School of Electrical Engineering and Telecommunications

Term 1, 2023
Electrical Technical Stream - Lab Program

ENGG1000
Introduction to Engineering Design and Innovation

Staff

Coordinator: Dr. Sirojan Tharmakulasingam, Building G17, Room EE447
                           Email: s.tharmakulasingam@unsw.edu.au

Head demonstrator: Dennis Otter
                           Email: d.otter@unsw.edu.au

Electrical Technical Stream Lab Program

The motivation behind these laboratory exercises is to expose you to some of the technical concepts and ideas that will be useful for you in designing the electronics in the ACD, R2R, RoV, and MAR projects.

Due to time and space limitations, we cannot provide more than an introduction and brief explanation of these concepts, and our aim here is more to expose you to some basic features of electronics. For more detailed explanation you are encouraged to consult textbooks and websites on this material.

Your most important resource in the labs is lab tutors. You're wasting a valuable and important resource if you are not regularly asking these tutors questions and for explanations.

The second point to emphasize is to take accurate notes when you work through these exercises. Many of the ideas you see here will be useful in your design project, and you want to make sure you can accurately repeat what you do here in your design development work. A journal recording of your circuits, settings, and measurement results will be a valuable asset to you later on and is something that should become a habit whenever you do experimental work in the laboratory.

Electrical Technical Stream Lectures

The electrical technical stream has recorded lectures. These are released on the Tuesday before your lab session. You **must** watch these recorded lectures sometime before your technical laboratory session on the Thursday. Not watching these recorded lectures will mean you may not understand the content in the laboratory session which may negatively affect your technical stream mark.

Table 1: Electrical Stream Lectures.

Week	Lab content relates to	Content covered
3	Lab 1	Introduction to voltage, current, resistance, power and energy and resistors
4	Lab 1	Important circuit equations, useful simple circuits, and voltage sources
5	Lab 2	Introduction to diodes, LEDs, photodiodes, phototransistors
7	Lab 3	Introduction to transistors
8	Lab 4	Introduction to DC motors and electric drive circuits

Assessment Guidelines

The breakdown of the electrical technical stream assessment items is shown in Table 2.

Table 2: Electrical technical stream assessment breakdown

Assessment Item	Percentage of Final Course Grade
Laboratory Work	20%

Laboratory Work (20%)
Checkpoints are listed throughout the four laboratory task sheets. There are four checkpoints in labs 1-3 and five checkpoints in lab 4. This means that there are 16 checkpoints in total.
You will achieve 1.33% for each checkpoint, which means that you will need to do 15 checkpoints to get the full 20% of the technical stream assessment.

Each checkpoint will have a task that you need to complete. This generally involves designing a circuit and demonstrating correct functionality. You should show your functioning circuits to a lab demonstrator to be signed and noted as having completed that checkpoint. It is recommended that students **work in pairs** in Labs 1-4, to gain basic familiarity with the lab equipment and lab environment (unless you are familiar with the equipment through a course like ELEC1111 or you have a remote partner).

The labs and the associated content covered is shown in Table 3. Note that the final Laboratory Work marks will be totaled at 5pm Thursday Week 8.

Table 3: List of laboratory programs for the electrical technical stream.

Lab. No.	Week No.	Content Covered
1	3-4	Resistors, breadboards, important lab equipment, Circuits on TinkerCAD, introduction to component ratings
2	5	Voltage/current divider circuits, batteries LEDs, IR LEDs, phototransistors
1-2	6	Optional open lab session
3	7	Temperature sensors, force sensors, transistors, transistor motor drive circuits
4	8	Voltage regulators, DC motors, H-drive motor drive circuits, servo motors, ultrasonic distance sensors

General Guidelines for Electronics

Your breadboard and the various electronic components you use are quite delicate, so be careful and make sure that each connection is firm.

Particularly when you begin to work on larger, more complex circuits, there are many things that can go wrong. It is unrealistic to expect to connect all the components together and expect them to immediately work. It is important that you incrementally test every component and connection as you build your circuit.

Only if every unit works can you expect the entire circuit to function properly. When debugging a circuit bear this in mind, and progressively check each component to verify that it is working as expected and that they are connected in the correct orientation.
As a last resort, ask a demonstrator for assistance.

