The University of Auckland
Department of Electrical and Computer Engineering
COMPSYS 301 Design:Hardware and Software Systems
18 July - 21 October 2016

1 Project Brief

In this project you will undertake the design and construction of *a part* of a robot. The robot will be multi-wheeled and incorporate an on-board microcontroller which you will program to make the robot do complete specific benchmark tests and also to solve specified goals or tasks. The shape and structure of the robot is prescribed. We will provide you with an assembled wheeled robot. Some of the electronics is pre-assembled and some of it is left to you entirely. Essentially, you will design, assemble and test a sensor circuit which will be interface to the provided microcontroller. These circuits will be implemented using printed circuit boards (PCBs) by going through the typical process: analysis, schematic capture, artwork design, circuit assembly and final testing.

The robot will be powered from an on-board energy storage system:re-chargable batteries. Battery chargers will be made available in the assigned project laboratory.

The higher level goals of this project is for your robot to play as the *Pacman*. A limited attempt has been made to be true to the original game but the essence is still strong. The field will be projected vertically down (from a ceiling mounted projector). The food pellets will be projected. The pacman will gobble up the pellet when it makes contact with the pellet. Ghosts (enemies) will also be projected and your pacman should be programmed to react to the specified goals.

2 Overview

The class will be organized into groups of 4. You are expected to form your own groups by the end of Monday in week 1. The project will be assessed on both implementation and understanding. In practise, these assessments will be made over an interview, technical tests and a practical design test. The project may be seen to consist of two parts: a construction part and a programming part.

1. Work constructively in a group to achieve specified objectives.
2. *Robot Construction* - In this phase you will
   (a) Configure hardware subsystems
   (b) Design and construct some circuits required for sensing
   (c) You will test subsystems, integrate them by physically installing and wiring them as well as writing some code
   (d) You will program the robot to complete specific benchmark tests

   The marks will reflect the following: analysis of options, the use of simulations and experimental verification, reliability of results, quality of construction and quality of code [1].
3. *Robot Programming* - This phase is also group based in which you will program the robot to behave as the Pacman.
   (a) Your Pacman should eat uniformly distributed pellets
   (b) Eat sparsely distributed pellets
   (c) Should eat pellets in the presence of ghosts - *This task will be discussed during class*

   To complete these requirements you will need the following
   (a) Create sensor PCBs

[1] Discussion with others is *strictly* not permitted and if detected it will be taken as plagiarism and dealt with accordingly. You are not permitted to brainstorm or discuss technical details with any other student other than your group members.

(b) Program your robot to track a path (using optical sensors and code)

(c) Program your robot to detect and negotiate intersections (using optical sensors and code)

(d) Localize the robot (odometry and code)

(e) Plan your route through the field (layout of the field given to you to include in your code).

Both these parts are compulsory and *ALL* members of the team are expected to contribute equally. You are also required to document the management of your project.

In addition to the implementation (construction and programming) of the robot, the following are also required.

- Two documents have to be submitted. The first one is the *Robot Datasheet* which lists the specifications and measured performances. This will include motion performances, sensor performances and any information necessary for others to use your robot. The second document is the *Project Report* which describes your project highlighting the design considerations, design decisions, verification, testing, software (flowcharts and data structures) and any other information that you think is necessary. *Both of these are group reports and every group member is expected to contribute to their crafting*.
- Every student has to demonstrate their project and make themselves available for the interview and the demonstration. The first one will be an individual interview while the second one will be a group based.
- Every student is required to submit three completed Peer Assessment survey forms. These surveys will give you an opportunity to comment on the contribution and performance of individual members including yourself. It is the primary channel for informing us of your group's dynamics and should be taken very seriously. Failing to submit these will result in a *zero* mark for this project. Submitting one in haste or with inaccurate details is a waste of time if not counter-productive.

3 Materials, Equipment and Resources

Laboratory The Design Project Laboratory 3, Rm 303.255 has been booked entirely for this course. It will be open from 7am to 10pm, Monday to Friday[2]. A locker will be provided for each group.

