THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY
Department of Electronic and Computer Engineering
ELEC 1100 Final Project

Project Demo Day: Aug 01 (Wed), 15:00-15:50, Rm2134
Project Report Deadline: **12:00noon** on **Aug 03 (Fri)**, upload to Canvas Assignment "Project Report".

This project accounts for 35% of your overall grade: demo (25%), post-demo interview (5%) and report (5%).

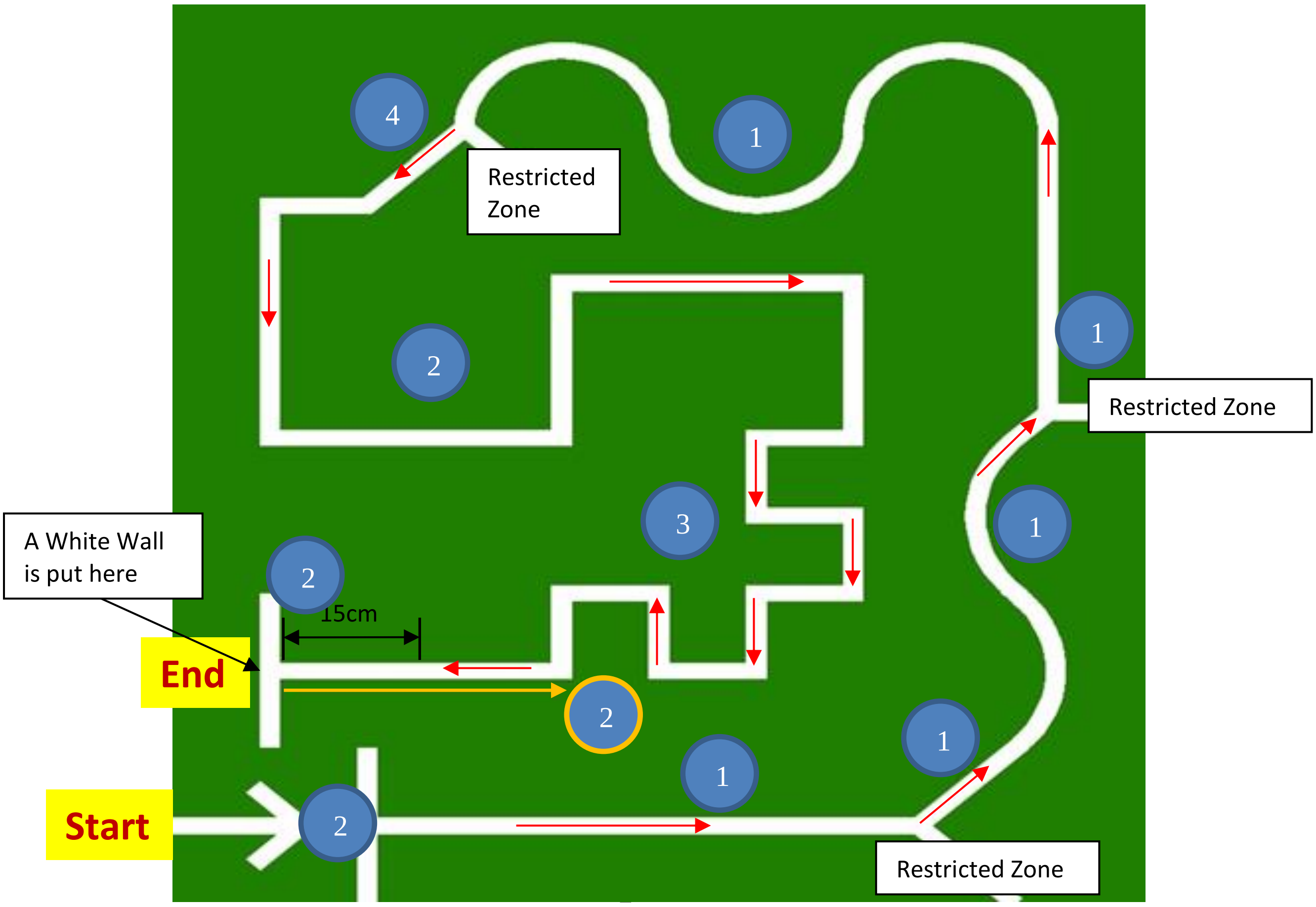
A) Objectives

- Put together your works from Lab01 to Lab06 to design a vehicle that can navigate through an obstacle course. Learn and practice the **art of debugging** and **teamwork**.
- **Write a final report** to summarize your work in building the vehicle. Each group needs to hand in one report.

B) Introduction

By now, you have learned many important concepts and techniques needed to build an autonomous vehicle. For the final project, you will optimize your design and enrich your Arduino code by adding conditional execution to tackle the final design challenge.

