1. **Introduction**
The objective of the design and build project is to gain an insight into design principles, together with prototype manufacture and testing. This will be achieved by the student teams operating in competition, to design, build, and test an autonomous roving vehicle. At the completion of the project it is hoped that the participants will be familiar with the constraints of working to budget, interpreting and meeting specifications, project management, and the demands of a development programme. This project is worth 85% of your overall mark for the module.

More detailed learning outcome information can be found here: https://secure.ecs.soton.ac.uk/module/1819/ELEC2209/38700/syllabus

2. **Background**
The teams have been tasked to develop a range of designs for a reliable sample retrieval vehicle that are both low cost, and require minimal technical support to operate. The design must be based on a specified servo and the “Il Matto” low power 8 bit microcontroller board that each student built and used in year 1.

3. **Project Objective**
The objective is to design, build and develop an autonomous roving vehicle capable of safely carrying a container of material. The vehicle has to be designed to travel a pre-defined path within the specified area.

The criteria placed on teams for satisfactory completion of the project are:

- To ensure that the vehicle follows a reflective track laid on a smooth surface. The vehicle is not permitted to follow the wall. If contact with the wall is made, immediate action must follow to relocate the guide track.
- The vehicle is to reverse after crossing a specified point. A reflective strip will be placed at 90° to the main reflective guide strip at this point. The marker strip will be the width of the track. To complete the trials the vehicle must change direction three times.
- To climb and descend slopes of 5%.
- To maximise the speed of the vehicle, subject to satisfactory path following and safe operation.
- To ensure the container is not dropped during transit.

4. **Design Constraints.**
- The design must be based around only one “il Matto” microcontroller board. Teams will be expected to build additional electronic circuits to interface with this existing board.
- The sample container is a cylinder 115 mm long and 65 mm in diameter. The approximate weight will be 600gms.
- No communication is allowed with the vehicle once it is within the environment.
- The vehicle together with its load must not exceed 160 mm in height, width or length. No part of the vehicle or any of its sensors is permitted to violate this boundary – this includes loose wiring. The track will in all probability incorporate obstacles, these cannot be negotiated if the vehicle is oversized.
• During normal operation the vehicle must cause no damage to the track or the reflective track. Sliding contact between the reflective tape and vehicle is not permitted.
• The vehicle will not be expected to pick up the sample container.
• A red flashing beacon will indicate that the vehicle is located on and following the reflective track and mounted to the back of the chassis using a plastic acrylic sheet, cut using the laser cutter. A second continuous flashing beacon (not red) will be located at the front of the vehicle again using a plastic acrylic sheet.
• The design requires the minimum use of machined components. No mechanical workshop is available to the project team. The vehicle must be constructed using portable hand tools. Teams will not be allowed to start construction of the Rover until they have provided evidence that they possess the practical skills required to build a working prototype. This will be achieved through completion of a three hour laboratory exercise (The live wire detector) details can be found on https://secure.ecs.soton.ac.uk/module/1819/ELEC2209/38700/resources. This work can start immediately after the first lecture by gaining access to the construction lab via Technicians Barry Bailey or Richard Howell (All construction work should use tools available in Lab 2, The Arthur Brunnschweiler Teaching Laboratory (ABTL), Level 2, Zepler Building). If there are too many students trying to gain access at the same time then a fair time tabling will be achieved via the Technician staff.
• The chassis must be constructed from aluminium sheet.
• The sample container must be carried in a holder attached to the chassis and made from plastic materials using a 3-D printer (additive manufacture). No other parts of the design can be constructed using 3-D printing methods. Teams will only be allowed to make two designs; one prototype and a final version.
• All vehicles MUST be clearly identified with the Group Letter, which will be allocated at the start.
• The cost for all parts per vehicle should not exceed £25.00, this does not include costs for metalwork and plastic which will be provided.
• The Module Supervisors reserve the right to vary the specification.

Each group is required to submit their vehicle for a competitive trial. during week 15 of semester 1 (7 - 11 January 2019). The following rules will apply:

• The direction of travel on the test track will be decided by the toss of a coin prior to the trials.
• All vehicles will be subject to weight and size scrutiny prior to competition.
• Disqualification will occur if the vehicle uses the top edge of the track wall or the track wall as a guide, loses its load, or leaves the trial environment.
• The vehicle will be disqualified if any member of the team aids its travel. The only exception is within a predefined starting area.

