Assessment Specification

EMATM0054 Robotic Systems

Teaching Block 1 2023/2024

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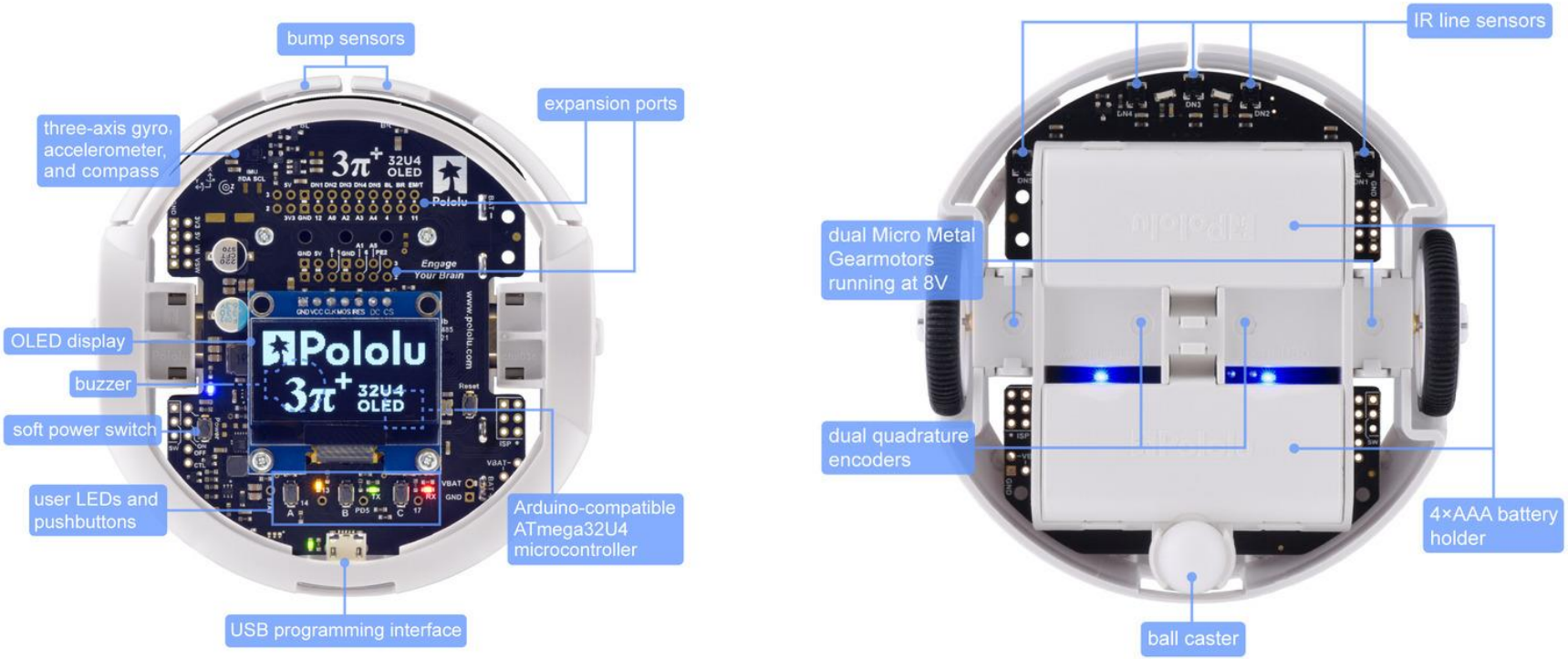
Assessment in Brief

EMATM0054 is assessed by 100% coursework split into two assessments, A1 and A2, weighted 30% and 70% respectively. The emphasis of this coursework is to prepare you to develop and conduct a scientific experiment with a robotic system, including how to report and evaluate results. The main teaching/learning mechanism of this unit is to give you direct, hands-on experience of these activities via project-based learning. You will be working with a robotic system: a Pololu 3Pi+ mobile robot. *Working with hardware takes an investment of time and practice.* The unit is split into two periods. In the first 6 weeks (weeks 1-6), you will be supported to develop fundamental skills with a robotic system. In weeks 7-11 you will be supported in self-directed study to conceive, design, conduct, evaluate and report a scientific experiment conducted with your 3Pi+ robot.

