

Robot Olympics Project

Just like humans, robots have their version of the Olympics, known as the “Robot Olympics”. Our Robot Olympics will take place in the final meeting of this module and will consist of three events:

1. Marathon
2. Curling
3. Hurdles

Your goal is to implement three programs, one for each of the three events. Once the competition begins, you will not be able to modify your programs.

Your robot will participate in each of the events in the competition and your grade will depend in part on the robot’s performance in the competition. Your robot will also earn points based on its performance in the competition. The winner of the competition will be the robot with the greatest number of points summed over all three events.

The project description is divided into five parts. The first section describes the general rules of the competition and provides some general hints. The next section describes the three events, their rules, and hints for building the programs. The last two sections describes the project report requirements and the deliverables.

1 General Rules

1.1 Programming

Before an event, a robot must contain the program for the event. Once an event begins, no reprogramming of robots is allowed. Rule violation will result in disqualification from the event.

1.2 Starting

Robots will be started in an event by pressing their **Forward Button**. The starter will say “Ready!”, “Set!”, “Go!”, and will start the clock while one of your team members pressed the **Forward Button**. It is recommended that the **Backward Button** be used to stop the robot, in the event of a false start or some other irregularity.

1.3 Scoring

For each event in the competition the top three robots will be awarded gold, silver, and bronze medals. A gold is worth three points, a silver is worth two points, and a bronze is worth 1 point. The robot with the largest point value over all three events will win of the Olympic games.

1.4 Interference

Once a robot begins an event it cannot be touched or interfered with in any way. If the robot is touched or interfered with in any way then the robot's attempt is disqualified.

1.5 Battery Charging

Robot batteries should be fully charged prior to the start of the competition.

2 Grading

Your robot will be graded using the following general grading scheme:

F	No show or robot does absolutely nothing.
D	robot attempts the event but does not complete any of the expected requirements.
C	robot completes some of the expected requirements.
B	robot completes the expected requirements.
A-	robot completes the expected requirements and comes in 3rd in the event.
A	robot completes the expected requirements and comes in 2nd in the event.
A+	robot completes the expected requirements and comes in 1st in the event.

Refer to each event section for specific grading. Fifty percent of your project mark will be the average of the three grades received for the events.

2.1 Hints and Suggestions

Remember that you have a limited amount of time to implement your programs. Start with the easier events and work your way up to the harder ones. You will have many opportunities to test and fine-tune your programs prior to the competitions. Be sure to take advantage of it!

3 The Events

3.1 The Marathon

The marathon is a traditional Olympic event. That marathon is a long race of endurance, in which (for a robot) there is plenty of opportunity to get disoriented. The marathon will take place in three $1.8m \times 0.9m$ tables (the large tables in the lab) which will be set up. (see Figure 1). Each robot will race separately, with the goal of racing down the tables and back in the shortest time possible. The robot will need to cross the black tape line at the end of the track and return. This is the simplest of the three events.

3.1.1 Rules

1. This event will take place in the marathon track which will be set up by three $1.8m \times 0.9m$ tables. The gaps between tables will be covered up by paper tape. The race track is 500cm long and 80cm wide.
2. The long sides of the race track will be demarcated by the green Duplo blocks that will be at least 6cm high.

3. There will be a black lines of electrical tape at each end of the race track denoting the start/finish line. The line will be at least 3cm thick.
4. The robot will be placed on the start line in the middle of the track such that its wheels are on the start line and its back is parallel to the start line.
5. There is a 35cm space at the end of the track for turning.
6. The robot will have up to four (4) minutes to race to the other end of the path **and back to the starting line**.
7. The robot must overlap the midpoint line before returning to the starting line.
8. The amount of time it takes the robot to race from the start line to the midpoint line and back will be timed. Note that the robot does not need to stop at the finish line
9. The robot will be graded based on whether it completed the race and the time that it took.