Robot A pre-assembled robot, a bag of components, breadboard, electronic components active and passive, LTSPICE, access to ECE laboratory, library, the Internet, PSoC Development kit and development software, Altium, Matlab, ECE Store.

PCB The PCB must be submitted on Monday 15 August. If required, a second PCB will be permitted. However, this will reduce your project grade by 5%. Every additonal PCB's after the second one will incur a penalty of 10%. All PCBs will be manufactured commercially and have a 5 day turn-around. If you get a PCB manufactured on your own it will be classified as *cheating* and you will automatically be awarded a DNC grade and consequently fail the course and made to appear in front of the UOA's Discipline Committee. The schedule for PCB manufacture will be discussed in class.

Robot Programming PSoC IDE

4 Assessment

Your performance in this course will be assessed over typical design components. The Technical Tests will evaluate your robot, the Interview and Design Test will evaluate your knowledge and understanding while the Implementation and Report will evaluate your complete solution and your written communication skills respectively. Failing to complete **any one** will result in a DNC grade for the course.

[2]Missing scheduled lectures to work on this design projects not acceptable

Component	Weighting	Date
Interview	20%	11, 12 August
Technical Test 1	15%	24 August
Technical Test 2	15%	23 September
Design Test	20%	11 October
Report	10%	18 October
Implementation	20%	18, 19 October
Professional Conduct (penalty)	-20%	18 July - 21 October

4.1 Interview

There are two elements to this interview: oral examination and a practical examination. The oral examination will be undertaken individually (or in groups of 2) but the pratical examination will be done individually. Typically it will take about 30 minutes for both elements. The students will be expected to show the functioning of the optical sensor to detect lines, present any simulations, experimental results, knowledge of the programming environment and the PWM block. The assessment criteria will be based on the extent to which an individual demonstrates a thorough understanding of that particular aspect. The log-book may be examined in this assessment.

4.2 Technical Tests

This assessment will focus on the technical aspects of your robot. Technical Test 1 will examine the quality of your construction and your robots ability to follow lines, with and without RF localization and the operation of the ADC. Various benchmark tests will be created to test tracking straight and curved lines. Technical Test 2 will examine speed control and robot localization. These tests form the basis for the next part i.e. the programming of the Pacman. It is unlikely that groups will get a good grade if they do not complete all of these tests.

These tests will be conducted in **your absence**. It is advised that this be kept at the forefront during the design process.

4.3 Design Test

The test will be 2 (or 3) hours in duration and will assess your competency in the use of the software and hardware design tools.

4.4 Technical Reporting

This includes the Robot Datasheet, your log-book and the report. The assessment will be based on thoroughness of your analysis and design, measurements, waveforms, graphs, simulations and analytical descriptions. The report describes your project highlighting the design considerations, design decisions, verification, testing, software (flowcharts and data structures) and any other information that you think is necessary. Both the datasheet and the report are a group effort. The datasheet is a single sheet of paper (2 sides of an A4 sheet) while the report is about 5 pages plus appendices. Each group members contribution to the project and the report should be tabled in the appendices of the report.

The logbook is an individual effort. You will be asked at **any time** to present your log book and hence it must be kept up to date *daily*.

4.5 Demonstration

During this assessment we will examine your robots complete the required objectives. The maze for this component will be unique i.e. different to the one you will use during the course of the semester. In addition, we will also interview the group to discuss the execution and understanding of the project related tasks and the performance of the Pacman. Usually, this is a 30 minute interview with the entire group.

5 Passing Grade

To pass this project you must satisfy *ALL* of the following

1. Construct a functioning robot
2. Construct the light sensing circuit
3. Program the robot to make its way through the projected maze
4. Attend and pass all the project assessments.

In simplistic terms, your robot must, reliably, complete the benchmarks in Technical Test 1. To do this you will need to have a good understanding of the optics and programming environment and hence your engagement in the design process from the very first day is essential.