Pololu 3Pi+ Mobile Robot



Images from: Pololu Corporation, Pololu 3Pi+ product page, https://www.pololu.com/product/4975 [Accessed 24/09/23]

Assessment Structure & Rules

Assessment 1, Summative (30%), Individual basis: UoB Weeks 1-6

You must program your robot to autonomously follow a line marked out on the floor, adhering to the Assessment 1 Specification detailed overleaf (the "Line Following Challenge"). Your assessment submission must be individual work. Your code will be checked for plagiarism against all other code submissions made to the unit.

- Deadline for final submission: UoB Week 18, **Friday 3rd November2023, 1pm**. Composed of:
  - An online self-assessment form with a valid URL to a web-hosted video of your robot completing the Line Following Challenge.
  - Your final version of working code used to uploaded Blackboard.
- If your video URL is not valid, if your submitted code does not compile, or if your code cannot produce the behaviours demonstrated in your video, your Assessment 1 mark will be based solely on the achievement evidenced in your code only and by the academic judgement of the unit director.
- You must use Arduino C in programming your 3Pi+.
- You cannot attach extra electronics (e.g. sensors) to your 3Pi+.
- You are not permitted to use any external software libraries within your solution with the exception of standard C libraries (e.g. math.h) or those specified within the provided labsheets.

In a circumstance of significant disagreement of team member contribution in Assessment 2, a voce viva process will be held between the involved students and academics to determine final contribution. Your prior submission for **Assessment 1**, the **supervision meeting minutes**, and your **personal statements** will be taken into consideration to determine whether you have achieved the fundamental Intended Learning Outcomes of the unit. A lack of any evidence will not support a case (e.g., absence from meetings). These factors will be taken into consideration when exercising academic judgement to resolve any disputes and determine final mark outcome.

Assessment 2, Summative (70%), team basis: UoB Weeks 7-11

Working in pairs, your team must produce a 6-page report which details a scientific experiment conducted with your robotic system (3Pi+), adhering to the Assessment 2 Specification, detailed overleaf.

- Your team must submit a single proposal of your Assessment 2 project by UoB Week 6, Wednesday 1st November 2023 via Blackboard.
- Final Report Deadline: **UoB Week 11 Friday 8th December, 1pm.**
- All team members must each provide via Blackboard:
  - A submission of the 6-page report.
  - The working source code used for your experiment.
  - An individual personal statement on the efficacy of your role within the project and team.
- You must use Arduino C in programming your 3Pi+.
- You cannot attach extra electronics (e.g. sensors) to your 3Pi+.
- You are not permitted to use any external software libraries within your solution with the exception of standard C libraries (e.g. math.h), or those specified within the provided labsheets.
- All team members must contribute equally to the body of work.
- Your team must attend weekly supervision meetings. Attendance to supervision meetings is mandatory.
- Supervision meetings will have minutes taken. On a weekly basis, the minutes will be emailed back to you, which will include your stated current progress, goals set, and an agreed distribution of equity to reflect team member contributions.
- The mark awarded for your 6-page report will be applied equally between members, unless there is a significant disagreement of contribution.
- If there is significant disagreement of team member contribution, the supervision minutes will be used together with a viva between all team members and two academics to determine a fair outcome.

Assessment 1 Specification, Summative (30%), Individual Basis

Fictional Context:

> *"Your robot will be dropped into the ocean, it must autonomously survey the length of a pipeline, and then return to its drop-off point by the most efficient path to be recovered."*

Working with the Pololu 3Pi+ mobile robot you must program your robotic system to autonomously complete the Line Following Challenge within the following Rules.

1. The exact line map configuration is provided to on page 6, with allowed alternatives for the mid-section of the line.
2. Your robotic system should operate autonomously once started with no further handling from you, or manipulation of the environment, after you activate your robot – otherwise you will forfeit any marks from the point which have interfered. The exception is to power-cycle your robot whilst moving it to the alternative start location.
3. Components 1-5 must be fully and correctly completed before marks for Component 6 can be achieved.
4. You can collect marks for travel in only 1 direction (1 run), or 1 direction and a partial completion in the other directions.
5. Your robot should use a single general solution, which does not require any switching of mode or human-provided input at robot activation concerning map orientation. Re-programming of the robot between runs is not permitted.
    a. For example, your solution should still function if we were to switch the order of the A3 sheets, whilst keeping the general distance covered the same.
6. For **Component 6**, your robotic solution must use a kinematic estimation of it's location to take the shortest path back to the start point. This solution must comply with Rule 4 above.
7. You are not permitted to use any additional software libraries in your code for your Assessments, other than standard C libraries (e.g. math.h), or those specified within labsheets.
8. You are not permitted to use any extra electronics fitted to the 3Pi+, for example sensors or wireless transmitters.