In the final project, your vehicle has to move on an obstacle course from Start to End, and move backward and stop at right angle corner after sensing the white wall. The course is a white line on a green surface with several challenging stretches. Below is a picture of the final course. The proportions and dimensions may not be on scale but it should give you an idea of how the real course looks like.



C) Rules for the Final Project

- About your vehicle:
  - You may use **up to 4 line sensors** (including one sensor used as a **bumper sensor** to sense the white wall). The placements of these sensors will be **up to you**.
  - You will be provided with a rechargeable battery (max. ~12.6V). You are responsible for charging the battery for running your tests. Read the document about using and charging the battery carefully ("Supplementary_2018su", pages 1-5).
  - You can only use the given breadboard & Arduino-Nano board for the project.

- During your demonstration:
  - Show clearly the **group number** on the breadboard to your TA.
    - Each team has **2 trials**. (Each team is allowed to test their car **once** on the assigned mat before the official trials, and the test will not be graded).
  - Touching the Restricted Zones or going out of the track will be regarded as failure, and you may select to resume from the point where you failed, **at the cost of the failed task score & perfect run score**, or start from the very beginning as **the next trial**.
  - Only three things can be changed on your vehicle between trials:
    - Sensor position
    - Variable resistor setting or PWM setting
    - Battery (if it is clearly needed)

  Your project demo score will be the **highest score** from the **two** trials.

- After the demonstration:
  - You will have a post-demo interview where your TA will ask you several project-related questions, including the contribution of each group member.
  - **Warning**: If the students' contribution ratio is too imbalanced, the lower contributed student may receive a mark penalty in demo score.
  - After post-demo interview, dis-assemble the car immediately.

D) Points Awarding Scheme for the Final Track Demo

Task No.	Task	Points
i	Start running after the wall sensor is triggered	2
ii	Straight Line	1
iii	Navigate the 1st Left Split	1
iv	Gentle Curves I	1
v	Navigate the 2nd Left Split	1
vi	Gentle Curves II	1
vii	Navigate Right Split	4
viii	Right angle Curves I (finish all 6 right angles)	2
ix	Right angle Curves II (finish all 10 right angles)	3
x	Move Backward from the wall	2
xi	Stop after move backward to right angle corner	2
xii	Perfect Run (all above, no failed tasks)	3
xiii	Time (finish each trial within 35 seconds)	2
	Total	**25**

Notes: <u>Video-recording of your project</u>

You may **use pre-recorded video** if you are not satisfied with the performance of your vehicle during your demonstration. Your video should show your vehicle moving from the starting point non-stop up to any point of the track. However, any grades given by videos will be **halved**, i.e. if the video shows a perfect run, your grade will be 25/2 = 12.5.

If you DO decide to use pre-recorded video for evaluation, **let us know** about your decision **at the end of the demonstration.** Also, follow the rules below:

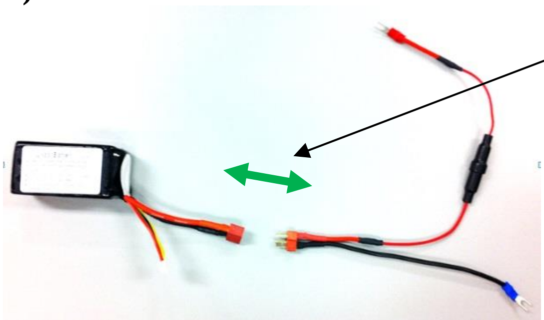
(a) Show clearly the group number on the breadboard in the video.
(b) Show clearly the IC connections on the breadboard in the video.

To protect your own interest, <u>it is recommended</u> that all students take a video-recording before the day of demonstration.

E) Debugging Strategies

- You must design, discuss, debug and work with your partner. It's teamwork!
- If your circuit does not work, instead of giving up, learn how to debug efficiently. Use your multimeter to check the signals at different parts of the circuit. For example,
  - Check the power supply applied to the breadboard: You should have a 12V voltage source and a 5V coming out from your voltage regulator.
  - Check your sensor output voltages: Could the sensors be damaged?
  - Check your motors. Connect the motors directly to the power supply to see if the motor itself is faulty. If the voltage levels are too low, charge the batteries.
  - A quick way to detect your problem: Back-tracking. If a particular signal is faulty, do the following:
    a) If the signal is connected to something else, disconnect them. If the signal returns to normal, then there is something wrong with those connections. Otherwise, go to step b).
    b) If the signal itself is faulty, check the IC that provides that signal. Check its power, ground, and inputs. If one of the inputs is faulty, return to step a) for that input. If the power, ground, and inputs are correct, but the output signal is faulty, then the IC could be damaged.
    c) Fix the errors according to your observations in step b). Be reminded that "floating" signals (signals that are at the middle, e.g. 2.5V) are usually a sign of damaged ICs or shorted outputs. Also, ICs that are very hot usually indicates that it is damaged. If you suspect that an IC could be damaged, go to step d).
    d) To check whether an IC is damaged, disconnect the IC from the rest of the circuit (ideally, put the IC on an empty part of your breadboard). Connect the power and ground, and some inputs (ideally not the output of another IC), then check if the output is correct.
  - Hold the vehicle away from the ground, so that it turns in mid-air. It allows you to check your logic part easily by changing the sensor inputs by, for example, covering them with your fingers.
- Talk to your lab partner. As with programming, sometimes telling someone else how your circuit works will point out the problem to you.
- Consult the TAs wisely. Sometimes the problems come from something you do not know. However, make sure you have tried your best before consulting helpers.

