2012 Mechatronics Competition: Capture the Flag

Overview

The mechatronics competition will be a capture the flag game between two alliances of three robots each. The goal is to be the first alliance to retrieve the opponent's true flag among two other false flags and return it to their alliance's base. The game will start in autonomous mode and transition to teleoperated mode. Robots may tag other robots out or in by hitting an easily accessible button which disables and subsequently re-enables them. The starting layout is shown in Figure 1 below. Robots are not allowed to enter their own base unless they are in possession of an enemy flag.

Note: 1. All rules are subject to change, 2. All questions should be directed to Dr. Minor or the TAs and official responses will be posted in updates on Canvas and at the end of this handout ***(ignore all gossip)****, 3. Lab/Project/Competition will be discussed on Fridays in class the week before new activities.*

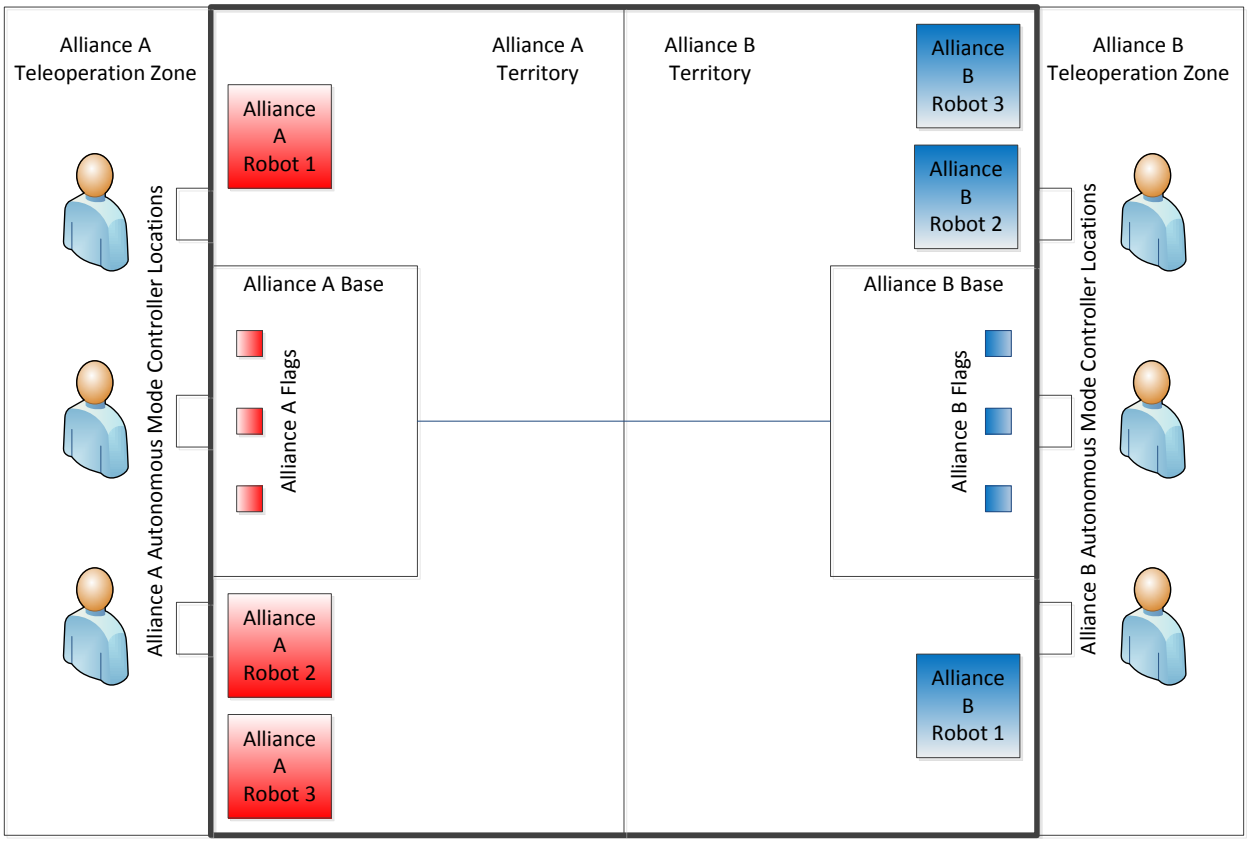

Figure 1: Capture the flag layout.