Laboratory Safety

You should complete the **Electrical Engineering OH&S Module** (Enrolment key = elecmood) on Moodle and **submit your certificate prior to being admitted to the laboratory in Week 2**. However, it is always worth emphasizing the importance of safe practices in an electrical engineering laboratory.

To begin with, please note that use of the EE&T laboratory facilities is conditional on adhering to the following rules:

- You may not smoke, eat or drink in the laboratories.
- Covered footwear must be always worn.
- Bags and loose clothing must be stored under the benches. The most common form of accident in laboratories is tripping, so this rule is much more important than you may think.
- You may not, under any circumstances, wire your own project directly to the mains. For this subject, all designs are to be powered either by batteries or from the power supplies provided in the labs.
- Please report any equipment failures or unsafe mains cords to laboratory technical staff or to one of the laboratory demonstrators.
- You must wear a facemask and maintain social distancing of 1.5 m where possible.

In addition to the above safety guidelines, you should remember that the School's laboratories are a shared resource, to be treated with care and respect. Before leaving the laboratory, please

- turn off and unwire any equipment you have used;
- put all equipment, leads and components away; and
- store all lab stools under the benches.

Electronic Components

The lab demonstrators will be able to give you the special components as you need them*.

Lab 01 Provided	Breadboard
Lab 02 Provided	Battery attachments (for 9V)
	9V batteries (normal)
	CSLR-N502TG4-A0R Standard Green LED
	L-53F3C IR LED
	Toggle switch
	L-53P3C IR phototransistor
	10 Ω 10 W power resistor

Lab 03 Provided	BC-549 NPN transistor
	BD139 transistor
	3V High torque DC motor (MM28 – Element 14 - 599128)
Lab 04 Provided	LM7805 voltage regulator
	3V High torque DC motor (MM28 – Element 14 - 599128)
	CMOS N Ch (IRL3803)

* Note: the model may varies depending on the components in stock.

The components should be returned to the lab demos after the completion of the laboratory session.

PROJECT SUMMARY

Project Staff

Project coordinator: Dr. Sirojan Tharmakulasingam, Building G17, Room EE447
                         Email: s.tharmakulasingam@unsw.edu.au

Head demonstrator: Dennis Otter
                         Email: d.otter@unsw.edu.au

Project Timetable

Project learning activities and important assessment dates are detailed in the ACD Project Timetable document in the ACD Project Overview section of Moodle. You need to be familiar with the timetable as it will tell you where and when the lectures and laboratories are being conducted.

INTRODUCTION

Today, autonomous delivery of large industrial goods is technically feasible and becoming a reality in mines (Mining video), ports (Port video) and warehouses (Warehouse video). In this project, we will build our own autonomous vehicles, learn about some of their basic electric principles, and have plenty of fun on the journey.

PROBLEM DESCRIPTION

A mining company needs to transport important fragile equipment from the storage-zone to the working-zone of a mine. At present, they are using drivers with freight trucks to perform this role. However, a company engineer has forecasted that switching to an autonomous freight vehicle will reduce the risk for accidents. Hence, the engineer wants to showcase this idea to their company's executive team. Your team has been contracted by the company engineer to create a scaled prototype of an autonomous freight vehicle. This prototype will be used to explain to the executive team how an autonomous vehicle could be used to transport fragile freight. Note that these stakeholders do not have engineering backgrounds and hence require an entertaining prototype experience. Therefore, you have decided to use an egg to represent the fragile mining equipment as this will provide entertainment upon failure.

The aim of the prototype is to prove that the vehicle can take an egg from the storage-zone to the working zone and then deposit the egg into a container. For the scaled model, we know that the container will be around 3 m away (but not exactly) from the storage zone. The company engineer has informed that the vehicle must travel along a road autonomously and must not traverse outside of the road area. Note that you will be presenting the prototype to the company engineer (who is played by a UNSW academic) in Week 10 to showcase its functionality.

DETAILS OF TEST CONDITIONS

Using the testing setup in **Figure 1**, the autonomous container delivery (ACD) prototype must be able to:
1. Once the start button has been pressed, the vehicle must autonomously pick up an egg from the first container. Note that the vehicle will start right next to the container here.
2. The vehicle must then travel to the second container and drop off the egg in this container.