F) Common Errors



Be careful!
Separate before transporting the battery

- The power from the battery terminals are not properly connected to the breadboard. The wires have plastic coating caught under the screw, so MAKE SURE YOU CATCH ONLY THE WIRE. Same for the motor terminals.
- Bad wire connections.
  Use the multimeter to measure connectivity (i.e. measure resistance). Connect the probes directly to the terminals or to the IC pins instead of to the breadboard (sometimes the breadboards can malfunction – open circuit inside the breadboard, or there can be false contacts in wire connections, so test directly the IC pins or components using the multimeter probes).
- The power and ground to the sensors bars have popped off from the breadboard.
- The height of the sensors is not appropriate.
  When a design works one minute and not the next, it is likely because the sensor height is not the optimal. You can fine tune the line sensor's variable resistor.
- The power and ground to the ICs are reversed (meaning that you are connecting 5V to the ground pin of the IC, and 0V to the power pin of the IC). If this happens for your line sensor, this will damage it!!! Though this error could have dramatic symptoms (e.g. the IC exploding), often the IC simply gets extremely hot but does not smoke. Feel the temperature of your chips to make sure they are at least hooked up in a non-destructive way.
- The chips are wired in the wrong way.
- The sensors are hooked up to the motor voltage instead of to the logic voltage.
- When ICs are reinserted onto the breadboard, the pins are shifted by one row.

G) General Suggestions

- Draw your circuit as early in the design process as possible, including pin numbers.
- Come up with a layout: decide where particular sub-circuits will be placed in the vehicle. Each sub-circuit should be placed on the breadboard in a way that it is easy to debug with the handheld multimeters, and easy to make changes to it.
- Build each sub-circuit individually (each group member can be in charge of building a specific sub-circuit). Test that each component of the sub-circuit is working as expected BEFORE connecting everything together. **NEVER just build the whole circuit and then test it - it rarely works and it is difficult to debug**.

H) Final Report (5 points):

- **Each group** must submit **ONE report** (doc/pdf) and **one Arduino sketch** (ino/txt). The deadline is **12:00noon** on **Aug 03 (Fri)**, rename the files to your Group number and upload them to Canvas Assignment "Project Report".
  - **Warning**: Your Arduino code will be examined by a similarity detecting software. Copying code from others may result in zero mark in your **demo & report** scores.

- **On the front page** of the project report, you must state **CLEARLY** the **personal contribution to the project** by each member of the group in "percentage (**%**)". The lower contributed student may receive a mark penalty in report score.
- The report, including the cover page, **must NOT exceed 6 pages** (A4-sized paper). "Presentation" and "use of English" will also be considered in the marking scheme.
- It should be a **documentation** of the design you used for the challenge so that we can **understand** your design.

Here is a summary of what you need to include in your report:

- **Introduction**
  Include a brief description of what you did. Someone not familiar with your project should be able to understand what you have done after reading your final report. You may include a photo of your final design.
- **Design**
  Here you will fully describe what you have built.
  Include the following:
  - Truth tables; describe your theory behind your design
  - Logic flow diagram; include the functions you used for coding or part of the code to explain more about your design
  - Describe the sensor placement and explain why you place them like that
  - PWM periods used to control the speed
- **Debugging Report**
  During your project, you should have encountered numerous bugs and defects in your circuit, such as bad wire connections, broken ICs, pin misalignment, and error codes on Arduino board. Describe in detail at least two cases that you encountered a bug during the project.
- **Results**
  This is your evaluation of your design performance:
  - What do you think works well in your design?
  - What works poorly? What does not work?
  - Did anything unexpected happen? How did you fix it?

  Also describe as you look back at the whole process.
  - What would you do now differently if you could start over?
  - How could you improve your design if you had more time?
  - Are there any bad decisions you have made during the project period?
- **Conclusion**
  Draw a conclusion on your final project and your experience with this robotic course.

Here is the grading scheme:

- **Content (2 points)**
  Content = Design + Results
- **Debugging report (1 point)**
  At least two bugs should be described, describe clearly what happened, how you found out the problem, how you identified the source of the problem, and how you fixed it, no less than 100 words for each bug description.
- **Arduino code (1 point)**
  Upload your Arduino code (Rename to your Group number) along with your report to Canvas.
- **Impression (1 point)**
  Includes your introduction, conclusion, writing style, etc.