Marking Criteria

The Line Following Challenge map is illustrated on the next page. This can be printed in A3 sections, available on GitHub and Blackboard. These components will be scored to sum to a mark out of a total of 100, where you complete two travels of the map, where you robot must start from each start box:

	Component:	**Marks**
1	Leave start box, join line:	5
2	Traverse Corners:	5
3	Traverse Curve:	5
4	*Mid-section, one of:*	
a	Traverse 20cm Gap:	5
b	Traverse Intersection:	12
5	Correctly Identify End-Point of Line:	5
6*	*Return Home, one of:**	
a	On A3 page, behind Line course	4
b	Overlapping Start Box	9
c	Within Start Box	18

* Scoring in Component 6 is only available when Components 1-5 are all completed successfully.

The components will be discussed heavily throughout the teaching block. If you have any questions, please raise these with the teaching staff.

Assessment 1 Example Marking

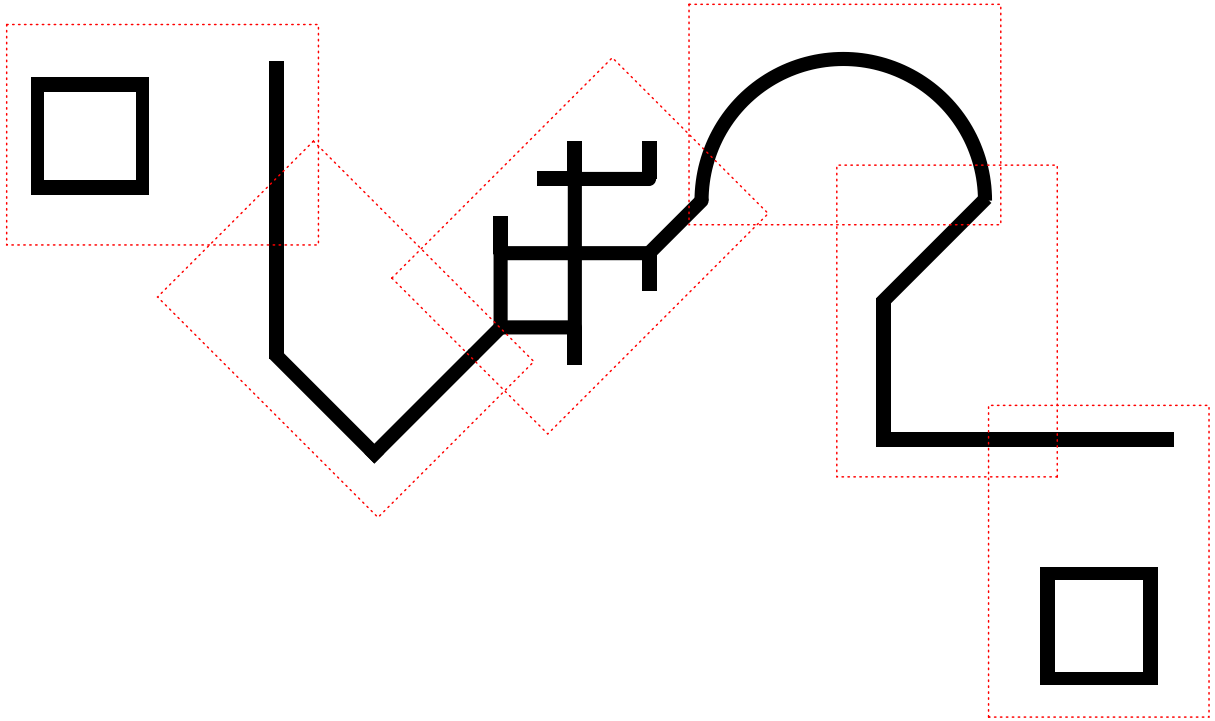
	Component:	Marks	Example A Run 1:	Example A Run 2:	Example B Run 1:	Example B Run 2:	Example C Run 1:	Example C Run 2:
1	Leave start box, join line:	5	5	5	5	5	5	5
2	Traverse Corners:	5	5	5	5	5	5	5
3	Traverse Curve:	5	5	5	5	5	5	5
4	*Mid-section, one of:*							
a	Traverse 20cm Gap:	5	5	5			5	5
b	Traverse Intersection:	12			12	12		
5	Correctly Identify End-Point of Line:	5	5	5	5	5	5	5
6*	*Return Home, one of:**							
a	On A3 page, behind Line course	4				4		
b	Overlapping Start Box	9			9		9	9
c	Within Start Box	18						
			Sub Totals:					
			25	25	41	36	29	34
			Final:	**50**	Final:	**77**	Final:	**68**