Rules

Alliances and Teams

1. Each lab section will form its own alliance.
2. Each alliance will have 3 teams.
3. Each team will consist of 3-4 members from the lab section to which they belong. Teams will self-organize at the beginning of the first lab during the week of Jan 23.
4. Each team will be in charge of the design and construction of one robot.
5. Teams within an alliance are expected to coordinate strategies and provide assistance to other teams in the alliance as needed.

Robot construction

Typically standard parts will be given to everyone, sometimes allowing a choice between parts. This will ensure everyone has the bare minimum necessary to complete the project. This does not force a specific robot design or strategy since you may redesign the robot if you choose to do so outside of lab. You may also choose and order parts different from those supplied in lab with few restrictions—you must use the Arduinos, Xbees, batteries, and tag button that will be given to each team.

1. Both a robot and a remote control must be designed and manufactured.
2. The robot must fit in a 12”x12”x12” box at the start of the round.
3. The robot must remain as one connected machine, and may not leave parts on the field or have parts that separate themselves from the robot.
4. *Micro-controllers.* One Arduino micro-controller will be used for the robot and one for the remote control for integrating control, sensors, and communication between the controller and robot.
5. *Power source:*
    a. Two batteries will be supplied, one for the remote control and one for the robot.
    b. No other power sources may be used such as pre-loaded springs, elevated weights, compressed air, etc., unless they are completely empty or unloaded at the start of each match and are powered during the match through means of the batteries.
    c. This rule does not preclude use of pre-loaded springs, weights, etc. as parts of standard mechanisms as long as the *intent* is not an energy storage device.
6. *Remote control.* Each robot must have a remote control for teleoperation of the robot.
    a. Communication between the robot and controller will be done through a pair of Xbee wireless modules.
    b. All robots can have no external communication except between the remote control and the robot itself. Sensors for detecting the environment and other robots are acceptable and encouraged, but not as a means of communication with anything originating from outside of the game area and remote control.
7. *Tag button.* There must be a tag button affixed to each robot.
    a. The tag button will be given to each team.
    b. It must be centered on the top of the robot.

c. It must be easily accessible and always open on three sides for being pressed or hit by another robot.
d. When pressed, the button must immediately disable the robot through software.
e. On subsequent presses, the button must alternate between activating and deactivating the robot.
f. If a robot has possession of a flag, it can keep it in its possession when tagged, and must immediately stop all motion.

8. *Protective shell.* The robot must have a shell in order to protect internal components from robots trying to tag it. The Arduino, Xbee, and other electronic components and wires must be protected. (Note that some shell materials may be more likely to interfere with your own wireless signals).
9. *Flag retrieval.* The robot must have some flag retrieval mechanism (eg. gripper) for lifting flags out of the flag retainers and transporting the flag back to base. The mechanism must still allow the tag button to be accessible from three sides.
10. *Tag mechanism.* A tag mechanism is optional, though strongly encouraged both for offense and for defense for reactivating robots on the alliance that have been tagged out. The flag retrieval mechanism and tag mechanism can be the same mechanism. Any tag mechanism must still allow the tag button to be accessible from three sides.
11. *Status lights.* The robot and controller must have both a green and red light that identify when the robot is active (green light on, red light off), and inactive (red light on, green light off). A robot is inactive when the tag button de-activates it. A light showing that the robot is in autonomous mode is optional since it should be obvious that it is under its own control when operators step away from the remote control during the autonomous period.
12. *Budget and bill of materials*.
    a. We will provide some parts throughout the semester. **If provided parts are damaged, you must buy your own replacements from your team budget or your own pocket!** Help parts last by using good design practices such as strain relief, one way connectors, and avoid over-driving motors, etc.
    b. Donated parts and materials are allowed, and do not count against the team budget, but they must be available to all teams if they are available to any team. It is the responsibility of the team arranging such a donation to notify the entire class about this possibility. We don't want any team to have an unfair advantage because of who they know.
    c. Donated manufacturing machine time is also allowed, but if the machine is of the type that is not readily available to the entire class, then the donated machine time must be made available to the entire class. Again, it is the responsibility of the team to notify the class in the event of such an arrangement. Use of an off-campus machine that is of the type that is available is allowed without any exceptions (e.g. using a drill press at home is fine, since all students have access to drill presses here on campus). Again, we don't want any team to have an unfair advantage because of who they know.
    d. There is a bin of old scrap robots and parts which may be used for the project. Any scrap parts or material taken from this bin must first be approved by your TA. You must have a