3. The egg must stay intact for the duration of the journey. You will be penalized for destroying the egg and will need to clean it up.
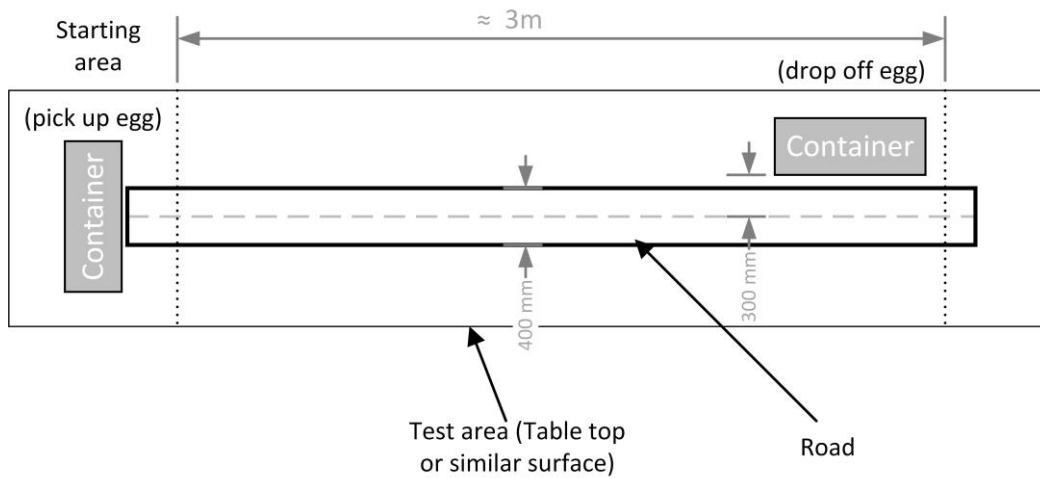

Figure 1. Testing area (top view), not to scale.

Your prototype must satisfy the following constraints:
- Your vehicle must comprise of only one physical system. For example, you cannot have multiple cars here.
- As a team you are restricted to spending no more than $100 on materials for the system as presented for testing (development costs do not need to be included in this total). Note that you may be asked for receipts to prove the cost of your design.
- The system must begin completely behind the start line of the storage zone, behind which manual adjustments/interventions/operations are allowed before beginning the test attempt. There must be a "go" button or switch, which initiates system operation.
- The system must operate autonomously (automatically), i.e., without any manual intervention: once the "go" button has been pressed, no manual adjustment/intervention/operation is allowed.
- Your vehicle must stay within the bounds of the road according to Figure 1. Note that you are allowed to add anything you need to the road system to help achieve this requirement as long as the $100 material cost limit is not exceeded.
- Each group will be given a container with the same dimensions to use for testing.
- The distance between the storage-zone and working-zone will be an arbitrary distance around but not equal to 3 m.
- The vehicle must have a wheelbase no wider than 200 mm.

Note that there are also additional features that will further impress the company engineer and result in extra marks. These features are listed in the next section.

FINAL ACCEPTANCE TESTING ASSESSMENT

Your prototype will be assessed during the final acceptance testing day in week 10. Note that the final acceptance testing contributes 15% to your final course grade.

Your vehicle **must** adhere to the specifications outlined in **Table 1**. Not adhering to these specifications, will result in your team receiving less than 50% for the final acceptance testing assessment component.

Table 1. Required Specifications to Pass the Final Acceptance Testing assessment.

Required Features
The width of the vehicle is less than 200 mm, and the length is less than 300 mm.
The cost of the prototype and materials is less than $100.
Your vehicle must comprise of only one physical system.

The final acceptance test grade is divided into four components according to **Table 2**.

Table 2. Final Acceptance Testing Assessment Breakdown.

	Important Specifications	Additional Features	Innovation Score	Aesthetic Score
Weighting	60%	20%	10%	10%

Innovation Score

This will be subjectively determined by the panel of judges based on the uniqueness of your design in comparison to the other entries. In general, this is related to the way in which you utilize technology to perform the primary functions of the design and the degree of difference between your solution and the other competitors. It is also related to the simplicity and elegance of your solution (simpler systems are cheaper to manufacture). Here, you will receive a score from 1-10 where 10 is most innovative and 1 is the least innovative.