Example A: The student has completed Components 1,2,3 4a and 5, on Run 1, and Components 1,2,3 4a and 5 on Run 2 - where their robot demonstrated this starting from each start box. Their final mark is 50%.

Example B: The student has completed Components 1,2,3,4b, 5 and 6b on Run 1, and Components 1,2,3,4b, 5 and 6a on Run 2 - where their robot demonstrated this starting from each start box. Their final mark is 77%.

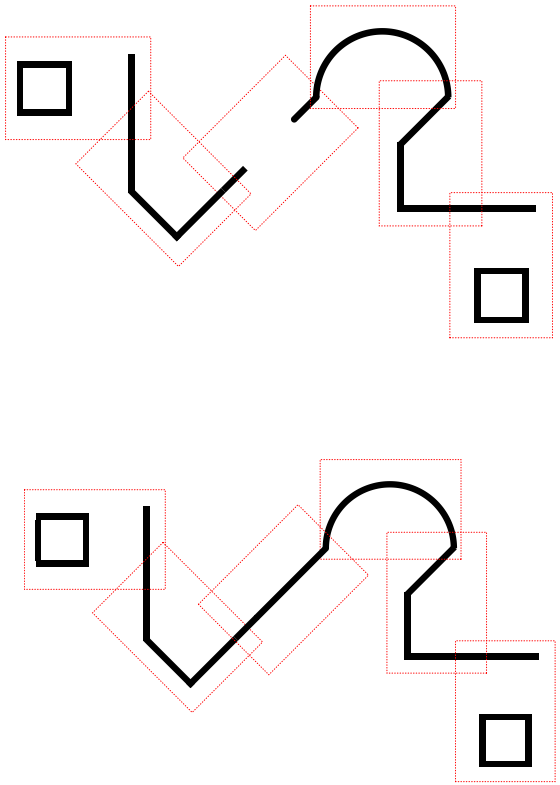
Example C: The student has completed Components 1,2,3,4a, 5 and 6b on Run 1, and Components 1,2,3,4a, 5 and 6b on Run 2 - where their robot demonstrated this starting from each start box. Their final mark is 68%.

Map Specification



The Line Following Challenge Map is provided to you as a set of A3 Printable Sheets. These are available to download from Blackboard and GitHub. The placement of these sheets is illustrated above, where red-dashed lines indicate the A3 Sheet boundaries.

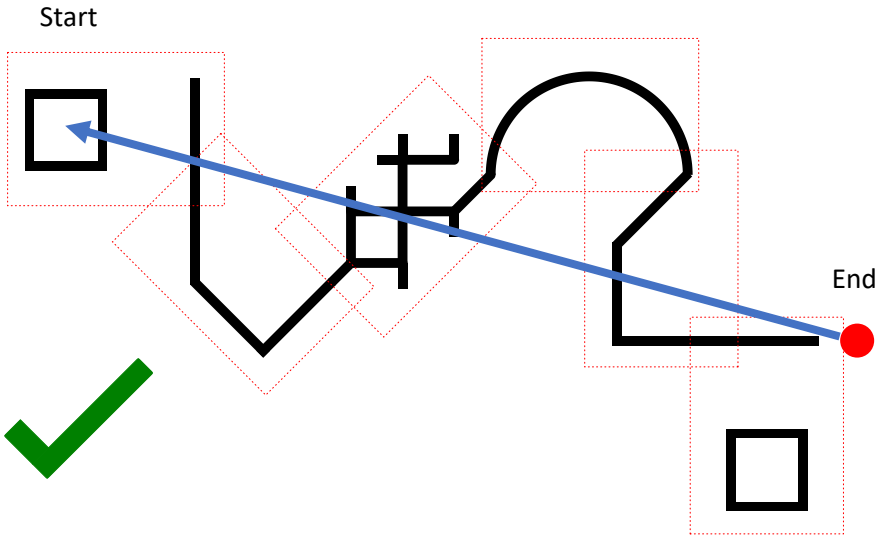
- Your robot must start and be powered on within the square box.
- The placement of the A3 sheets must take the same form as above.
- You can use black vinyl tape (electrical tape) provided to you to bridge small joins in the line, or fold or cut the edge of a sheet of paper.
- You can place extra blank white sheets to create a larger white surface if



