Team Bonding Design Challenge

UTS Motorsports

Version 1.0

Project Scope

There are 4 key problems the design challenge aims to address:

1. Software section requires a test bed to experiment with different control algorithms/systems and integrate all the components together. It is crucial for the high-level control section, especially for perception, to be deployed in the real world so that the team can explore its interaction with other components.
2. New team members need to work on a project to gain experience and understand how subsystems integrate together before they can design and build subsystems for the FSAE car.
3. The team needs something substantial to present at Tech Fest beyond steer-by-wire and simulation videos.
4. The Business Section requires more content for media channels.

Hosting a Design Challenge to build a quarter-scale version of the car addresses all 4 of these problems. The design challenge will get people working together and develop their understanding of how the different subsections contribute to the team. The challenge will involve three key phases: design, review and construction. The design and review phases will happen six weeks before the construction phase, with progress checkpoints occurring during the respective sections meetings each week. The construction phase will take place over 1 week in the Mechatronics Lab (Building 11, level 10).

Safety Requirements

Prior to commencing the design challenge, all participants must be inducted to work in the Mechatronics Lab. A corresponding risk assessment (RA) has been filled out as requested by technical staff. A detailed list of safety requirements and considerations can be found in the RA which has been included in the appendix, however the key safety considerations are listed below.

Key Safety Considerations:

- All participants are to be inducted before the commencement of work in the mechatronics lab.
- Inducted supervisors are to be in the Mechatronics lab at all times. No one is to enter or be working in the mechatronics lab unless there is a supervisor present. There are currently 3 team members inducted to supervise for the design challenge.
- Everyone wears safety glasses and enclosed shoes when working in the Mechatronics lab. Long hair to be tied up at all times.
- Clean up the workspace during and after each session to prevent hazards and ensure cleanliness.
- Participants are limited to hand tools to complete the design challenge, all of which can be found in the mechatronics lab.

Learning Outcomes
Team is to develop a requirements list and deliverables for the challenge as that is one of the learning outcomes. The team is expected to develop a requirement list based on the project scope and present it to the leads. An outline of the learning objectives can be summarised in the following table.

Table 1: *Learning outcomes for the design challenge with the suggested approach.*

Section	Learning Outcome	Desired Approach
Embedded/Electrical	Wiring diagrams	Do on a Miro Board.
	Motor controller considerations	Develop a selection table.
	PWM signal generation	Programmed on the STM microcontroller.
	Power delivery	Consider the power requirements of all components
	Embedded programming	Programming of STM32 Microcontrollers
	Prototype boards	Safer than breadboards. If the team is skilled enough, print and test a PCB.
	Motor selection [+ DC motors, Servo]	To work with the mechanical team to choose and justify motors.
	CAN interface	Programming the STM32 MCUs to develop the CAN network.
	GUI development [+ Push buttons]	Produce a low level dash display that emulates the one of the real car. Integrate push buttons for state control also.
	State Controller	Incorporate the Autonomous system state machine from the FSAE car.
	PID Control	PID control implemented for each of the motors
	Data logger	Integrate the data logger from the real car on the model car.
Software	Path Planning	A functional ROS Node for Track Boundary Extraction in real-time
	Computer Vision [+ ML]	A functional Perception ROS Node that returns the position of the cones in the car egocentric frame
	Configuring the CAR	Setting up development and deployment

	computer	environment
	CAN interface	Integrate embedded CAN network
	Telemetry	Visualise data using Foxglove through WebSocket
	Integration	System testing and Performance Monitoring
Mechanical	3D printing	UTS 3D printers are not optimal, so individual printers are preferred.
	CAD and Design to manufacture	SolidWorks 2023 (Azure VM if actual SolidWorks software is not attainable)
	Hands-on manufacturing skills	Use hand tools to complete assembly in the Mechatronics Lab.
	Modular bodywork Design	Design a single body to be attached to the chassis over the top of other components
	Mechanical considerations for motor and actuator selection	Liaise with other sections in the early stages of the first week to confirm selections
	Chassis Design	Tube Chassis, material to be determined by mech team
	Steering, braking and drivetrain design	Minimal functional design within design constraints that closely mimics the dynamic behaviour of the full-scale car.
	Mounts and fasteners	Liaise with other sections to calculate mounting and fastener requirements.