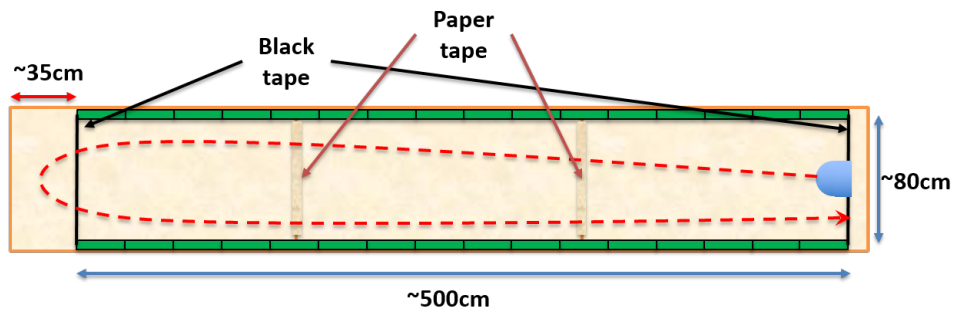


Figure 1: Diagram of the marathon event.

3.1.2 Grading Scheme

F	No show or robot does absolutely nothing.
D	Robot does not make it past the midpoint line.
C	Robot makes it past the midpoint line but does not complete the race.
B	Robot completes the race.
B+	Robot completes the race with an above average time.
A-	Robot completes the race and has third fastest time.
A	Robot completes the race and has second fastest time.
A+	Robot completes the race and has the fastest time.

3.1.3 Hints and Suggestions

Since the robot will be traveling at full speed, it will likely go off-course and bump into a wall. Use the wall avoidance programs as the basis for your program so that the robot can correct its trajectory. Use the ground sensors to detect the tape. Then, turn around and head back. You will need to calibrate your thresholds to detect the tape on the floor. Use the program that you used in Tutorial 2 to accomplish this.

In general, you will know that your Olympics programs are effective if they not only run correctly on your robot but on one of the spare robots as well. In the past some students found that on the

day of the Robot Olympics their solutions did not work as they expected. Testing on other robots is a way to guard against this. Another general recommendation is to ask a Teaching Assistant to watch the operation of your programs *before the day of the Olympics* to confirm that they correctly complete the events.

3.2 Hurdles

This is an event of medium difficulty. In the human version of Hurdles, humans must race down a track, jumping over several barriers as they race to the finish. In the robot version of hurdles, the hurdles are obstacles that the robot must go around. In this event your robot must negotiate the obstacles and complete the race course (see Figure 2) while remaining within the boundary.

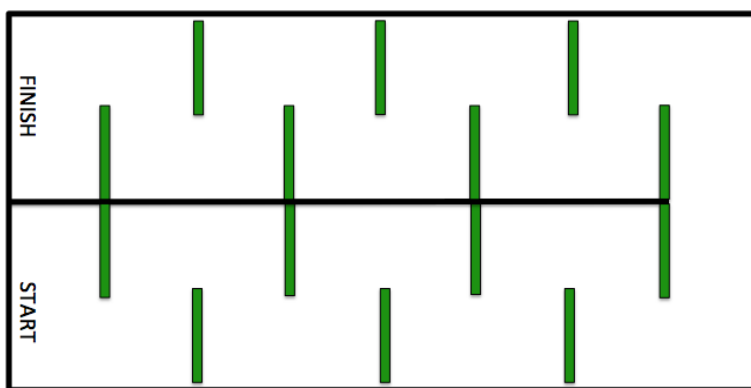


Figure 2: The hurdles race course.

