School of Engineering/ College of Systems and Society

Rover Project Overview

This document explains the details of the major group project to be completed during Discovering Engineering. The project is to design and build a vehicle called a rover to achieve a set of clearly stated goals and be able to autonomously navigate a maze. Throughout the course students will be taught a variety of technical and design skills needed to complete the project. They will also be provided with components which can be supplemented with additional parts and found items within a $20 budget.

This document outlines the details of the project including the goals to be completed, the rules, testing process and the resources available to complete the project. It also provides details of the assessment associated with the project and the team member contribution (TMC) assessment relating to this project. In addition to this document students should also view the Rover Design Report, and the Rover Milestone specifications.

Contents

Project outline

In a group of three to four students you will work together to design and build a vehicle that can autonomously navigate an unknown maze. To achieve this your vehicle or rover will need to be able to achieve the specific goals listed in Table 1. Over the semester you will be provided with the materials and training in the skills required to do this and access to the test maze. Your team will also be able to purchase components to a maximum combined value of $20 (funded by the group).

You are encouraged to follow the simplified ANU systems engineering process (ASEP) to complete your project. To help your group keep on track, there are several small group deliverables, known as Rover Milestones, spaced throughout the semester that correspond to different parts of the ASEP. Milestone submissions will include prototypes, and several working documents designed to help teams plan and execute their projects. These documents provide the foundation for final testing and support comprehensive documentation of the systems engineering process in the final design report. The final testing will assess the ability of your rover to achieve the goals listed below.

Table 1: Rover project goals

Travel in multiple directions	The rover can execute an algorithm to demonstrate the rover can travel in multiple directions. It must demonstrate motion forward and in reverse, the ability to turn to both the left and the right and the ability to come to a stop.
Anti-collision using sonar	Using the sonar sensor for object detection, when instructed to drive forward the rover will not collide with an object or wall in its path.
Autonomous maze solver	The rover must execute an algorithm to navigate through a **known** maze without user intervention.
Advanced Autonomous maze solver	The rover must execute an algorithm to navigate through an **unknown** maze without user intervention.

Group formation

Groups will be allocated within your workshop. Groups will have a maximum of four people. For more information see the ENGN1211 Course Guide.

Resources

Training and information

Lectures will cover a range of topics which will support you in this project including the steps of the ASEP, project management, and a basic introduction to programming and electronics. The lab sessions will provide you with essential skills for this project such as Arduino coding and circuit construction, and use of the simulation tool TinkerCAD.

You will complete workshops and group updates with your project team that will help you progress towards the project goals.

Provided Materials

You will be provided with all the electrical components needed to build a rover capable of meeting the goals in Table 1. However, teams will need to manufacture a chassis. For options, see section Manufacturing the chassis. Table 2 lists the items provided to you and you may use them in your rover in the quantity provided.

- Any additional items must fit within a $20 budget or be repurposed from waste materials (see section Manufacturing the chassis.)
- Replacement items may be provided at the teaching team's discretion. Please email engn1211.cecc@anu.edu.au to arrange replacements.
- AA and 9V batteries are the responsibility of team members to source. These are **not** included within the $20 budget.
- You are not required to use all the items provided and are not required to purchase and use additional items.

Table 2: Provided components

Arduino Uno	Wires (M-M jumper wires, M-F jumper wires, and breadboard wire kit)
HC SR-04 Sonar module	4 x AA switched battery holder with 2.1mm plug
DC Motors (Pololu 4790 Micromotor) x 2	9V snap to DC plug
Breadboard (400 Tie point Breadboard)	Jewellers Screwdriver set (6 pieces)
SN754410 H-Bridge IC x 2	220Ω, 0.5W Resistor x 2
5mm Red LED x 2	USB 2.0 cable A to B (long and short)
2.1mm DC socket with screw terminals	2 Wheels and tires (Pololu 1425 70x8mm)
Castor wheel (Polou-956 I inch)	Micro servo SG-90

Manufacturing the chassis

As part of the project your team will need to design and build the chassis (or base frame) for your rover. There are several methods that you can use, or you might like to combine several. The 2020 COVID-19 lockdown proved that you could build a rover chassis without access to 3D printers and other complex tools. Be creative, make prototypes, experiment, and use what you have around you.