reason for taking the part/material of interest. For example, if you would like to take a Hall-effect sensor from an old robot, you must first explain to your TA how you are going to use the Hall-effect sensor. It is never allowable to take an entire robot from the shelf; if you want a part, you must remove the part in the lab. This rule is to prevent hording and unfair advantages for these limited first-come first-serve parts.

e. At the end of the semester, you must be able to explain the source of every component of your robot.

Game Layout

13. The capture the flag area has the following features that are described subsequently:
    a. The robot game area
    b. The teleoperation zone
14. The robot game area (refer to Figure 1 above):
    a. It is an 8’ x 8’ area.
    b. It includes the following sub-areas:
        i. Alliance bases
        ii. Robot starting zones
        iii. Flags and Flag retainers
    c. It will be a white painted surface with black outlines around each alliance base, robot starting zone, and flag retainers. (Note that dark marks on the course typically begin to appear as robots begin driving on the course from their wheels and castors)**.**
    d. Two black tracking lines will be on the course. One will be down the middle of the course to separate alliance territories. The second will be a straight line in the middle of the course leading from the center of the edge of one alliance base to the center of the edge of the other alliance base. Black borders will also surround each base and each robot starting zone.
    e. Magnetic tape will also be placed around the edges of the course right next to the walls.
    f. Inch wide magnetic tape will be used for all lines except for the robot starting zones. The tape has 0.06” thickness raised from the floor of the course. These tracking lines could be used for standard infrared line following or magnetic line following.
    g. There will be short 3.5” tall walls around the edge of the robot game area. They will be painted white.
    h. Robots will not be allowed to exit the game area unless they are removed for repair during the competition.
15. Teleoperation zone:
    a. The teleoperation zone is located outside of the game area just behind each alliance’s base. It is an 8’x2’ rectangle.
    b. This is the area where robot operators will be allowed to stand while controlling their robots during the teleoperated portion of the competition.
    c. During the autonomous portion of the competition robot operators will not be allowed to be in this zone, except for the very start where they may press a start button on their remote control.

d. During the autonomous period, the remotes must stay in the marked autonomous remote control locations next to the course in the teleoperation zone and may not be touched until the autonomous period has ended.

16. Alliance Bases:
    a. Bases are a 3'x2' wide area centered on the far wall of each alliance territory.
    b. An alliance's flags will be placed inside the alliances own base.
    c. No part of an alliance robot may enter their own base:
        i. Unless they are in possession of an enemy flag, or an enemy flag is already inside the base and they are going to get possession of it.
        ii. Violations longer than a few seconds (or repeated momentary violations) will result in a referee deactivating the robot by hitting the robot's tag button and returning it to an alliance start position chosen by the referee. Alliance robots may then re-activate the robot.
        iii. If a robot deactivates another robot while in violation of this rule, then in addition to the previous penalty on the tagging robot, the tagged robot will be reactivated by the referee.
    d. Robots may freely enter enemy bases.
    e. Only the active flag may be removed from an enemy base.
    f. Robots that successfully remove an inactive flag from an enemy base will be de-activated with the tag button and the flag returned to its original location. (Touching an inactive flag or even removing a flag from the retainer is not sufficient reason for enacting the deactivation penalty since a robot may still be able to take corrective action).
17. Flag descriptions:
    a. There will be three flags belonging to each team.
    b. Flags will be colored red for one alliance and blue for the other.
    c. Each will be nearly identical cubes with 3" sides.
18. Flag retainers:
    a. At the start of the game each flag will be placed in a flag retainer. This retainer will be such that the flags cannot be pushed out of position, but must be lifted out of the retainer.
    b. Retainers will be 1" tall, 0.75" thick and provide a pocket approximately 0.125" larger than the flag.
    c. Retainers will be placed as shown in Figure 2. They will be 9 inches apart, center to center and from the edges of the base. Each retainer will be spaced 4.5 inches from their center to the back wall.
    d. LED indicators on and around each retainer will be used to indicate the active flag.
    e. Lights will only be lit for the retainer holding the active flag.
    f. Nine LEDs will be placed around each retainer as shown in Figure 3. Three will be IR lights, centered with each side of the retainer except the back. Four will be colored lights, blue or red depending on the alliance base it is in. They will be placed at the corners of the light formation. These seven LEDs will be placed in the floor so that their