5. Academic involvement

Each group is allowed a maximum of three consultations with members of the academic staff during the project. The consultation is an opportunity for project teams to receive guidance, demonstrate (at their own discretion) progress, understanding and their approach to problem solving. In addition, there will be 3 formal timetabled project reviews, these are not considered as consultations as they will constitute part of the formal assessment of the project.

• The first formal project review will take place in week 3 of semester 1 (Tues 16th Oct 2018). No construction or expenditure may be undertaken prior to this review. The group will be required to make an appointment for the review via a signup sheet; each review is 25 minutes long and will be strictly timed. At the review each group will provide evidence that they have the practical skills to meet the requirements of the project (i.e. 2 working live wire detectors and one page review of the lessons learnt from the exercise by the group). Then they will
make a brief presentation of their design studies (~10mins). A 4 page document including preliminary design sketches, plan/flowchart for microcontroller program, time plans, and budget details should also be submitted to the member of staff undertaking the review; to be read after the review and feedback to be provided via email. Following a satisfactory review, written permission to proceed will be issued. If the review is unsatisfactory, a resubmission will be required.

- A second formal review will take place during week 6 of semester 1 (Tuesday 6th November 2018); teams are required to submit a working chassis for inspection. The chassis will be required to travel a distance equal to the length of the track under its own power. There should be evidence that the microcontroller is able to control the steering mechanism e.g via a servomechanism, speed controller etc.. (e.g a demonstration program that moves the servomechanism output shaft between a number of fixed positions, it does not have to be mounted on the chassis at this point).

- A detailed design study for the control system that will be implemented must be submitted (all documentation is to be submitted via the SEMS group Secretary Office, Level 2 Building 1) by noon on 23rd November 2018 (Week 8). This should include: Controller Pseudocode, Engineering drawings of the final rover, Final report introduction sections and an Expenditure review. This should be of sufficient detail and length to be included in your final report. Feedback will be provided via email.

- A third review will take place during week 9 of semester 1 (Tuesday 27th November 2018); teams are required to submit a chassis for inspection that incorporates the microcontroller and working sensors. The team will be required to demonstrate the operation of the sensing circuit and a basic microcontroller programme.

- The final trials of the fully operational rovers will be during week 15 in semester 1 (week commencing 7th Jan 2019) it is aimed for Tuesday 8th January but because the track needs to be laid out in full in the main lab it will depend on availability nearer the time.

- A final submission of logbook, report and rover is due by noon on Friday 11th January 2019 (Week 15).

Discussions between the teams and supervisors are in the public domain, unless an individual group make specific arrangements.
Details of the reviews and assessment are given in the appendix of this document.

6. Material for Assessment
The details of the material required for the assessment of the teams and individual members, together with the times of submission are as follows:

- Satisfactory submission of material (reports, logbooks) at the three-benchmark reviews.
- Submission of a vehicle for the formal competitive trial. The conduct of the trial is detailed above.
- All team members are to keep a personal logbook, which is to be submitted no later than noon, Friday week 15, semester 1 (11 Jan 2019). The following additional points must be noted:
  - The logbook must be of A4, hard cover format – official University of Southampton logbooks will be supplied and only these can be used.
  - The logbook must be used for no other purpose than for this project.
  - No pages are to be torn or otherwise removed from your logbook.
  - Any additional material must be securely glued or stapled to the pages in the logbook, any loose paper will not be considered for assessment.
- The logbook must be presented at each review for validation. Failure to comply will result in a poor individual performance mark.
It should be noted that the logbook is the primary individual record of the project, and is considered to be of considerable importance to the examiners. In the industrial environment it can constitute a primary document in any legal action. It should be noted that a diary is not required, but an action-by-action record of your involvement in your teams’ activity. It is expected to see crossings out, mistakes, lines of approach eventually discarded etc. Entries should be dated clearly.

Each team requires two copies of the final formal report to be submitted no later than noon, Friday week 15, semester 1 (11 Jan 2019). The main body of the report should follow a standard technical document format (e.g. introduction, aim, method, results, conclusions, etc.) and must not exceed 3000 words. However any group previously published material should be included in the appendices. The report should contain information on the vehicle’s operation, operating instruction, management of the project and full budget details. The minutes of formal meetings and full accounts are to be attached as an appendix to the report.