Recycling or Upcycling

Up-cycled materials might include things like cardboard, scrap wood, scrap metal sheet or scrap plastic like bottle cap lids. Materials that are demonstrably rescued from recycling or rubbish do not need to be included within your additional budget. **Items such as Lego wheels and blocks from home are not an up-cycled item**, as they are being used for their intended purpose and can be easily purchased on-line. You can use parts you already have but the cost should be included (or at least estimated with evidence) in the budget.

Purchasing parts or materials

You may purchase additional materials or components so long as they fit within the $20 budget. Groups will cover the costs of any additional items. Additional items in total must not exceed $20 and proof of the purchase costs must be included in an appendix within the Rover design report (see report specifications).

Additional materials might include extra sensors, rubber bands, sheets of corflute, balsawood, Lego items, additional wheel assemblies or other electronic components.

Additional batteries, and consumables such as tape, glue, and blu-tack do not need to be included in the budget. If in doubt, check with the teaching team.

ANU Engineering Technology Hub and ANU Makerspace – 3D printers, laser cutters and more

ANU Engineering has a technology hub in the Birch Building ground floor. Inducted students will have access to equipment such as 3D printers, soldering equipment, laser cutters and basic hand tools. Please see the QR codes on the doors for information and to book an induction.

The ANU also has a community of maker spaces. Inducted students will have access to equipment like that of the Engineering technology hub and more. The closest venue is in Physics. Please see the ANU MakerSpace website for information and to book an induction. Note that unlike the engineering technology hub, the ANU MakerSpace facilities are not limited to course projects, but you will need to pay for consumables including 3D printer filament.

Students may use personal 3D printers or other manufacturing methods if they have access.

Maze access

The maze is built on a rig which will be in the Birch building in room 1.31 (Whiteboard Collaborative space) from week 3.

Students will not have access to the maze during scheduled workshops in weeks 10 and 11 as it will be in use for Rover testing.

Assessment and other deadlines

Your group will submit small pieces of assessment (known as rover milestones) according to the schedule provided in Table 3. Your group will also submit a final design report on the rover and put the rover through testing at the end of the semester. Deadlines relating to the rover project are detailed in Table 3. In addition to these, students will also reflect on their experience during the rover project as part of the individual reflection (worth 25% and due during the exam period).

Table 3: Group assessment for the rover project

Assignment	Value	Type	Due
M1: Team charter, initial plan and project constraints	2%	Milestone	Week 4: 10 am Tuesday 11 March
M2: Requirements, concepts and evaluation	2%	Milestone	Week 6: 10 am Tuesday 25 March
M3: Rover-in-motion	4%	Milestone	Week 7: 10 am Tuesday 15 April and demonstration during workshop
M4: Draft documentation and testing plan	2%	Milestone	Week 10: 10 am Tuesday 6 May
Preliminary rover testing	10%	Demonstration	From Week 8-10 workshops or Rover drop-in
Final rover testing			Week 11 workshop
Rover design report	25%	Written report	Friday week 12

Rover Milestones

The milestones are worth a total of 10% from four submissions. A brief description of each milestone, designed to align with different stages of ASEP can be found in Table 4. Submissions will consist of prototypes and multiple working documents which will help you to document your systems engineering process and allow tutors to objectively assess your progress, and help you learn to plan and execute a

long-term group project with active contributions from every team member. Elements of the design documentation will serve as drafts for portions of your final rover report.

A working document is an in-progress record that is continually updated and refined throughout a project. It serves as a collaborative resource, capturing drafts, notes, and iterative changes, and helps track progress, support planning, and facilitate decision-making until the final version is completed. Your team will create the following working documents during the project:

1. The team charter – Submitted as part of milestone 1, the purpose of the team charter is to document the agreed expectations for how the team will work together.
2. Design documentation
3. Project plan

The team charter is unlikely to require changes through the project. The design documentation and project plan will be working documents that evolve over the project. The expectations for content at each milestone submission are summarised in Table 4. For more details on the rover milestones refer to the milestone assignment sheets.

Your tutor will provide brief written feedback on submissions via the Wattle gradebook. In some cases, you will also need to complete a demonstration during your workshop timeslot. Tutors will be available to discuss your feedback and answer questions during the workshop or Rover drop-in's during each week a milestone is submitted.

Late submissions will **not** be accepted on rover milestones.