3.2.1 Rules

1. This event will take place in a $2m \times 1m$ track (one of the large tables in the lab).
2. The boundary will be marked on the table using black electrical tape. The boundary will be 80cm wide and 160cm long, and 140cm long down the middle of the table.
3. The course contains 14 hurdles as shown in Figure 2. Each hurdle will be 23cm wide, 6cm tall, and 3cm deep. The hurdles will be spaced every 20cm along the course.
4. The **START** line will be on the right side of the course and the **FINISH** line will be on the left side of the course.
5. The robot starts in the middle of the **START** line such that both wheels are on the line.
6. To complete the event the robot must traverse the course and cross the **FINISH** line. A robot is deemed to have crossed the **FINISH** line if any part of it overhangs the line.
7. The robot will be allowed three 2-minute attempts.
8. The robot may not cross the center line. It is allowed to overhang the center line, but must travel the long way around the center line to complete the course. If the robot completely crosses over the center line, its attempt will be deemed over.
9. If the robot leaves the race course such that no part of it is on the course then the attempt will be deemed over.
10. A ten second penalty will be assessed for each hurdle that is dislodged by more than 3cm.

11. The robot will be graded based on how quickly it traverses the course from **START** to **FINISH**, the number of hurdles it displaces, and how close it gets to the **FINISH** line.
12. The best attempt will be graded.
13. The three fastest times for completing the event will be awarded 1st, 2nd, and 3rd place.

3.2.2 Grading Scheme

F	No show or robot does not complete more than half the course.
D	robot completes more than half the course.
C	robot completes course.
C+	robot completes course, displacing at most seven hurdles.
B-	robot completes course, displacing at most five hurdles.
B	robot completes course, displacing at most three hurdles.
B+	robot completes course, displacing at most three hurdles and a better than average time.
A-	robot completes course, displacing at most one hurdle and has the 3rd fastest time.
A	robot completes course, displacing at most one hurdle and has the 2nd fastest time.
A+	robot completes course, displacing at most one hurdle and has the fastest time.

3.2.3 Hints and Suggestions

You already know a lot about the course: the location of the hurdles and the general layout. You have several strategies that you can follow. A simple one is the maze traversal strategy that uses both the horizontal and the right ground sensor to perform a right-hand rule traversal of the course. Another strategy is to use a simple line following approach and bulldoze the hurdles—this will only yield a C+ though. For a really fast strategy, you need to get the robot to perform a tight zig-zag between the hurdles, using the horizontal sensors to detect the hurdles.

3.3 Curling

This is probably the hardest event. Traditional curling takes place on a sheet of ice, like hockey, and involves players taking turns “throwing” rocks (blocks of granite) down the ice by giving a rock a push at one end of the sheet and letting it slide down the ice to the other end. The goal is to get the rocks as close as possible to the center of the rings at the other end of the sheet. As the rocks slide, they may bump into other rocks, changing their position and altering its own course.

In robotic curling, two robots compete to get to the center of the rings in a limited time frame, called an “end”. The robots start at one end of the sheet (see Figure 3) and attempt to get to the center of the rings. The robots may bump into each other, get into each other’s way, and try to dislodge each other. After a fixed amount of time, both robots must stop and the robot that is closer to the center of the rings is deemed the winner of this end.

3.3.1 Rules

1. This event will take place in a 2m x 1m arena (one of the large tables in the lab).
2. A 80cm by 160cm sheet will be marked on the table using black electrical tape.
3. The rings will be placed inside the sheet, at one of the ends, centered, 40cm from each of the three sheet boundaries.

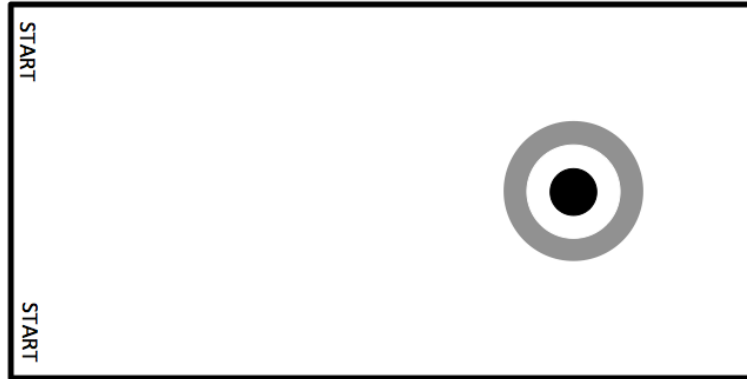


Figure 3: The robot curling sheet.