tops are just below the level of the floor. Two more IR LEDs will be placed on the front face of the retainer 0.5” up from the floor of the course and will slightly protruding from the face of the retainer.

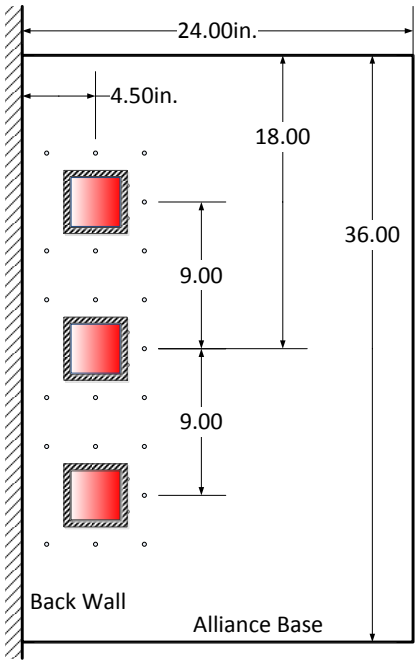

Figure 2: Retainer placement in each base.

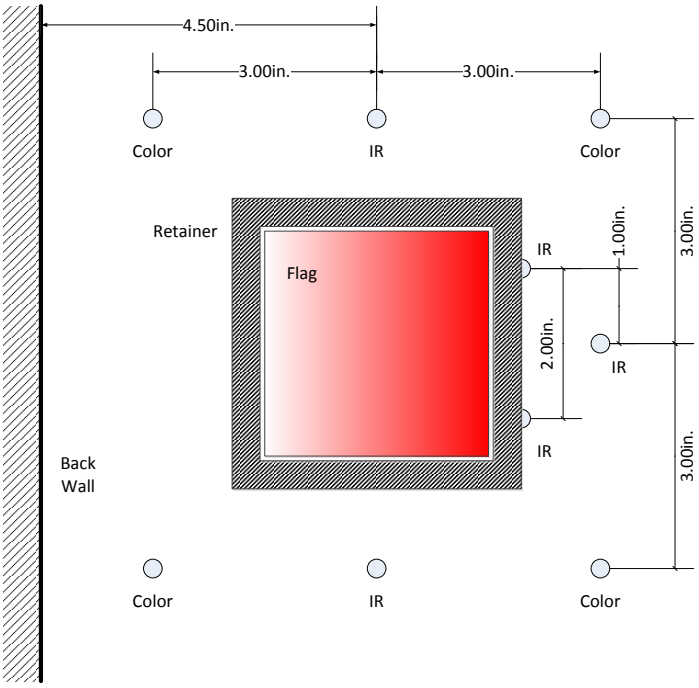

Figure 3: LED light placement centered around each retainer.

g. The active flag will be illuminated at the beginning of each match after the round has started, all robots have been started, and all operators have left the teleoperation zone. This is so that the robots will not know a-priori which is the active flag for the autonomous period.

19. Robot start zones:
    a. There are three robot starting zones for each alliance. These starting zones are 12" x 12".
    b. Robots must start entirely inside these regions at the start of the competition.
    c. One robot starting zone will be on one side of the alliance base centered between the base and the wall, with a two inch space between the starting zone and the back wall.
    d. The other two starting zones will be evenly spaced between the alliance base and the other wall. This will leave two inches between the base, each starting zone, and the wall. Starting zones will have a two inch gap between them and the back wall.