If the “intersection” cannot be completed, this can be substituted with either the A3 sheet “Gap_20cm.pdf” or “StraightLine.pdf”, as illustrated above. Marks will be awarded following the Specification & Rules (see page 4). Using the “StraightLine.pdf” will mean no marks for component 6 can be achieved.

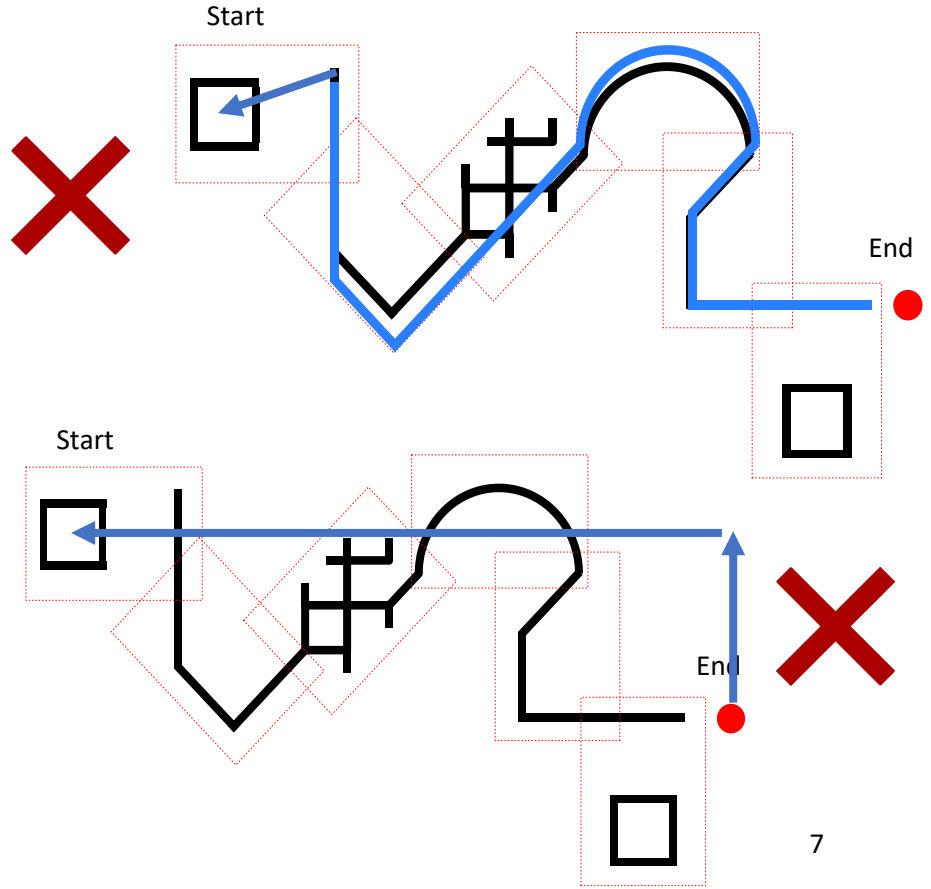
Return Home Requirements

Your robotic solution should attempt to make the most direct path back to the start box using a kinematic method of location estimation. Your robot can deviate from this path to a reasonable degree, where a straight-line path is clearly the intention.