6 Unsatisfactory Behaviour

This is a professional degree and hence conduct appropriate to it is expected. Plagiarism, sabotage and other such matters will be immediately referred to the University Disciplinary Committee. Please respect the laboratory rules as they are only put in place for the collective good. If you find anyone behaving in a manner that compromises these rules you are welcome to report the matter to the ECE Technical Manager or any ECE staff or your class representative.

7 Staff

Teaching Assistants		
	Mr Joseph Tsoi	ktso005@aucklanduni.ac.nz
	Mr Nathanael Esnault	nesn277@aucklanduni.ac.nz
	Mr Rav Brar	rbra121@aucklanduni.ac.nz
	Mr Thomas Hendeson	then095@aucklanduni.ac.nz
	Mr Peter Kiang	ckai740@aucklanduni.ac.nz
	Mr Soumya Puri	spur859@aucklanduni.ac.nz
Technicians		
	Mr Fung Yang	fung.yang@auckland.ac.nz
	Mr Howard Lu	h.lu@auckland.ac.nz
Course Lecturers		
	Dr Muhammad Nadeem	muhammad.nadeem@auckland.ac.nz
		Rm: 401.806
	Dr Nitish Patel	nd.patel@auckland.ac.nz
		Rm: 401.805

8 Robot/System Specifications

The specifications will be discussed during lectures.

9 Benchmark Tests

Your robots performance will be tested against the following benchmark tests. You will be expected to complete these tests and document the results. These results will be submitted to the academic team together with your robot. The