Game Setup

20. Each alliance will be assigned blue or red.
21. Each robot must be placed in one of the robot starting zones for the given alliance as shown in Figure 1.
22. Each robot must start entirely within the square drawn on the course (including parts hanging over the line), but may be placed in any desired orientation otherwise.
23. Alliances may decide between themselves which robot will be placed in which location.
24. Each flag will be placed in the flag retainers in the appropriate alliance bases. There is no guarantee that flags will be perfectly centered in the flag retainers, but will be flat on the ground.

Game Play

25. *Game start.* To start the game a signal will be given, the game clock will be started, and each team will be allowed to press one button on the controller to start their robots and then must immediately step out of the teleoperation zone.
26. After everyone has stepped out of the teleoperation zone one flag for each alliance will be activated at random, but such that only one flag for each alliance is active.
27. *Autonomous mode:*
    a. The first 45 seconds of the round will be autonomous mode.
    b. During autonomous mode, all robots can have no external communication except between the remote control and the robot itself. No one may be within the teleoperation zone where the remotes are located, nor touch the remotes or have any other form of communication with the remote or robot except as stated for the initial activation at the start of the game.
    c. All robots must remain on the course during the autonomous period even if they do not individually participate in the autonomous period.
28. *Teleoperation mode.* After autonomous game play, a signal will be given to identify the start of the teleoperation mode. In teleoperation mode, one person from each team can be in the

teleoperation zone to control their robot. A team member may exit at any time to allow another team member to step into the teleoperation zone and take control of the robot.

29. *Game time limit.* The game will last until a captured flag is returned to an alliance base or five minutes total have expired. The time limit for the game includes the time for autonomous mode.
30. *Course boundaries.* Robots must stay on the course.
31. Rules about entering alliance bases are stated under *Game Layout, Bases*.
32. *Tagging.* Robots can only be tagged in enemy territory except for limitations of entering an Alliance base as specified in 16.c above.
33. Flags can be moved in any manner desired, but must be in a robot's possession in order to cross into the enemy base and win.
34. There may be no intentional wireless interference to disrupt communication channels.
35. There may be no attempt of intentionally damaging other robots or the course. Trying to tag a robot is not considered intentional damage unless excessive force or senseless swinging is used.
36. Robots cannot leave parts on the course and must remain as one entity throughout each match.

Winning, scoring, tournament bracketing

37. The first robot to completely enter their alliance's base while in possession of the active enemy flag is the winner and the game immediately ends. Possession is counted as a flag being in contact with a robot and not being in contact with the ground in a stable position (not a momentary occurrence).
38. If no one wins by the time limit, the alliance that has an active enemy flag closest to or farthest inside their own territory wins. An enemy flag could be inside the base and not be a win by the previous rule if it is not in the possession of a robot. That scenario would be declared a win by this rule after the time limit has expired.
39. If neither alliance has been able to retrieve a flag, the alliance with the most robots in enemy territory or has the most net robot distance into enemy territory wins. This is to encourage offense so that a team that has played only hard defense causing the other player from being able to get to the flags cannot win.
40. In the case of ties (distances or times are too close to call), then ties are broken by the following sequence of tie breakers: fastest prior win, shortest cumulative prior game time, and then flip of a coin.
41. The competition winner will be determined by single elimination. Brackets will be set up so that in the case of 10 alliances there will be two preliminary matches, 4 matches in the next round, two in the semi-finals, and then the final match. If there are more or fewer alliances than 10, matches will be added or eliminated in the preliminary round.
42. A team may only be eligible to progress in the competition bracket if it has successfully demonstrated all required functionality prior to the competition. Required functionality is identified by milestones that are to be demonstrated during milestone lab demonstrations.

Grading

1. For the most part, your team will be graded as a group and individual grades will be based upon the team grade.
2. Throughout the semester, we will be keeping track of individual contributions, which will be used to bias your individual grades relative to the team grades.
3. Competition grading will be determined by alliance and team performance. Participation through the preliminary match is up to 80%, through the first round is up to 85%, through semifinals is up to 90%, finals are up to 95%, and the winning team alliance earns up to 100%.
4. Grade Weightings:

Memos/Progress Reports:	25%	Robot:	25%
Labs:	25%	Competition:	15%
Poster:	10%		

Schedule

Lab schedules and tasks are shown in Table 1 with descriptions of each lab following it and then descriptions of memos. Specific tasks for building team robots will be performed during each lab although teams are expected to work together outside of the scheduled lab periods.