Aesthetic Score

This will be subjectively determined by the panel of judges based on the visual attractiveness, use of a theme or visual novelty. Here, you will receive a score from 1-10 where 10 is aesthetically appealing and 1 is not aesthetically appealing.

Important Specifications

The important specifications are listed in **Table 3**. Note that a 'pass' is 10% and a 'fail' is 0% per specification. Since there are six important specifications, this table sums to 60% if a pass is achieved for all specifications.

Table 3. List of important specifications.

Important Specifications	Pass or Fail
The vehicle can be dropped from a 1.5 m height onto the ground (wheels first) and is able to drive forward after this test. Ten seconds of maintenance is allowed after the drop test. However, no external items (like tape, new components, etc.) may be added to the car during this time.	
The vehicle can pick up an egg from the storage zone container without breaking it and can hold the egg for at least 3 seconds.	
The vehicle can travel from the storage zone to the drop-off zone and will stay within the bounds of the road.	
The vehicle can autonomously detect where the drop-off zone container is and will stop next to it.	
The vehicle can deposit the egg into the drop-off container without breaking it.	
The vehicle can automatically detect an obstacle (like a hand in front of it) and stop before a collision occurs. This simulates a pedestrian running out in front of the vehicle.	

Additional Features

The additional features have different weightings depending on their importance to the company engineer. These weightings will be used to scale the 'additional features' mark. The additional features and their weightings are given in **Table 4**.

Table 4. List of additional features.

Additional Features	Weighting	Pass or Fail
Team arrives on-time to their session within ± 1 minute.	Low	
An LED circuit has been used to show a green light when moving and a red light when waiting for the egg.	Low	
No connection to or programming of the Arduino is required during testing session. Vehicle comes in ready to go.	Medium	
The vehicle is in the top five fastest teams to perform delivery of an egg from the start line to the container without breaking the egg.	Medium	
The vehicle makes a beeping sound from a speaker when it is reversing. This should sound like a truck reversing.	Medium	

A demonstration of project risk minimization has been shown. These risks are real, plausible risks that are likely to occur and could jeopardize success for the project team.	High	
The vehicle can go backwards autonomously to pick up another egg and then can take this egg back to the drop-off container and deposit it. No interaction with the vehicle is allowed and the vehicle must switch to the backwards operation mode by itself.	High	
Any other creative feature that aids in the demonstration of the prototype to the company engineer.	Depends on the Feature	

FINE PRINT

Any materials may be considered for use. However, no toxic or dangerous materials will be allowed. Use of remote controls is not permitted.

ELIGIBILITY

The prototype system must be designed and built by engineering students registered in ENGG1000, without the help of either design or construction from anyone not registered in the course. Staff, students or university technicians may be used as consultants for specific information.

TESTING PROCEDURE

The final testing of the systems will be conducted in a competition on **Thursday 20th April from 2:00-5:00 pm during Week 10**. The likely location of the testing is **Room EE202**.

You will be given two attempts to demonstrate your system. You will only be given 11 minutes to showcase the prototype and perform these attempts. It is strongly advised that teams do not plan to make modifications between attempts. No equipment will be provided to do so. You may wish to bring any tools and materials to make running repairs if necessary.

GROUP ORGANIZATION

The group of 6 must be sub-divided into two or three sub-groups of 2-3. Your group must elect a leader and at least one note-taker[1] by the start of the first mentor meeting in **Week 2**. The members and purpose of each sub-group should be decided (by the team) by the end of this first mentor meeting as well. A suggested approach for determining the purpose of each sub-group is to come up with a conceptual design that breaks the overall problem into two or more sub-problems, which are then allocated to the sub-groups.