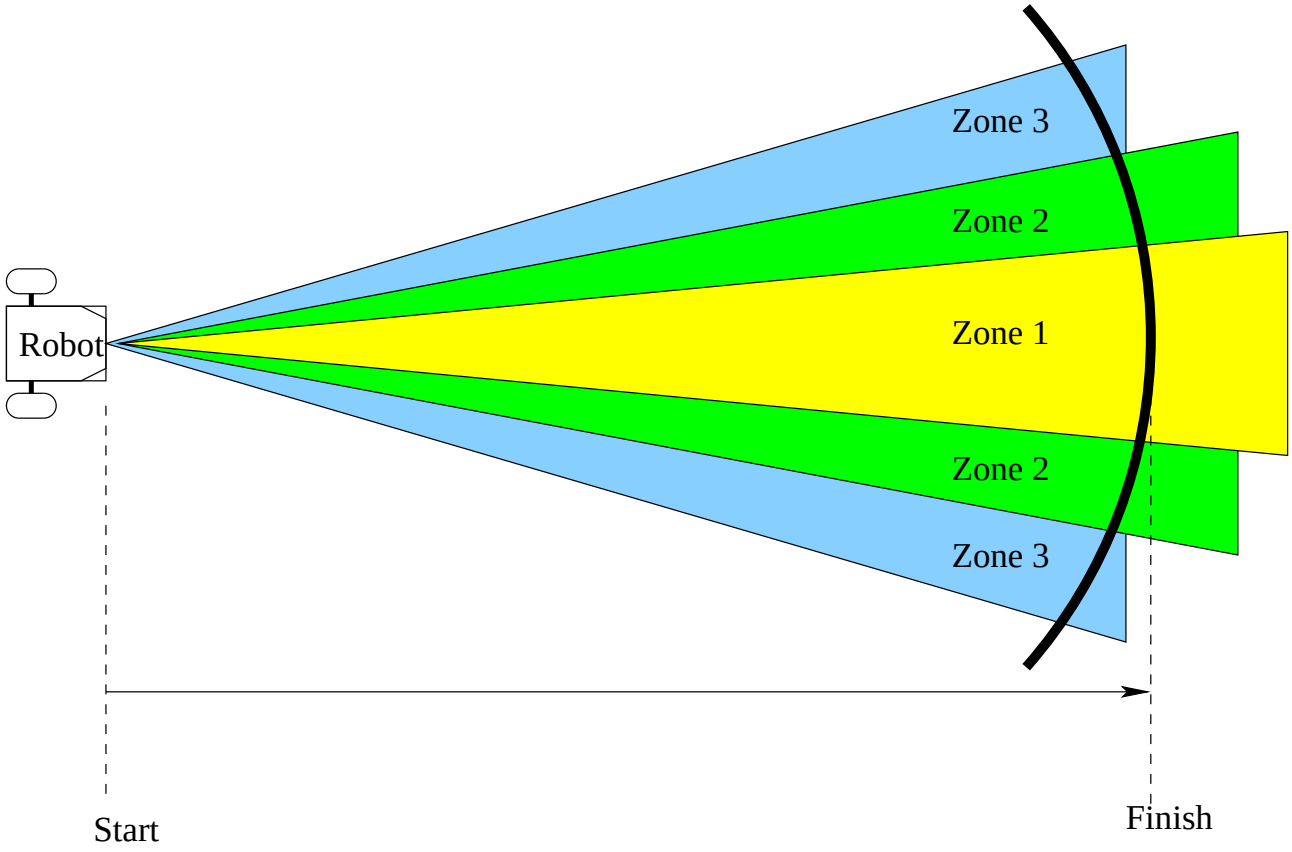

Figure 1: Benchmark Test 1 - Open Loop Line Test

academic team will verify the performance independently and *in your absence*. Hence we require that you include in your schematic/PCB, a DIP switch using which we can conduct these tests with ease. The test will be applied by setting the DIP switches to the required position and *power cycling* the robot (turning the power Off and then back On). Each test will be repeated 5 times and your marks will be an averaged over these 5 tests.

The fields for testing your robots will be made available in the laboratory and the field specifications will be published on CECIL.

9.1 Open Loop Line Test

DIP Switch position: [OFF OFF OFF ON]

The purpose of this test to gauge the 'balance' of your robot i.e. the ability of your robot to travel in a straight line without the use of the line sensors. Figure 1 shows a diagram of the test field. This diagram is for indicative purposes and the actual field will be published on CECIL. The robot will start from the *Start* mark and run at full speed towards the *Finish* marker. The zones will be used to grade the performance of your robot. For example finishing the test in zone 1 will result in the highest mark while finishing in neither of zones 1, 2 or 3 will result in a failing grade.

9.2 Straight Line Test

DIP Switch : OFF OFF ON OFF

This is a closed loop test since you will use your light sensor array to keep the track centred within the array. The purpose of this test is to assess your robots ability to track a straight line while ignoring RH/LH intersections. Also included in this is a curved track with a large radius of curvature. The radius of curvature should be big enough to minimize tracking errors. If your robot fails to track this curve, then you are permitted to lift the robot