Table 1. Lab Schedule.

Week No.	Date	Lab Activity/Milestone	Memo
1	1/9-1/13	No Lab – Setup lab sections via Canvas poll	
2	1/16-1/20	*MLK week – No Lab*	
3	1/23-1/26	Lab 1: Initial Meeting – Basic Mobility Platform	
4	1/30-2/3	Lab 2: Power Circuitry and Micro-Controller	
5	2/6-2/10	Lab 3: Prototype Remote Control – Discuss mechanism proposal	1: Mechanism Proposal
6	2/13-2/17	Lab 4: Communications and Teleoperation – Review final mechanism designs	
7	2/20-2/24	*Presidents Day – No formal labs – Build retrieval mechanisms*	
8	2/27-3/2	Lab 5: Flag and Tag Demo and Encoder Odometry—Review autonomy proposal.	2: Autonomy Proposal
9	3/5-3/9	Lab 6: Sensors	
	3/12-3/16	*Spring Break – No Lab*	
10	3/19-3/23	Lab 7: Autonomy 1: PID Line and Wall Following	3: Control Code Proposal
11	3/26-3/30	Lab 8: Autonomy 2: Flag and Robot Detection	
12	4/2-4/6	Lab 9: Scrimmage 1: Practice, Fine-tuning, Troubleshooting	
13	4/9-4/13	Lab 10: Scrimmage 2: Full Run-through	
14	4/17	Design Day – Mechatronics Competition!	Poster
15	4/23-24	No Lab – Return Toolboxes	4: Final Memo

Lab Descriptions

Lab 1: Initial Meeting and Basic Mobility Platform (1/23-1/26)

During lab,

1) Teams will be formed from the lab alliance.
2) Toolboxes will be given to each team.
3) Each team will construct their initial basic mobility platform which will include:
    a. Choose motors, gear ratios, wheels, and castors.
    b. Determine resulting robot speed or max holding force.
    c. Place and assemble the selected components to the robot base.
    d. Test motors with test batteries and label wires for direction.
    e. Provide motor lead strain relief.
4) Meet with team and alliance to form strategies and general robot design and characteristics.

Lab 2: Power Circuitry and Micro-Controller (1/30-2/3)

During lab,

1) The power system and Arduino Mega will be integrated in with the mobility base:
    a. Assemble the H-bridge.
    b. Mount the Arduino, battery, H-bridge, power switch, and electrical safety device(s).
    c. All components will be wired using proper strain relief and plugs.
2) Test that all components work appropriately
3) Perform a dead-reckoning task on the course (feed forward only, no feedback): get from a start position to the enemy base.

Lab 3: Prototype Remote Control and Discuss Mechanism Proposal (2/6-2/10)

During lab,

1) A remote control will be designed and assembled using parts in the lab.
    a. Physically build/solder and breadboard remote control circuitry and battery for:
        i. Power switch
        ii. Control inputs
        iii. Green/red status LEDs
    b. Integrate circuitry with Arduino and verify sensor signal ranges and proper use.
    c. Begin remote control code for interpreting inputs.
2) Turn in and discuss Memo 1: Mechanism proposal for flag retrieval and tagging mechanism.

On your own,

3) Begin construction of case for protecting and mounting remote control components.

Lab 4: Communications and Teleoperation – Final mechanism designs (2/13-2/17)

During lab,

1) You will enable communication between the remote control and robot.
    a. Integrate the Xbee modules into both the robot and remote control.
    b. Write/utilize code for sending simple commands from remote to robot.
    c. Write/utilize code for sending robot status to the remote.
    d. Demonstrate communication between remote and robot by performing simple forward and turn commands with the remote.

On your own,

2) Review and select design for robot's flag retrieval mechanism.
    a. Obtain parts from lab or order parts for the retrieval mechanism.
    b. Build mechanism during following week of 2/20-2/24. (There will be no formal labs during that week because of Presidents day holiday).