The vehicle, together with all unused components, should be submitted no later than, noon, Friday week 15, semester 1 (11 Jan 2019). All items must be clearly identified.

7. Conduct of the project
   • The group is responsible for resource management. Each group is free to manage the project as they wish but a Chairman and a Secretary are to be appointed for administrative purposes. Minutes should be kept of all formal meetings, these should be concise and should detail any action required by group members.
   • All practical work is to be carried out in Lab 2, The Arthur Brunnschweiler Teaching Laboratory, Level 2, Zepler Building, if required a timetable showing when access is allowed will be issued in due course. No work in the laboratory may be undertaken outside of normal lab working hours (9-5pm weekdays).
   • It is the responsibility of the groups to familiarise themselves with the current regulations for working in the laboratory, and the safe operation of any equipment.
   • It is the responsibility of the team to ensure that the design complies with current Health and Safety at Work requirements.

8. Financial matters
The overall budget for each group is a maximum of £25.00.

The budget will be allocated as follows:
   • The initial review will allow you to claim payment to 66% of the total budget
   • Release of the final 34% of the budget will depend on satisfactory completion of the final review. Money may be committed over the 66% mark prior to this review, but it is at the teams own risk

No form of private sponsorship or funding is permitted. This sum is to cover all components, and consumables. Standard aluminium sheet used for the chassis construction will be provided, as will 3D printing and laser cutting materials and costs.

Any expenditure over this figure is the liability of the group. ECS will stop all orders if a team’s budget’s is exceeded. Any overspend will have a significant detrimental effect on the group’s overall assessment.

It is the responsibility of the group to ensure the VAT at the current rate has been included in the budget when components are ordered.

Procedure for Ordering Components.
   • Components should be purchased against an order. Details for the component purchase will be given to the teams once their design has been approved for manufacture, using the specified ECS
paperwork.

- If components are to be obtained privately, any request for payment MUST be accompanied by the supporting receipts, and a **requisition form signed prior to obtaining the component**. Teams are expected to consolidate requests for payments on a monthly basis. Any request for payment must be countersigned by the supervisor. A credit card slip is not considered to be a receipt.

The final report should be produced by the group using the computers in the University or by other means. Your budget does not include any allowance for secretarial support. The photocopying cost is to be found from the budget. Binding is to be in covers supplied by the Student Office, Ground floor, Zepler Building.

Dr Russel Torah
28 September 2018

ps Official world record (one lap of the track)
Group B 2012/13 11.63 Seconds
<table>
<thead>
<tr>
<th>Activity</th>
<th>Date</th>
<th>Location</th>
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| 1        | 2nd Oct 2018 | B13-Room: 3021 | Briefing  
Group Allocation  
Introduction to system design | Two fully functioning Live Wire Detectors  
One page review of the exercise |
| 2        | 2 October 2018 – 16 October 2018 | Lab 2 ABTL, Bld 59, Lvl2 | Live Wire Detector Exercise – Each group to contact Barry Bailey in the Lab for training session | |
| 3        | 5th Oct 2018 9th Oct 2018 | Lab 2 ABTL, Bld 59, Lvl2 | Training for 3D printing  
(Additive manufacture) and laser cutting | Live Wire Detectors + 1 page review  
Proof of manufacturing ability  
4 page report containing:  
- Initial Rover design sketches  
- Il Matto program concept  
- Team roles and time plan  
- Preliminary Rover costing |
| 4        | 16th October 2018 | B13-Room: 3021 | First review | |
| 5        | 6th November 2018 | B13-Room: 3021 | Second review | Manufactured chassis  
Flow diagram of controller  
Evidence of steering control |
| 6        | 23rd November 2018 | Secretarial Office, Bdg 1, Rm 2013 | Submission Review Material | Controller Pseudocode  
Engineering drawings  
Final report introduction  
Expenditure review |
| 7        | 27th November 2018 | Lab 2 ABTL, Bld 59, Lvl2 | Third Review | Vehicle capable of following track in one direction |
| 8        | w/c 7 Jan 2019 | Lab 2 ABTL, Bld 59, Lvl2 | Trials | Working vehicle |
| 9        | 11 Jan 2019 | Student Hand-in office | Final submission date | Working vehicle  
Two copies of the report  
Individual logbooks |