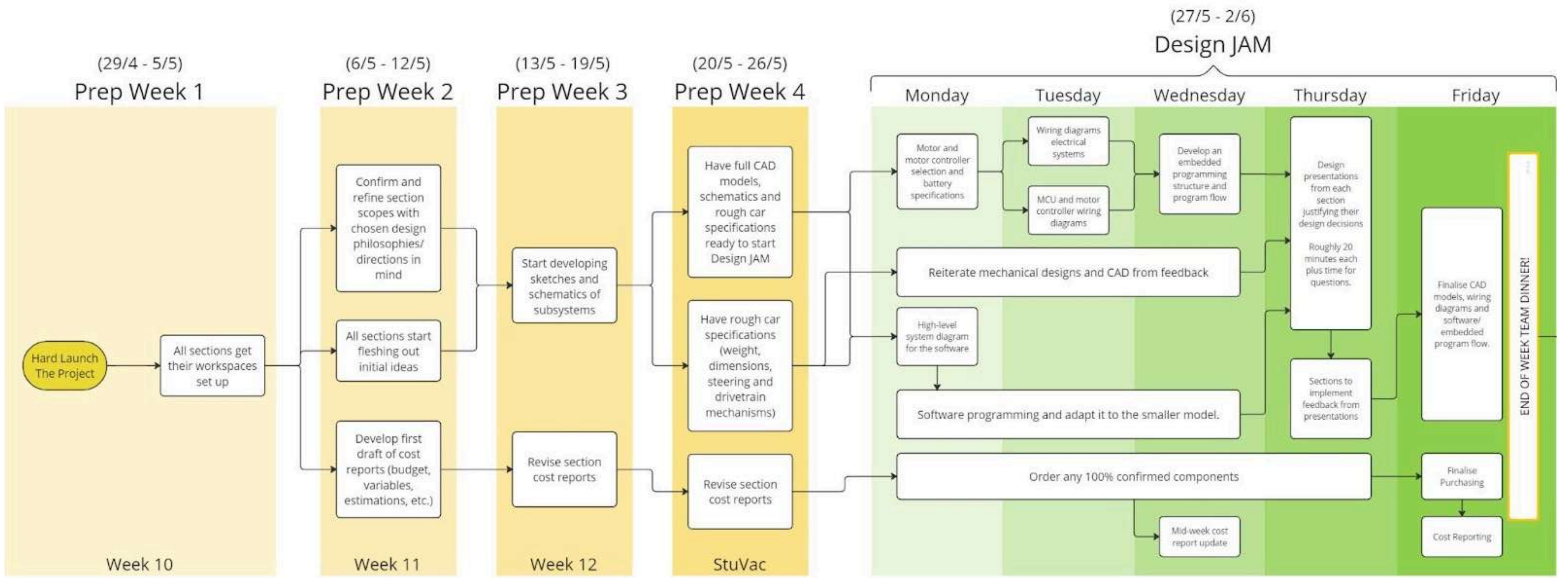
Equipment List

A full equipment list and cost sheet will be developed in the Design Jam during the challenge by participants. Below are the essential components for the challenge.