Lab 5: Flag and Tag Demo, Encoder Odometry and Discuss Autonomy Proposal (2/27-3/2)

During lab,

1) Demonstrate teleoperated operation of flag retrieval mechanism by getting flag from a retainer.
2) Demonstrate teleoperated tagging if robot designed with one.
3) Integrate and use encoders for performing odometry task.
    a. Wire encoders to Arduino.
    b. Calculate pulse to distance conversion.
    c. Perform odometry task (Feedback): get from a start position to the enemy base.
    d. Compare performance to dead reckoning.
4) Turn in and discuss Memo 2: Autonomy proposal and progress update.

Lab 6: Sensors (3/5-3/9)

During lab,

1) Integrate all remaining sensors onto robot for tagging and autonomous operation.
    a. Assemble, mount and wire tag button.
    b. Mount and wire status LEDs on robot.
    c. Mount and wire flag recognition sensors.
    d. Mount and wire any range sensors, line and wall following sensors.

On your own,

2) Begin construction of protective shell

Lab 7: Autonomy 1: PID Line and Wall Following and Discuss Control Code Proposal (3/19-3/23)

During lab,

1) Perform the following course traversal tasks using a PID controller:
    a. Magnetic line following
    b. Wall following
2) Turn in and discuss Memo 3: Control code proposal and progress update.

Lab 8: Autonomy 2: Flag and Robot Detection (3/26-3/30)

During lab,

1) Use the sensors of your choice for finding the active flag. Demonstrate ability to autonomously identify the active flag.
2) Use the sensors of your choice for recognizing the presence of a robot and approaching or avoiding it.

Lab 9: Scrimmage 1: Fine-tuning, Practice, and Troubleshooting. (4/2-4/6)

During lab,

1) Integrate functionality for and demonstrate ability to traverse course, retrieve flag, return flag, tag (if capable of tagging) and chase or avoid robots:
    a. Autonomously.
    b. Through teleoperation.
2) Demonstrate that tag button is fully functional.
3) Demonstrate that status lights on robot and remote are fully functional.
4) Test, fine-tune, practice, troubleshoot and finish any loose ends for robot.

Lab 10: Scrimmage 2: Full Run-throughs (4/9-4/13)

During lab,

1) Final demos and robot requirement verification
    a. Check size requirements.
    b. Re-verify ability to perform during autonomous and teleoperation modes.
    c. Check tag and status lights.
2) Full run-throughs as alliances.
3) Final competition prep as needed: more practice, fine tuning, etc.

Memo Descriptions

Memos will include 2 major parts, first an update on what has been done, and second the proposal of what is to be done as specified individually for each memo. Progress updates should state specifics of decisions made about the robot as well as what each individual on the team contributed and their time spent on the project. Individual and team grades will be determined from the progress report as well as

from the proposal part of the memo. Memos must follow the memo format and guidelines (to be posted on Canvas). Assigned memos must be submitted electronically on Canvas before lab on the week it is due. Memos will be reviewed and graded during the lab when it is due while discussing it with the team.

Memo 1: Mechanism proposal

This proposal will focus on the design of the flag retrieval mechanism or gripper. It should include several general ideas considered by the team and one detailed design of the choice selected by the team. The selected design should have basic dimensions, parts to be manufactured and components that will need to be bought or ordered such as actuators. Reasons for why the design was selected should be given.

The memo should also address possible designs for a tagging mechanism and the final choice about which mechanism to build. Reasons for why the selected mechanism was chosen, or why the team opted not to build one should be clearly stated.

Memo 2: Autonomy Proposal

The goal of this proposal is to get teams thinking about strategy and the physical design of their robot to achieve their strategy during the autonomous period of the competition. Identify which sensors will be required, where will they be placed, and basic control strategy that will be used in order to achieve the chosen strategies.

Memo 3: Control Code Proposal

The purpose of this memo is to help teams organize the many tasks and functions of a robot in a form that will allow them to integrate them together in their robot code. Flow charts showing programming logic and control integration between sensors, micro-controller and motors, and remote-control communication both for robot and remote control will be required. This memo does not require actual lines of code as they are expected to be (finished) written in the coming weeks, but should include everything a robot should be doing and when and under which conditions.