4. The robots start at one end of the sheet, in opposite corners, with their wheels on the line. The starting positions are determined by a coin toss.
5. The robots must stop 60 seconds after they start. If they do not, they automatically lose the match. Thus, each end takes 60 seconds.
6. If the robot moves outside of the sheet, it is deemed to have lost this end.
7. After the robots stop, the robot that is closest to the center is deemed the winner of the end.
8. Each match will comprise three (3) ends of 60 seconds each. The winner of two of three ends is deemed the winner of the match.
9. A robot must first qualify to compete in the curling tournament.

Qualifier #1 :

- (a) The robot is placed on the sheet on its own.
- (b) The robot is started, the robot should start moving and turn off the circle LEDs.
- (c) The robot must stop after 60 seconds and light up its circle LEDs.

Qualifier #2 :

- (a) The robot is placed on the sheet on its own.
- (b) The robot is started.
- (c) The robot must stop within the outer ring once the 60 seconds.
- (d) The robot passes the qualifier with honours if it ends up on the inner-most ring.

10. The robot will have 2 attempts at qualifying.
11. The qualifying robots shall participate in a double elimination tournament.
12. The robots will be graded on how well they perform in the qualifiers and how well they compete in the tournament.

3.3.2 Grading Scheme

F	No show or robot does absolutely nothing.
D	robot passes Qualifier #1.
C	robot passes Qualifier #2.
B	robot passes Qualifier #2 with honours.
B+	robot passes Qualifier #2 with honours and wins at least one match in the tournament.
A-	robot comes in 3rd in the tournament.
A	robot comes in 2nd in the tournament.
A+	robot comes in 1st in the tournament.

3.3.3 Hints and Suggestions

The robot needs to work in two (or three) phases. In the first phase, the robot needs to find the rings because they are not guaranteed to be in the same place each time and because the robot is not starting from exactly the same position (it has to be able to start on both sides of the sheet). Once the robot locates the rings, it will need to orient itself towards the center and move forward. It can use the different shades of grey of the rings to determine its position and identify when it reaches the center (see Figure 4). Once it is in the center, it may decide to enter a third phase. In the third phase, the robot stops and waits. If it is tapped (checkout the **tap** sensor) it determines whether it has been pushed off center, and attempts to correct its position. Hence, you can implement your program in these corresponding phases. You should also think about your strategy: do you let the other robot find the center first and then push it off? Or, do try to find the center first and remain on it? In real curling, having last rock (going last) is a significant advantage. **Warning:** Be careful to thoroughly test your solution and ensure that it can routinely accomplish the qualifiers. You only get 2 attempts at each qualifier, so you will not want to rely on chance as a strategy.

4 Lab Period Questions

For the five lab reports that you will need to fill out while working on your project please answer the corresponding questions.

Period 1 :

1. Describe your initial strategies for each of the three events.
2. Provide a Gantt chart describing your project plan. It should include all your group members as resources. Your time-line should be in terms of hours or project periods. Note, some work may need to be done outside of lab time.

Period 2 :

1. Describe in detail your strategy and tactics for one of the events—you can reuse this in the final report.
2. Describe what has been accomplished so far and what remains to be done.
3. Is your progress in-line with your project plan? If not, provide a plan update.
4. Were you graded on any of the events? If so, what were the grades and why?