Table 4: Description of rover milestones

1. Team charter, initial plan and project constraints (2%)	This submission includes: 1. Team charter: completed using the template provided 2. Design documentation: To begin the design documentation you will specify the goals and constraints of the project (in your own words). 3. Project plan: To begin your project planning you should list the assessment deadlines for the project. You will continue to add team deadlines to this document as you plan your project These documents should be housed on a shared platform (e.g. One drive folder) that all team members have access to.
2. Requirements, Concepts and evaluation (2%)	This milestone aligns with the Requirements Analysis and Conceptual Design Stage Gates in ASEP. It includes: 1. Design documentation: ○ List of requirements traceable to the stated goals of the Rover project, quantified as far as possible. ○ Sketches or descriptions of three concepts for your rover (these may be CAD drawings, descriptions of algorithms, or other). They should consider multiple aspects of the rover design such as the chassis, method of object detection and method of maze solving. ○ Evaluation of the three concepts against the requirements including measures where appropriate ○ A description of any changes made to elements previously submitted and why those changes were made 2. A 3D cardboard model/prototype of the preferred concept for the rover chassis (should be to scale for testing purposes). 3. Project plan: Document work completed since the last milestone and add a draft work plan describing the steps needed to successfully complete

	Milestone #3 in Week 7, and division of the tasks in the group. These can include prototypes of the chassis, electronics or code, simulations that are needed to progress design, integration of more components, ideas for maze solving algorithms, elements of the design documentation, or other required steps.
3. Rover-in-motion (4%)	This milestone aligns with the Preliminary Design Stage Gate 1. A prototype rover with chassis, wheels, and motors able to drive in a straight line and turn 90 degrees. 2. Design documentation: ○ A diagram of your circuit layout (a TinkerCAD model or similar is acceptable) and code or pseudo code required for the rover to drive in a straight line and turn 90 degrees. ○ List of at least 5 quantified design criteria for your design to this point (i.e. design criteria for your rover prototype to drive in a straight line and turn 90 degrees). ○ A description of any changes made to elements previous submitted and why those changes were made 3. Project plan: Document work completed since the last milestone and add a draft work plan describing the steps (at least 4) needed to progress the detailed rover design and division of the tasks in the group. These can include tests of rover performance, simulations that are needed to progress design, integration of more components, ideas for maze solving algorithms, or other required steps.
4. Draft design documentation and testing plan (2%)	Demonstration of progress towards detailed design. This submission includes: 1. Design documentation: ○ An updated diagram of your circuit design (a TinkerCAD model or similar is acceptable) and code or pseudo code explaining your anti-collision using the sonar module or other sensors. ○ An updated list of design criteria including those for required for sensors. ○ A description of at least two tests that will be done to evaluate the performance of the rover against design criteria. Testing should aim to verify the performance of the rover and ensure that it consistently and accurately achieves the goals outlined by your team. Testing should aim to demonstrate that the design is traceable to the design criteria. ○ A description of any changes made to elements previous submitted and why those changes were made 2. Project plan: Document work completed since the last milestone and add a draft work plan describing the steps needed to successfully complete the detailed design of the rover and its documentation including the division of the tasks in the group.

Rover testing

Rover testing is a group assessment accounting for 10% of your final grade. Testing is divided into five levels with each level being worth 2 points for a total of 10 points. These levels, testing and points (including penalties) are outlined in Table 5.

Levels 1 to 3 are the preliminary tests. These are the functions that the rover will need to be able to perform to navigate the maze (levels 4 and 5). These preliminary tests can be completed any time from week 8 up until week 11.

Levels that are attained during preliminary testing do not have to be demonstrated during the final rover test. Points that are achieved cannot be lost if modifications to your rover mean that it can no longer pass a previous test.

Testing over an extended time-period will give teams ample opportunity to fix errors and further refine their designs before completing the final test.

Final rover testing will take place during the week 11 workshops. At this point teams can be assessed on their rover's ability to complete the known and unknown maze.