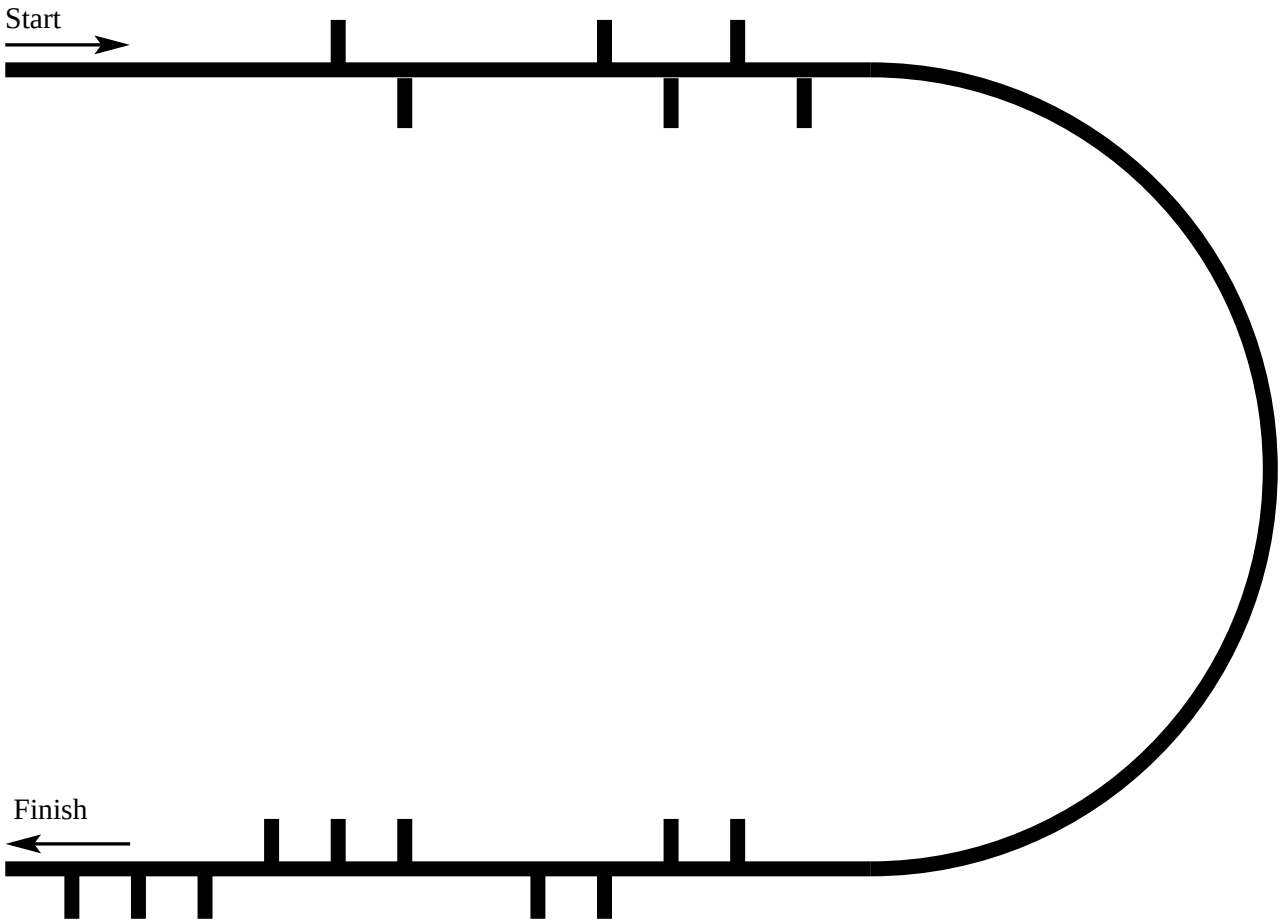

Figure 2: Benchmark Test 2 - Straight Line Test

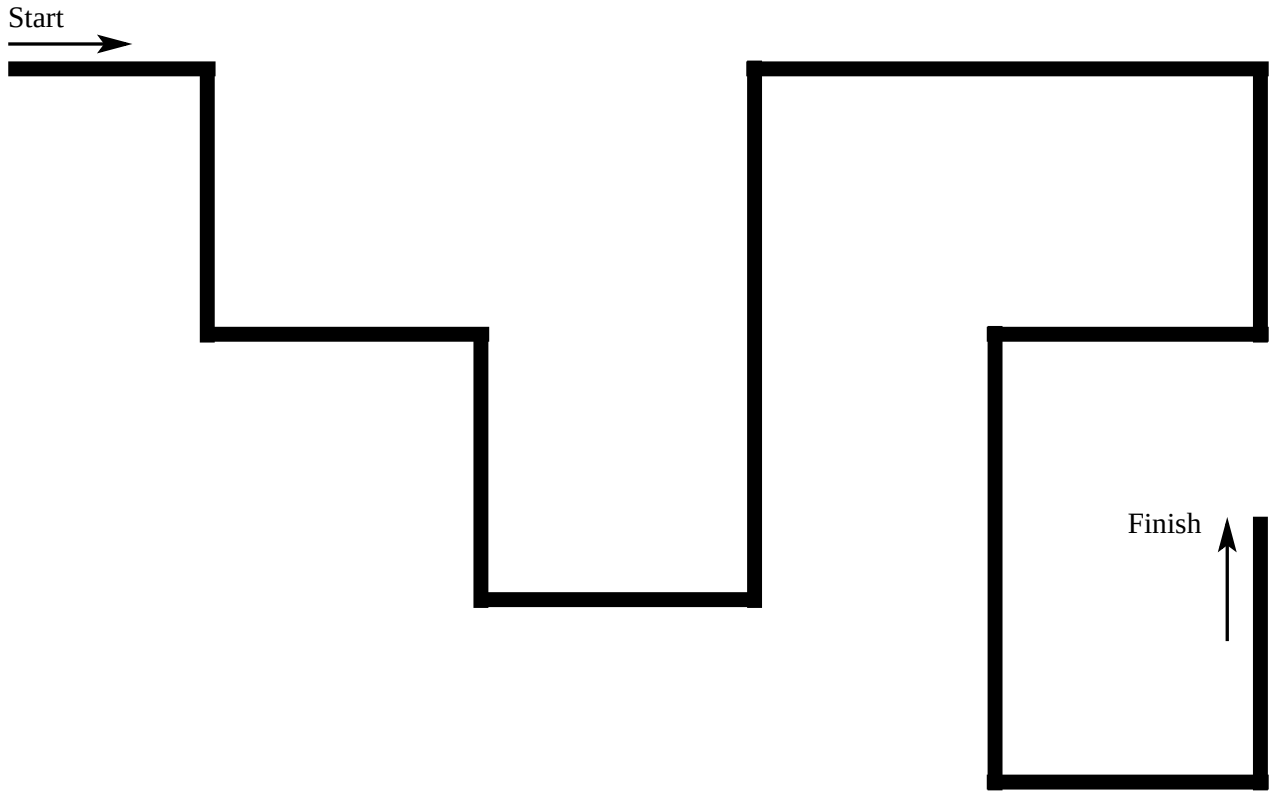

Figure 3: Benchmark Test 4 - Turn Test

9.3 Curve Tracking Test

DIP Switch : OFF OFF ON ON

The purpose of this test is to assess your robots ability to track a curved line. The field will consist of several curves with varying radii of curvatures.

9.4 Turn Test

DIP Switch : OFF ON OFF OFF

The purpose of this test is to assess your robots ability to take RH or a LH 90 degree turn. The field will consist of several RH and LH turns.

10 Pacman Avatar

This section describes the tasks for the programming part. The robot will be autonomous in a field of play which is fixed in size and granularity. It is broken into a grid of 19x15 squares. Food pellets will be distributed over this field with a maximum of one pellet per square. The primary objective of the Pacman avatar that you will create, is to consume these pellets. Three levels of difficulty are incorporated and your final mark for the project will depend on the level you have conquered. At this point, a time limit has not been set but it is reasonable to assume that we will enforce a time limit. The levels of difficulty are

Level 1 The static food pellets will be evenly distributed across the field. There are no ghosts or rewards. This is a passive, non aggressive, level and the only challenge is to complete the level within the time-limit.

Level 2 In this level, 5 pellets will be placed across the field. The location of the pellets will be given to you as list. The challenge is to make the Pacman plan a route from the current robot position to first uncomsummed pellet in list. The robot starting position will be given.

Level 3 *Note: This will be discussed in class and the specifics of this test will be based on discussions in class*. In principal, the pellets will be uniformly distributed but the ghosts are also present. If the ghost touches the Pacman, a life is lost. The number of ghosts will be restricted to three. The location of the ghosts will be transmitted on a RF link. The challenge is make your Pacman plan its motion taking into account the position of the ghosts.

11 Preferred Components

There are far too many components which can be used. We will provide to you with a set of essential components. However you will have access to the stock in the ECE Store. Please note that all components issued from the ECE store will be recorded against your ID.