Period 3 :

1. Describe in detail your strategy and tactics for another one of the events.

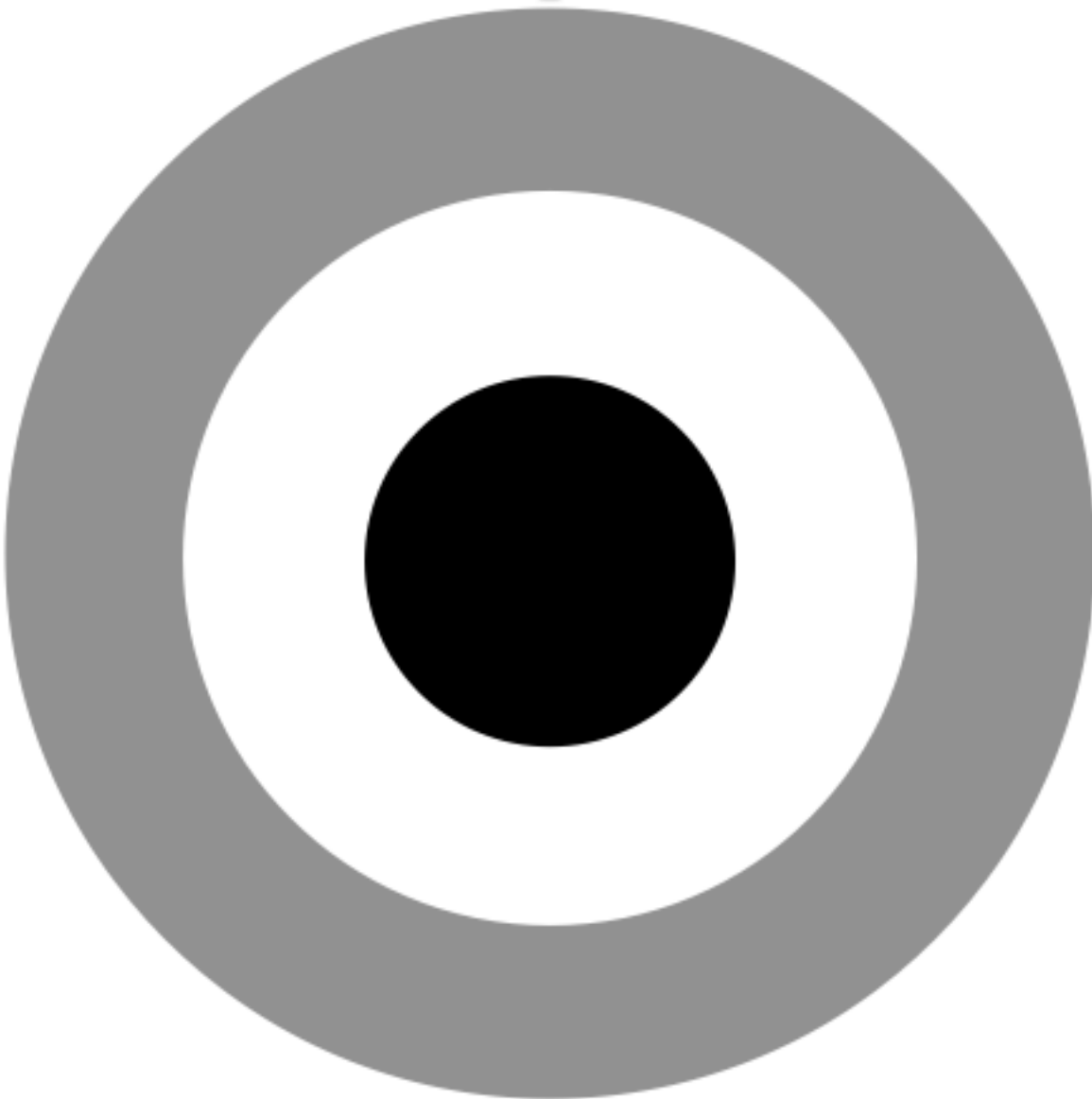


Figure 4: The approximate grey-settings for the rings.

2. Describe what has been accomplished so far and what remains to be done.
3. Is your progress in-line with your project plan? If not, provide a plan update.
4. Were you graded on any of the events? If so, what were the grades and why?