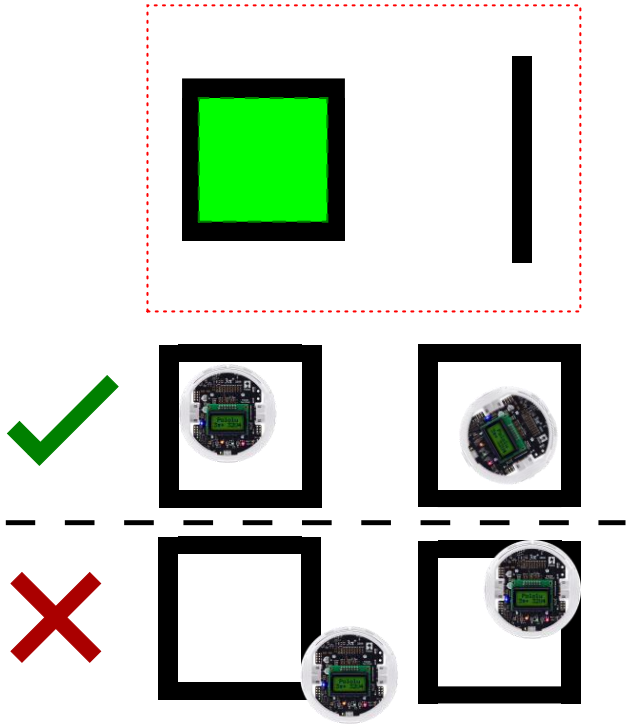
Your robotic solution <u>cannot:</u>

- retrace the line path back to the beginning to then re-enter the start box.
- Travel along orthogonal directions, or an otherwise clearly inefficient path.
- Use any extra markers or cues placed onto the map or into the environment.

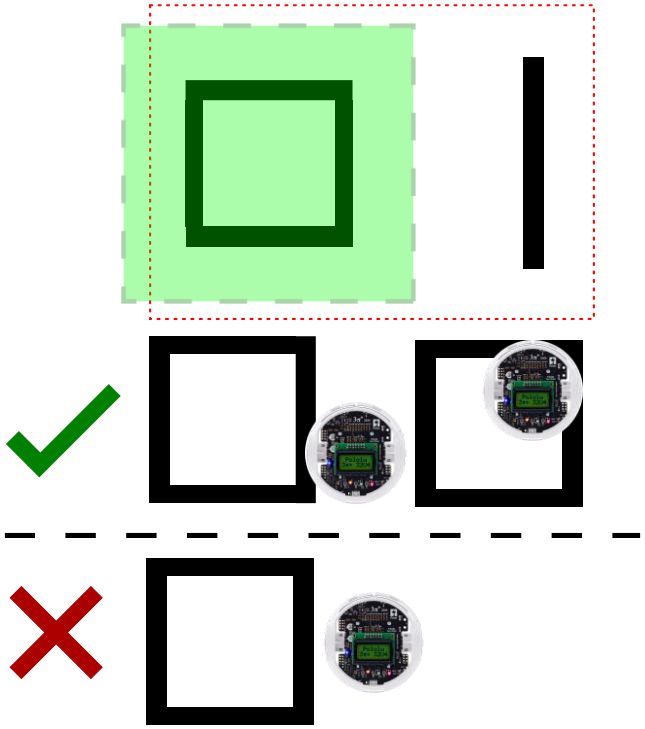


Return Home Marking Criteria

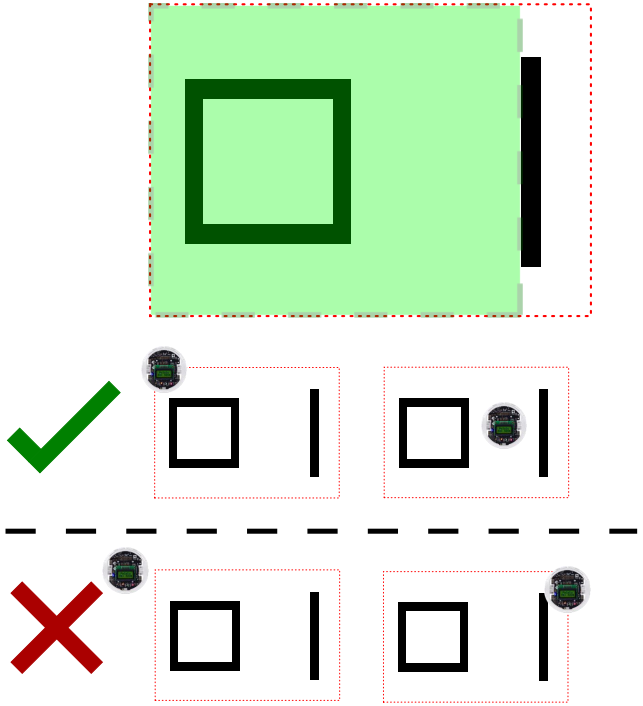
9 a: [18 Marks] Stopping fully within the start box, with no part of the robot touching the edges. This must be made clearly visible in your video.