Materials and Suppliers

The following suppliers of materials may be useful:

- Bunnings Randwick (Clovelly Road & Kemmis St, Randwick)
- Bunnings Eastgardens (140-148 Denison St, Hillsdale)
- Bunnings Alexandria (8/40 Euston Rd, Alexandria)
- Sunlite Mitre 10 (452 Oxford St, Bondi Junction)
- Jaycar Electronics (366-370 Botany Rd, Beaconsfield)
- Jaycar Electronics (125 Bronte Rd, Queens Park)
- Hobbyco (Shop 50/53 Queen Victoria, Building Level 2 & 3/455 George St Sydney)

An electronics starter kit of components will be supplied to each group in the **Week 2** lab. Note that these components will be used for the electrical technical stream labs. A limited range of electronic components (e.g., integrated circuits, transistors, diodes, LEDs, but not motors and not unusual or very specific components) will be available from the EE&T Electronics Workshop (EEG15). You can purchase these components from this workshop (so bring money). You are strongly advised to purchase your own prototyping board (or "breadboard"). These can be conveniently purchased from the Electrical Engineering School Office for $15.

---

[1] All team members should be taking their own notes anyway. The team note-taker should be certain to record all decisions, tasks, times/dates and other key information.

Teams wishing to purchase other electrical equipment may consider trying Jaycar. Hobbyco may have some helpful materials and components. Online suppliers like Dick Smith, Little Bird Electronics or the locally based Oatley Electronics might be helpful.

This listing of materials and suppliers is not intended to be exhaustive nor even comprehensive. Rather, it is to provide your team with ideas that they may wish to follow up on. Neither the mentors nor the Course Coordinator can provide any information beyond that contained here.

It is quite likely that not all team members will have contributed equally towards covering expenses. It is therefore up to the team to decide how these costs are covered. It is strongly recommended that each team member makes an equal financial contribution.

TECHNICAL STREAMS

There are four technical streams associated with the ACD project. These are:
- Electrical
- Computing
- Mechanical
- Design

It is highly recommended that you divide your team into groups and each group attends a different technical stream. For example, **two team members will attend the electrical stream, two different members will attend the mechanical stream, one will attend the computing stream and the last one will attend the Design stream.** Note that an individual cannot attend multiple streams and must select one stream. This is because each technical stream comprises its own assessment. You will select your technical stream in **Week 2**.

Electrical Stream
The electrical stream will cover technical information on electrical lab safety, basic electrical components (including the breadboard), electrical test equipment, circuit diagrams, building motor drive circuits (including traction motors and servo motors), power packs, LED circuits, IR circuits, and some other relevant basic circuits.

Computing Stream
The computing stream will cover how to connect to an Arduino and program an Arduino to perform many different functions (including traction motor control, servo motor position control, and the interface with different sensors).

Mechanical Stream
The Mechanical stream will cover how to use CAD software to build important design drawings and how to use the 3D printer and laser cutting equipment.

Design Stream
The Product Design technical stream will focus on the skills and knowledge useful in product design development. It covers the drivers that influence product design: ergonomic drivers, functional drivers, market drivers, economic drivers, and technology drivers. Also, guide students in using tools and methods they can adopt in the Project stream and future design courses.

Note: The technical streams will **NOT** give you all the information you need to build your prototype. You will need to do at least 2 hours of independent learning per week to solve different design challenges and be successful in this course.

PROJECT ASSESSMENT STRUCTURE

The autonomous container delivery project uses the following assessment structure for ENGG1000:

Assessment	Weight
Reflective writing (individual)	5%
Engineering Design Process (EDP): Problem statement and concept generation presentation (group/individual)	15%
Technical Stream Assessment (individual)	20%
Design journal mark (individual)	15%
Compliance testing, marked by the lecturer (group)	5%

Design proposal report, marked by the mentor (group)	10%
Final acceptance testing, marked by the lecturer (group)*	15%
Final design report, marked by a different mentor (group)*	15%

* This mark is moderated by a 'Learning, Planning and Participation' mark as well as peer assessment (see below)

The assessment is approximately distributed evenly between individual and team marks, reflecting the requirement of the project. Experience from previous offerings of this course shows that well-organised groups that communicate, set high standards, self-organise, and resolve conflicts effectively are essential to succeeding in the project.

The Learning, Planning and Participation Mark

The 'Learning, Planning and Participation' mark will be used to weight individual marks within group assessment. It is assessed by your mentor in weeks 3, 5 and 9 during the Monday 4-5pm mentor meetings. During these meetings, the mentor will give each team member a score of 1-10 for their learning, planning and participation in the project up until that point in time. Achieving a score of 10 means that you have been an extremely active team member. The mentor will average the scores from weeks 3, 5 and 9. If you receive an average score of less than 5 (four or lower) than you may receive an overall subject grade of unsatisfactory fail. This assessment item is here to discourage students from letting the rest of the team do all the work for them.