Table 2: *Essential equipment list for the challenge and their use case. Green means the item has been acquired and red means that they need to be bought or yet to be decided upon.*

Section	Acquired	Equipment	Use
Embedded/ Electrical NO BATTERIES ARE TO BE USED IN THE LAB.		CAN transceiver	To communicate with CAN Network.
		Kvasser [or another CAN logger]	To Communicate with CAN Network.
		STM32 Boards	Controller for Steering Actuation and Acceleration. Implement State Machine
Software		Orin Jetson Nano	To run software such as path planning and computer vision.
		Camera	Computer Vision
Mechanical		Plywood/ Chassis Base Plate material	Manufacture chassis and other mechanical components
		PLA Filament	For 3D printing of mechanical components.
		Citrix SolidWorks 2023 Installed (minimum)	For Mechanical CAD

Timeline 1a: *Prep week 1 to Design JAM (29/04 - 02/06)*



Timeline 1b: *Refinement and purchasing Lead Times Weeks to Fabrication and Testing JAM (03/06 - 16/06)*

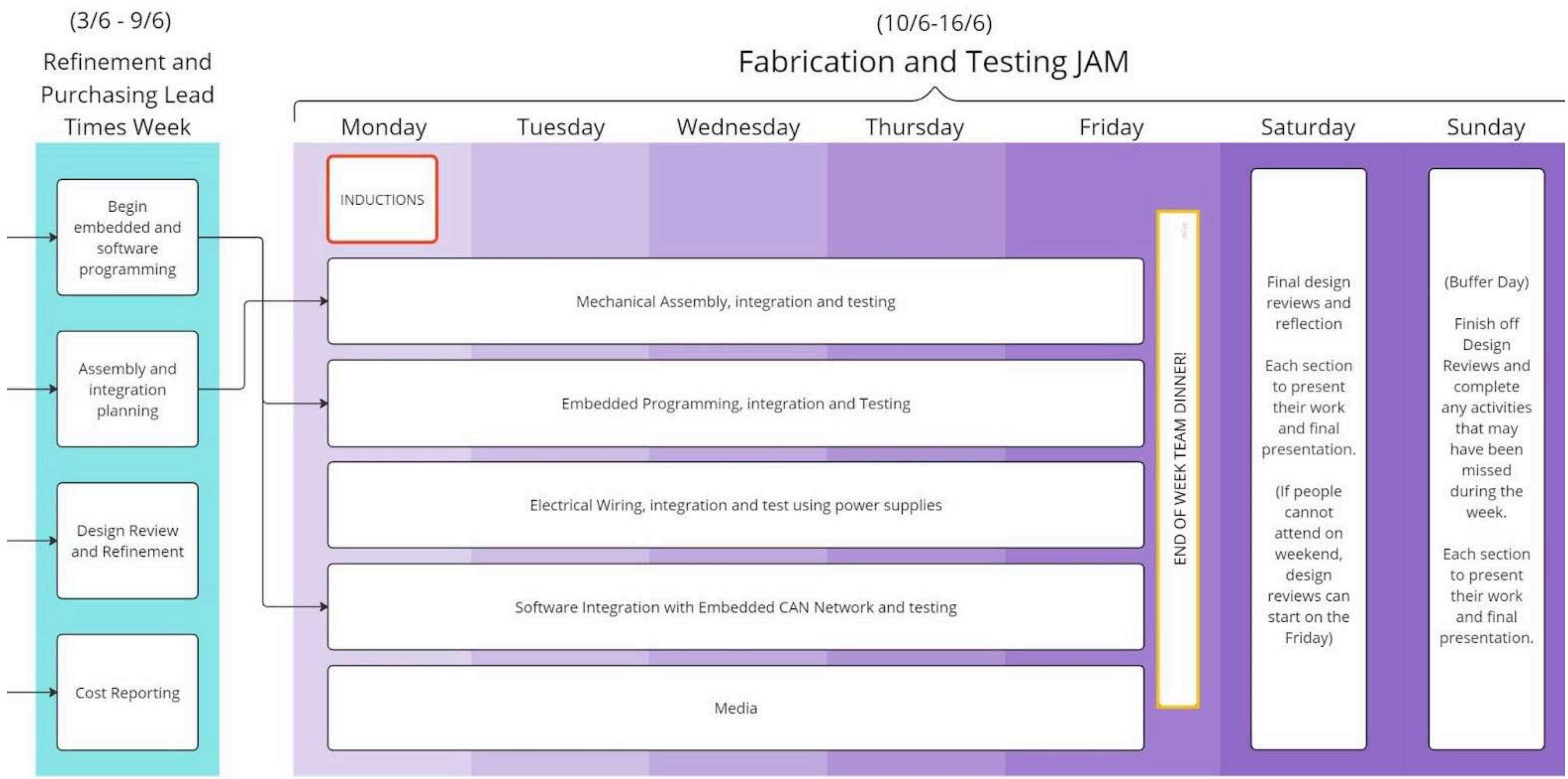


Table 3: *Project Overview for the design challenge. This will be broken up into 4 weeks with the first being the Design Jam followed by two weeks of refinement and a Construction Jam.*

Phase + Time Frame	Plan	Comments
Prework Start Date: **29/04 (Wk10)** Duration: 4 Weeks	• Sections to do their online inductions. • Develop fleshed out scopes and designs	• Depending how section leads want to run it. It's suggested that 15 min of your meetings should be dedicated to this challenge as a design catch up. This could be done in the team meeting as well. Designs need to be done early to make purchases then.
Design JAM Start Date: **27/05 (AW1)** Duration: 1 Week	• Students work closely with leads to design, validate and prototype [MCAD, ECAD, sketches] their scaled down model. • Work within their sections to develop the necessary components for the car. • Work with other sections to ensure all systems are integrated properly. • Getting sections to present their work to other sections.	• 'Mimic' the integration process. Once everyone has presented, work on how it's going to be integrated with the rest of the system. • Must pass the first two dot points in order to move into the making phase. • Have this during the team meeting where each section group has 5-10 min to present their work.
