified above (they must be **sufficiently flexible so as not to interfere with the movement of other robots**). These Whiskers may be used to detect proximity to other robots. One acceptable implementation would be to attach plastic straws to electric snap-action switches.

The Air Tank tire may also be wrapped in up to 1/8" thick material, such as duct tape or fabric. This may reduce the likelihood of your robot getting stuck against other robots, but likely will not make much of a difference.

The rest of the robot must fit inside the 12" diameter cylinder **when the piston is retracted and while the wheels are facing forward**. Parts **may** extend outside the 12" diameter when the piston fires and when the motor steers left or right.

Compliance with dimension constraints will be assessed by testing whether the entire robot fits inside a cylindrical shell (teams may remove Whiskers during this assessment). If any part of the robot resists the easy sliding of the robot into this shell, or prevents the shell from standing perpendicular to the ground while it encloses the robot, the robot will be deemed to not comply with this constraint.

Propulsion: All propulsion must be generated by the action of the single provided Pneumatic Cylinder. Moreover, at the start of the race, all potential energy utilized for propulsion must be stored in the form of compressed air in the Air Tank Tire at no greater pressure than 40 PSI. **No other actuators may directly utilize the compressed air and no other potential energy may be utilized for propulsion**. Make sure to test propulsion behavior at 40 PSI and below to inform your design process.

Ground Contact: For efficient coasting and maximizing the movement and speed contributed by each stroke of the Pneumatic Cylinder, four roller blade wheels have been provided to offer a high performance baseline available to all teams. However, there are no restrictions on the contact between the robot and the ground. Therefore, alternative wheels, or even alternatives to wheels, may be freely employed.

Steering: The only actuator that can utilize the electric potential energy stored in the battery is the provided Servo Motor, which may be used to actuate a steering mechanism.

Controller: The project is designed around the idea of using a single Arduino to control the robot, but you may use an alternative microcontroller if you wish. You may upload new sketches to the Arduino before each round of the competition. However, **all contact with the robot must cease 15 seconds before the start of each race.**

Provided Sensors: You will be supplied with a Magnetometer and a Reed Switch. The Magnetometer can be used as a **compass to determine the robot's orientation**. The Reed Switch can be used to **measure rotation** of one of the robot's Rollerblade Wheels. These sensors can be used to track your robot's movement and remain within the "trench".

Additional Sensors: You may equip your robot with additional sensors whose combined new value does not exceed $40, **receipts or documentation of sensor value must be presented to your TA**. The simplest, most useful additional sensors are likely a button to initiate the 15 second countdown before the race, snap-action switches attached to plastic straws (as described above) to measure proximity to other robots and initiate evasive maneuvers, and perhaps a potentiometer attached to a single useful control parameter you would like to adjust in the last second before the "Clear!" signal.

Manufacturing: You will be provided with **basic** materials, including a sheet of plywood, although you may use any additional materials you purchase or have access to. You will be given access to **basic** tools such as a band saw and drill press which are sufficient to construct a competitive robot. You may employ any manufacturing techniques you have access and permission to use. 3D printing and laser cutting is available at UCI FabWorks. You are also responsible for the storage of your robot/parts as well as procuring your own work space(s). You will have open lab hours where you can go work on your robot, otherwise you will need to find your own work space. Do not damage UCI property if you work on campus.

FINAL REPORT

System Description

1. Written description of your design concept. For **both** your mechanical and software design include the following:
    a. State **two** design goals
    b. Describe how your **final** design set your robot apart from other robots with regards to each of these design goals (and how successful you were)
2. Photograph and CAD model of your **final** robot design, include sufficient views
3. Electrical and pneumatic circuit diagrams of your **final** robot design
4. Documented software code of your **final** robot design

Testing and Development

1. Experimental testing:
    a. Identify **one** performance criterion you experimentally optimized for your robot, pertaining to the Pneumatic Cylinder or the Servo Motor (e.g. optimize speed of the robot, or optimize accuracy of the robot)
    b. Describe at least **one** experimental parameter you varied (e.g. duty cycle of the Pneumatic Cylinder) and at least **two** control parameters you kept constant for **each** experiment. You should test your robot with at least five values of the experimental parameter, and perform at least 10 runs with each value of the parameter to characterize the performance.
    c. Provide at least one plot for your experiment, showing mean and standard deviation.
    d. Referring to this plot, explain how you optimized the parameter

    NOTE: If your team has a fourth member, the experimental parameter you report in your final project write-up must be different than the one that that team member analyzed for Verification 2.

2. Comparison with mathematical model:
    a. Collect data for identifying your robots impulse response. Plot the impulse response (both position versus time and velocity versus time).
    b. Compare your robot's actual performance for a straight line with 10 impulses to that predicted by the simulator. Make sure to input your experimentally-identified impulse response into the simulator. You will have to modify your control code and the simulator to study the 10 impulse case. Make sure to use the Reed switch to measure your actual robot's performance.
    c. List the most likely causes of discrepancies between the simulator and your actual robot performance.

Summary of Contributions

1. For each team member include a list of at least **four** key ways they participated in the final project, at least one inside and outside their specific role.
2. Describe at least **two** strategies that you think are helpful for making sure an engineering design team works well together and is productive.

GRADING

Robot performance	*Performance of your robot in the day of the competition*		**40**
	Plausible robot	20	
	Robot steers and drives	10	
	Robot follows Trench	10	
	--- Extra Credit ---		
	1^{st}-2^{nd} Place in **Section** Competition	+10	
	1^{st} Place in **Final** Competition	+30	
	2^{nd} Place in **Final** Competition	+20	
	3^{rd} Place in **Final** Competition	+15	
	4^{th}-8^{th} Place in **Final** Competition	+10	
Design Checkpoints	*Assessment of your teams' progress towards the completion of your project*		**30**
	Verification 1	15	
	Verification 2	15	
Report	*One final report must be turned in per group*		**30**
	System description	13	
	Testing and development	12	
	Summary of contributions	5	
TOTAL			**100**