9 b: [9 Marks] Stopping with any part of the 3Pi+ robot overlapping with the start box square. This must be made clearly visible in your video.



9 c: [4 Marks] Stopping any part of the robot on the A3 page, but behind the line course and with no part of the robot touching the line course.



Assessment 1 Video Requirements

For Assessment 1, you are required to provide video evidence of the performance of your final solution for the line following challenge. This will be compared against the code you submit via Blackboard, which must be the same code producing the performance captured via video.

The following rules and requirements apply:

1. The video must be a single-take, with no editing. For example, if you capture your robot traversing the line in both directions, do not stop the video or edit-out when you pick up and relocate your robot.
2. Do not handle your robot until it has finished. If you handle your robot during it's autonomous operation you will forfeit all marks from that point onwards.
3. At the beginning of your video, you must capture your Student ID card, and the writing must be legible. It is recommended you place your Student ID card with your numbered kit box, as demonstrated in the example video (https://www.youtube.com/watch?v=vdM5BzcTyUw). You must capture the ID number your kit box at the start of your video, which you will have registered at the start of the teaching block.
4. Your robot should remain visible within the video at all times – do not allow the video to leave the picture.
5. Your video must provide clear observation of your robot at all times. For example, Component 6c requires the robot to stop fully within the start box boundary – if your video ends with your robot still moving, or if it is not possible to see if the robot is clearly within the start box from all angles, you will not achieve these marks.
6. Your 3Pi+ must be untethered – that means not plugged in via USB.
9. If you are not attempting Component 6, your robot must clearly stop when for Components 5 (Identify the end of the line). If attempting Component 6, (Return Home) your robot must clearly stop before your video is finished. Therefore, your video should not end abruptly, but give enough time to view the robot at a complete halt.
10. When activating your robot, use only the Power On/Off button. The use of other any other buttons will compromise Rule 5 (page 4) *"Your robot should use a single general solution, which does not require any switching of mode or human-provided input at robot activation concerning map orientation. Re-programming of the robot between runs is not permitted."*
7. If your submitted code does not compile, or your code cannot produce the behaviours demonstrated in your video, your Assessment 1 mark will be based solely on the achievement evidenced in your code only and by the academic judgement of the unit director.
8. If the URL you provide to your video is incorrect, unavailable or inaccessible, your Assessment 1 mark will be based solely on the achievement evidenced in your code only and by the academic judgement of the unit director.

Assessment 2 Specification, Summative (70%), Team Basis

Using the skills you have developed in Assessment 1 through weeks 7-11, you must identify a scientific experiment to conduct with your robotic system. You should draw on your critical insight of robotic systems to form a hypothesis, to demonstrate via the analysis of collected results, of either:

- An improvement to the robotic system operation from a baseline level of autonomous operation.
- A proof of an underlying characteristic, phenomenon, or principle of a robotic system and its consequence on autonomous operation.

Your ability to conceive of a scientific experiment, to conduct the experiment, and to communicate the results is representative of the depth of your understanding of a robotic system, allowing you to demonstrate skills of analysis, evaluation and synthesis.

Your experiment should be designed such that the body of work is reproducible and repeatable via a robust implementation and experiment methodology. The conclusions you can draw and the insight you can articulate will be underpinned by the credibility of the results presented. The value and significance of your work should be reflected in the introduction where context is provided, and in the analysis, evaluation and conclusion of your study.

These elements will be assessed by the evidence provided in your team submission of a 6-page report in a conference style. A template of a report is provided which also contains guidance.

Working in pairs, your team must produce a 6-page report which documents a scientific experiment conducted with your robotic system (Pololu 3Pi+). Your report must be based on and include data retrieved through empirical study of your robotic system. Your report should effectively communicate:

- the problem/challenge/hypothesis under investigation, and why it is significant.
- the experiment methodology designed and used as suited to the investigation.
- a discussion of metric(s) selected to evaluate your data and robotic system in context.
- clear presentation of results captured from your robotic system, and their analysis and evaluation.
- a conclusion and/or discussion, drawing from the methodology and results presented, including a brief evaluation of the study.

Assessment 2 Criteria:

Your report will be assessed with consideration to the following unit criteria and general University marking criteria and scales. Feedback will be provided addressing the same criteria where appropriate.