Please note:

- High marks will be given for demonstration of commitment to the success of the group (as defined by the group at the beginning of the project) and for helping the group to function effectively. You will also require active contribution to:
    - o Mentor meetings and non-timetabled meetings.
    - o The design, implementation and testing of the prototype.
    - o The written submissions.
- Low marks will be given for:
    - o Non-attendance without advance explanation.
    - o Lack of engagement or participation (including silence in mentor meetings).
    - o Failure to deliver on tasks assigned by the group.
    - o Poorly detailed/missing lab notebooks.
    - o Obstruction to group progress (e.g., falling out of contact while holding key project details).

Design Journal Assessment

Design journals are a means of recording design, technical and organizational information for later use, and are a helpful tool both during study and in professional life. You must bring your design journal to all classes, and record both the introductory lab and notes from mentor meetings and later labs. Design journals will be assessed according to the following criteria:

- purpose of notes (why were they made?)
- date (when were they made?)
- clarity (could someone else understand them?)
- detail (e.g., if you sketch your circuit diagram, could someone else build it exactly from the sketch?)
- completeness of experimental notes
- interpretation of results or discussion of design/circuit
- and evidence of research or individual input (i.e., repeating lecture notes will not attract marks).

The design journal is assessed by your mentor in weeks 3, 5 and 9. Each journal assessment is worth 5%, yielding a total of 15% for this assessment item. The lecturer or mentor may request your design journal at any time for viewing.

Compliance Testing Assessment

Compliance testing is a functional testing technique that is done to validate and confirm that the system developed meets the prescribed specifications. The motivation for the Compliance Testing on Thursday in Week 8 is to ensure that your team will be able to present a viable prototype for final testing on Thursday in Week 10.

Detailed objectives of this compliance testing include:

- Determining that the development meets the prescribed specifications.
- Ensures whether the deliverables of each phase of the development, meets the standards, procedures, and guidelines.
- Evaluate the documentation of the project to check for completeness and reasonableness.

A panel of mentors/demos/coordinator are the final judges of whether your prototype device is progressing accurately. This represents 5% of your overall grade for ENGG1000.

Design Proposal and Final Report

Written communication is consistently among the top priorities for engineering employers. Hence, developing report writing skills is an important aspect of design and innovation. The criteria for assessing the design proposal and final design reports are given on the respective report cover sheets.

Teamwork Evaluation Assessment

The final testing and final report marks will be moderated on an individual basis by peer assessment (as well as the Learning, Planning and Participation' mark). Formative peer assessment (i.e., does not contribute towards your final grade) will be conducted in weeks 3, 5 and 7. Here, you will score all your fellow team members on their contribution to the project. A poor score informs a team member that they should change their attitude and work ethic to achieve a better score for the assessable peer assessment in week 9. Feedback on whether your participation has been satisfactory is available at any time from your mentor and from your group.

A summative peer assessment (i.e., does contribute to your final grade) from your group members will be conducted in the final mentor meeting on Thursday Week 9. You must pass this assessment item to pass the course. Failure in this assessment item can result in an overall grade of Unsatisfactory Fail (UF), even if your overall mark is above 50. This would usually occur when both the mentor and group find that participation has been unsatisfactory. If you believe that your circumstances pose risks to your group participation, act early and discuss these with your group and mentor ahead of time, to avoid disappointment.

Formalized peer assessment will be conducted as follows:

- At the final mentor meeting, you will score all your fellow team members on their contribution to the project. The scores of your team members will be averaged to produce a peer assessment score for the project. This score will then be used to moderate the final testing and final report marks. Therefore, if you contribute little to the team, then your final testing and final report marks may be lower than other members in the team. However, if you are a strong contributor to the team, then your final testing and final report marks may be higher than for others. The peer assessment will be applied as an individual weighting to the final testing and final report group marks.

Peer assessment is an important part of assessing group projects, because your contribution to the team is vital to the team's success.

Late Submission of Assessment

Late submissions of assessed work attract a penalty of 5% per day, including weekends. After 10 days, a mark of zero will be awarded.