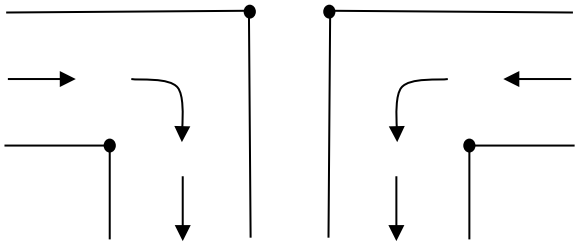

Figure 1: Right and left walled turns

Table 5: Tests, points, and penalties at each level of testing

Levels	Test	Points
1. Movement in multiple directions	1. Create a program that demonstrates the rover can drive forward in a straight line, stop for 3 seconds and reverse back to its starting position	Forward 0.4 points Stop 0.4 points Reverse 0.4 points
	2. Create a program or programs that demonstrates the rover can complete a rectangular (or square) path in a clockwise and anti-clockwise direction	Clockwise 0.4 points Anti-clockwise 0.4 points **TOTAL 2 points**
2. Object detection	1. Demonstrate that the rover will not collide with a wall placed directly in-front of its path. The rover must stop and reverse or turn to avoid collision.	1 point (-0.25 penalty if the rover does not continue to operate after stopping)
	2. Demonstrate that the rover will not collide with a wall placed at a 45° angle to its path. The rover must stop and reverse or turn to avoid collision.	1 point (-0.25 penalty if the rover does not continue to operate after stopping) **TOTAL 2 points**
3. Walled turns	Navigate a left-hand and right-hand walled turn as seen in figure 1. • spacing between walls will match conditions in the maze (18-19cm) • The order of the turns (left or right) will be the tutor's choice, the rover must use the sonar sensors to navigate the turn the rover **cannot** touch the walls	1 point for each turn (-0.25 penalty if the rover touches a wall. Applies once during each turn) **TOTAL 2 points**
4. Known Maze	Demonstrate that the rover can navigate the known maze autonomously. This test has a time limit (see General rules below) and a penalty for wall contact.	0.5 points for each quarter of the maze completed. (-0.25 penalty if the rover touches the wall, only applied once) Marks at the tutor's discretion **TOTAL 2 points**
5. Unknown Maze	Only if a rover successfully completes the known maze. Rovers that pass the known maze but touch the walls may attempt the unknown maze. This test has a time limit (see General rules below) and a penalty for wall contact.	0.5 points for each quarter of the maze completed. (-0.25 penalty if the rover touches the wall, only applied once) Marks at the tutor's discretion **TOTAL 2 points**

The general rules for testing in Table 6 apply to all testing goals.

Table 6: General rules

Rule	Description
Power supply	The rover must be powered by batteries for all tests. The rover cannot be connected to a computer via a cable.
Number of attempts	Groups are permitted 2 attempts on each goal on each testing day. This ensures all groups can be tested in the time available.
Time limit within maze	- Each attempt to navigate the maze will have a time limit of 3-minutes. - An attempt will be considered over if the vehicle is stuck in a dead end or similar for more than 1 minute.
Tutor judgement	Tutors may use their own judgement to terminate an attempt.

Rover design report

The rover design report is a group assignment worth 20% of your final grade. It will be due on the final day of term in week 12. See the assignment sheet for more details.

Team member contribution

Each team member's contribution to the project will be evaluated by the other members of the team. This process is known as Team Member Contribution (TMC) assessment and is designed to hold team members accountable for meeting the team's expectations as set out in the Team Charter in Milestone 1. An individual's mark for the rover project will be adjusted either up or down based on the TMC assessment they receive from their group members.

TMC will be evaluated at two points within the project. The first peer moderation will take place at the end of the teaching break (due at the start of week 7) after the initial concept design stage of the project. The second peer moderation will take place in week 13 following the submission of the report in week 12 and will cover involvement in the implementation, testing, analysis, and report writing components of the Rover Project.

Working effectively as a member or leader of a team is a vital skill for all engineers[1]. The assessment of TMC provides an opportunity to ensure all group members are contributing to the project as expected by the other members of the team. It is an opportunity for team members to give and receive feedback to help develop these competencies and reflect on their own contributions and possible improvements. When required, it also flags situations where outside assistance and guidance may be required from tutors or the course convenor.

Measuring TMC at multiple points during the project gives students that are not meeting expectations a chance to improve their contribution to the remainder of the project. It also supports group members to align their expectations. Involvement in team member contribution evaluations is an important part of your professional development and can assist you in developing improved teamwork capabilities. Failure to complete the TMC will result in a deduction of 1 grade point from your individual overall course grade for each offence (maximum loss of 2 %).

Tutors will be discussing the contribution of all team members in the weekly meetings. They will be consulted before any grade adjustments are made as part of the TMC.

[1] For example, the Engineers Australia Stage 1 competencies include professional and personal attributes relating to effective team membership and leadership (See section 3.6 of https://www.engineersaustralia.org.au/sites/default/files/2019- 11/Stage1_Competency_Standards.pdf)

For more information on the TMC process and how it alters grades please refer to the ENGN1211 Course Guide.

Version control

Document information

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