Poster

A poster must be made for display on design day. The poster will include general overviews of the functionality of your robot for visitors to see.

Memo 4: Final Memo: Robot Design Overview

A final memo will be required to summarize the final design of your robot, specs, program flow charts, game strategy with alliance, etc. It should include lessons learned from the actual competition as well as what things you learned from the project and what you would change in your robot if you did it again.

Updates

This is considered a "living" section. As updates, changes, or clarifications are necessary, they will be recorded here. If there is any contradicting information, newer information supersedes older. Please be sure you are always viewing the most recent version.

1/27/2012

Rev 1) *Lab guidelines*:

a. Always bring your toolbox to each lab throughout the semester.

b. Tasks identified to be completed in lab must be performed for the lab whether or not your final robot design will include the parts or features used in lab. There are two options on what to do if you do not intend on using supplied parts in lab or a given feature that is developed during lab:

   i. Complete the lab using the supplied parts, but return unneeded parts at the end of lab or replace the parts and/or redesign the feature on your own time outside of lab.

   ii. Bring acceptable substitute parts that your team has ordered or obtained on your own to lab in order to complete the lab with your own parts. If you intended to do this, but were unable to get the needed parts you must do option i above.

It is not acceptable to not complete a lab or a part of a lab because your specific robot will not make use of that part of the lab.

Rev 2) *Robot weight limit*: The robot weight limit will be 4kg.

Rev 3) *Retrieval mechanism and tagging mechanism*:

a. The only part of your robot that can extend outside of the 12" cube size limit after the game has started is the flag retrieval and tagging mechanisms.

b. The retrieval and tagging mechanisms must be designed for and only for tagging and retrieving the flag. They may not be used as blocking mechanisms (other than for tagging). As such any expanding or extending nets or similar devices for the purpose of blocking a base cannot be used. This is to stay in the spirit of standard capture the flag rules as much as possible, which doesn't permit such defensive tactics as completely blocking the flag. Any flag or tag mechanisms must be approved by your TA and their decision will be based on whether they stay within the spirit of the game.

c. Mechanisms which physically restrain another robot are not allowed. Mechanisms may not completely surround another robot and must allow them at least one direction of escape. Mechanisms which are used as physical guides (like feelers, whiskers, or mechanically actuated guide bars) for the purpose of centering the robot for tagging it are allowed, but again, must not physically grip onto it or restrain the robot from moving away from it.

d. Robots may not be disabled except through the tag button: this precludes actions such as pinning, holding, flipping and lifting robots.

e. Commercial grippers and arms are not acceptable for use on the robot. The tag mechanism and flag retrieval mechanism must be of your own design and manufacture.

f. It is now optional whether or not the final robot design has a flag retrieval mechanism; however, a robot that does not have a flag retrieval mechanism must have a tagging mechanism. Each team must still design both flag retrieval and tagging mechanisms for Memo 1, whether or not their final design will have either one.

Rev 4) *Tag button*:

a. The tag button will be approximately 3" in diameter with a 3.5" diameter base and 1.5" tall from the base to the top of the button.
b. The bottom of the tag button must be placed at least 3.5" up from the floor of the course, and may be placed as high as the maximum height of 12" will allow.
c. The tag button must remain in a fixed location on the robot. It cannot change height or move around on the robot. It must remain centered on the robot according to rule 7.b.
d. The tag button must ***always*** be open from the three fixed sides. The only side that can block the button is where any flag or tag mechanisms have been mounted. This precludes various blocking mechanisms that even temporarily block one side or another of the button.

Rev 5) *Throwing the flag*: The flag may be thrown or tossed, but a robot that causes a flag to go outside the bounds of the 8'x8' playing field will be tagged out by the referee and moved to a starting position of the referee's discretion. Then the flag that went out of bounds will be returned to its flag retainer.

Rev 6) If a robot is pushed into its own base then the robot at fault will receive the penalty specified in 16.c.ii. This means a robot that is overpowering another robot and does not attempt to move around it will be penalized, whereas a defensive robot that does not try to move out of its base when being pushed in will be penalized.

Rev 7) You may not move your own flag if it is dropped on the course by the enemy team.