Period 4 :

1. Describe in detail your strategy and tactics for the last event.
2. Describe what has been accomplished so far and what remains to be done.
3. Is your progress in-line with your project plan? If not, provide a plan update.
4. Were you graded on any of the events? If so, what were the grades and why?

Period 5 :

1. What changes did you have to make to your strategies and tactics as you built and tested your programs?
2. Did you manage to complete most of your programs? Why or why not?
3. Describe what has been accomplished so far and what remains to be done.
4. Is your progress in-line with your project plan? If not, provide a plan update.
5. Were you graded on any of the events? If so, what were the grades and why?

5 Report Guidelines

You must submit a technical report as one of the deliverables. The purpose of this report is to describe the three programs that your group implemented for the robotics competition. For each of the three events the report should describe the program's design, the reasons for the design, and the strengths and weaknesses of the design.

The audience for your report are your class peers, the teaching assistants for the course, and the course instructor. Consequently, your report must contain a sufficiently detailed description of your project, but must not be overly long because we will need to read many of them in order to perform the evaluations. Put another way, another student in the course should be able to reproduce your project from the description you provide. Your report should comprise the following sections:

Title and Author Information is the first part of the report containing:

- the report title,
- the authors' (your) names, and
- the authors' affiliation (Faculty of Computer Science, Dalhousie University, Canada).

The title itself should be a meaningful phrase giving the reader a succinct description of what the report is about. I.e., "Our Project" is *not* a good title.

Abstract is a brief summary of the entire report, briefly stating the purpose of the project, what was done during the project and what the results were. The abstract is limited to 100 words.

Introduction sets the stage for the report. It should introduce the topic(s) and problem(s) at hand, state the purpose of the project (what is being solved), outline what was done in greater detail than the abstract, and possibly discuss the results of the project. A student, having read the introduction, should have a clear picture of the problem(s) and what was done.

For example, your introduction should briefly describe the area of robotics, then give an overview of your project, including: the robot system that was used, the events in the robotics competition, the major problems encountered during the project and the resulting solutions.

Background sets the context for the report. It describes previous work and concepts that were used in the project and discusses common assumptions made in the course of the project. This section will typically have quite a few citations because it discusses work, ideas, and concepts that preceded your project report.

For example, your background section should thoroughly describe the robot platform that was used, including its basic structures, the sensor capabilities, its mobility, and also the platform's limitations. This section should also describe features that are common to the three events. Lastly, you should discuss (and cite) any related work that you encountered while working on the project.

The content in this section typically comprises material compiled from other sources. Be sure to properly cite all material that you reference in your report.

The Marathon Program section answers the following three questions about your program for the Marathon event. Namely, what is the problem being solved? How was the problem solved? And, why was this solution chosen? Thus, the report must describe the event and the particular challenges that it entails.

The report must then describe your solution to the problem. It should describe the basic strategy of your solution and the tactics used to achieve it. For example, following one of the Duplo blocks walls by using the horizontal proximity sensors. you can use state transition diagram.

Lastly, and most important, your solution must be justified (you can use state transition diagram). You need to justify both your strategy and your tactics. I.e., Why did you decide on a particular strategy to solve the problem and why did you use the tactics your report describes. Your justification should also describe the strengths and weaknesses of your solution.

The Hurdles Program section describes your program for the Hurdles event and, has the same format and addresses the same issues as the previous section.

The Curling Program section describes your program for the Curling event and, has the same format and addresses the same issues as the previous section.

Results describes and analyzes the quality of your solutions. This section will be based on the competition that will take place at the end of the module and should describe how well your programs performed, why the programs performed as well or as poorly as they did, and how well your programs performed relative to other programs. For example, your Marathon program may have taken 90 seconds to complete the race, but this does not mean anything until you mention that only two programs managed to complete the race with a faster time, indicating that your program was one of the better ones.