Criteria	Weight
Aims & Objectives (e.g., the "what"): - Identify relevant investigation - Realistic & challenging aims - Situation of topic within robotics - Appropriate technical difficulty	0.1
Context of work (e.g. the "why" / "value"): - Problem/research area is discussed so value is clear - Ability to meaningfully decompose a problem - Relevant literature when appropriate - Critical assessment of problem/research area.	0.2
Scientific Argument (e.g. "how" / "academic"): - Development and coherence of argument and/or proposal made. - Clearly stated hypothesis or research questions. - Evidence of synthesising reasoning and understanding. - Comparative analysis between project outcome and initial proposals. - Evidence of the ability to evaluate information and synthesise conclusions. - Correctness of work presented and evaluated.	0.25
Research/Experiment Method (e.g. "how" / "practical"): - Sufficient level of detail in documentation for reproducibility of the work. - Appropriate selection of methods, quantitative and/or qualitative. - Identification of appropriate techniques to gather and analyse credible data. - Appropriate quantity and quality of data captured. - Discussion of limitations and advantages of methods and/or metrics, impact on study. - Evaluation and interpretation of discoveries / anomalies in results with respect to the hypothesis.	0.25
Evaluation and Accomplishment (e.g., the project as a whole): - Critical appraisal of the project and process throughout - Achievements, reflections on shortcomings of the project in relation to explicit aims. - Realistic outline of further work (e.g., from what was learnt)	0.1
Report Presentation: - Logical structure, clarity of presentation. - Conformity to style (academic presentation of work) - Quality of writing, spelling, grammar, diagrams and figures. - Clarity of the use of English - Appropriate communication to audience. - Citation: Sufficient, Appropriate; accuracy, consistency, completeness.	0.1

Grade	0-20 point scale	0-100 point scale	Criteria to be satisfied
A	20 19 18	100 94 89	➢ Work would be worthy of dissemination under appropriate conditions. ➢ Mastery of advanced methods and techniques at a level beyond that explicitly taught. ➢ Ability to synthesise and employ in an original way ideas from across the subject. ➢ In group work, there is evidence of an outstanding individual contribution. ➢ Excellent presentation. ➢ Outstanding command of critical analysis and judgement.
	17 16 15	83 78 72	➢ Excellent range and depth of attainment of intended learning outcomes. ➢ Mastery of a wide range of methods and techniques. ➢ Evidence of study and originality clearly beyond the bounds of what has been taught. ➢ In group work, there is evidence of an excellent individual contribution. ➢ Excellent presentation. ➢ Able to display a command of critical analysis and judgement.
B	14 13 12	68 65 62	➢ Attained all the intended learning outcomes for a unit. ➢ Able to use well a range of methods and techniques to come to conclusions. ➢ Evidence of study, comprehension, and synthesis beyond the bounds of what has been explicitly taught. ➢ Very good presentation of material. ➢ Able to employ critical analysis and judgement. ➢ Where group work is involved there is evidence of a productive individual contribution.
C	11 10 9	58 55 52	➢ Some limitations in attainment of learning objectives, but has managed to grasp most of them. ➢ Able to use most of the methods and techniques taught. ➢ Evidence of study and comprehension of what has been taught ➢ Adequate presentation of material. ➢ Some grasp of issues and concepts underlying the techniques and material taught. ➢ Where group work is involved there is evidence of a positive individual contribution.
D	8 7	48 45	➢ Limited attainment of intended learning outcomes. ➢ Able to use a proportion of the basic methods and techniques taught. ➢ Evidence of study and comprehension of what has been taught, but grasp insecure.
E	6	42	➢ Poorly presented. ➢ Some grasp of the issues and concepts underlying the techniques and material taught, but weak and incomplete.
	5	35	➢ Attainment of only a minority of the learning outcomes. ➢ Able to demonstrate a clear but limited use of some of the basic methods and techniques taught. ➢ Weak and incomplete grasp of what has been taught. ➢ Deficient understanding of the issues and concepts underlying the techniques and material taught.
	1 - 4	7 - 29	➢ Attainment of nearly all the intended learning outcomes deficient. ➢ Lack of ability to use at all or the right methods and techniques taught. ➢ Inadequately and incoherently presented. ➢ Wholly deficient grasp of what has been taught. ➢ Lack of understanding of the issues and concepts underlying the techniques and material taught.
0	0	0	➢ No significant assessable material, absent, or assessment missing a "must pass" component.