Use of tables and graphs to present your results is strongly encouraged.

Conclusion and Future Work is a summary of the report with particular emphasis of the results of the project. Along with a summary of the results, you can also describe what else you would have liked to do with your project, how the project could be improved or extended, etc. This section provides the closing bracket to the report and complements the introduction.

For example, the report should briefly state the purpose of the project, i.e., “We did ...”, The report should then summarize your results, with focus on how well your programs did and any major difficulties that your programs encountered. Important ideas that were part of the solutions should be recapped here. Lastly, this section describes what should be done if more time to improve the programs was available.

References contains a complete citation listing of any other works that you referred to or used for preparing this includes Wikipedia, which you really should not use as an official source for anything. Citations in computer science are typically done using end-notes[4]. However, using other styles such as the APA [1], Chicago Manual of Style [3], ACM [2], etc, are all acceptable as long as they are used consistently.

The project report should use 11-point font and be no more than eight (8) pages in length, except for the program code. This means that the title, all figures, and references must all fit within the eight page limit.

Standard conventions for grammar, word use, spelling, citations, headings, paragraphs, figures, and tables are expected. A template is provided on the course website (<http://moodle.cs.dal.ca>)

so you know how they should be formatted. The report will be marked using the following rubric¹.

	Exceptional: A	Acceptable: B	Substandard: C-D	Unacceptable: F
Content and Structure (50%)	Contains all required information. Ideas well organized and logically laid out always or almost always.	Contains most of the required information. Ideas well organized and logically laid out with competence.	Contains some of the required information. Minimal organization and logical progression of ideas.	Is missing most of the required information. Little or no organization or logical flow of ideas.
Analysis and Depth (30%)	Identifies and explains all issues and design decisions. Considers the issues from multiple points of view. Shows superior understanding of subject.	Identifies and explains most of the issues and design decisions. Shows commonplace understanding of subject.	Identifies and explains some of the issues and design decisions. Shows partial or limited understanding of the subject.	Identifies and explains few of the issues and design decisions. Shows a great deal of misunderstanding about the subject.
Presentation, Style & Tone (20%) Standard conventions for grammar, word use, spelling, citations, headings, paragraphs, figures, and tables. Word choices set appropriate style and tone.	Always uses standard conventions. The document looks professional. Shows exceptional use of tone and style. Speaks to the reader with precise, concise, appropriate language, and choice of words.	Mostly uses standard conventions. The document could use some editing. Shows competent use of tone and style. Makes good word choices.	Does not consistently use standard conventions. The document requires significant editing. Shows minimal attention to tone and style. Shows poor usage or ineffective word variation.	Standard conventions are flouted. Document is unreadable. Shows little or no understanding of appropriate tone. Uses inappropriate language and word choice.

6 Deliverables

The deliverables for this project are:

- Three Programs** loaded on your robot to compete in the Robot Olympics.
- Technical Report** in PDF or Word format.

The *three programs* should be ready to go for the competition at the start of the presentation period for this module. The technical report is due on Monday, April 8, in pdf format and hard-copy. Students must include their programs as part of their reports. These can be generated by copying and pasting the programs into an appendix at the end of your report. Be sure to format this nicely. The reports must be submitted electronically, via `moodle.cs.dal.ca` and the reports must also be submitted in hard-copy.

¹Based in part on Fleming, "Grading Rubric for Written Assignments", CSCI 2100, 2011

References

- [1] American Psychological Association. *Publication Manual of the American Psychological Association*. American Psychological Association, Washington, DC, USA, 6th edition, 2009.
- [2] Association for Computing Machinery. <http://www.acm.org/publications/submissions>. Accessed August 17, 2012.
- [3] University of Chicago Press Staff, editor. *The Chicago Manual of Style*. University of Chicago Press, 15th edition, 2003.
- [4] Mary-Claire van Leunen. *A Handbook for Scholars*. Oxford University Press, New York, revised edition, 1992.