Refinement and Purchasing Lead Times Start Date: **03/06(AW2)** Duration: 1 Week	• Any preliminary manufacturing such as laser cutting or 3D printing. • Waiting for deliveries on parts.	• Use this time to talk with other sections and refine through feedback from the design week.
Fabrication and Integration JAM Date: **10/06** Duration: 1 Week	• Using the allowed workspace to make the components for the car. • Four benches will be used, one for each section for discussion. • Mini progress checks along the way.	• This will depend on the lab we are able to access. • Leads are to be less involved and only there for guidance.

Table 4: *Weekly Breakdown of tasks*

Week	Day/s or Timeframe	Task	Location	Comments
Prep 1 (Week 10) *29/4 - 5/5*	Wednesday During section and team meetings	Hard Launch the Project Sections to get their workspaces set up	Anywhere	This week is about introducing the project, showing timelines and getting sections set up with the tools they will need to complete it. Have project scopes for sections ready to present.
Prep 2 (Week 11) *5/5 - 12/5*	Monday - Friday	Confirm Section Scopes and start fleshing out ideas. Include a cost report (budget, variables, estimations, etc.)	Anywhere	In prep week 2, sections should have taken the base scope from prep 1 and developed a more refined scope with ideas on specific design philosophies/ directions as well as cost reports. Have sections decide which design direction they want to go in (i.e. Chassis chooses between tube frame or base plate with shell). Start developing rough sketches. Team Leads are to evaluate the initial cost report for each section by the end of the week (this is to be revised each week).
Prep 3 (Week 12) *13/5 - 19/5*	Monday - Friday	Start developing models and schematics of components Revise section cost reports	Anywhere	This week, sections should be turning their ideas/ rudimentary drawings into more developed sketches, models and schematics. Designs should be about 50% complete as we are expecting a lot of iteration to take place during Prep 4 as teams should have more time to flesh out models/ schematics then. Concept sketches/ideas finalised for Mechanical

				and Embedded/Electrical: Low Fidelity
Prep 4 (StuVac) *20/5 - 26/5*	Monday - Friday	Have full CAD models, schematics, and rough car specifications ready to start the Design JAM Revise section cost reports	Anywhere	Full preliminary mechanical and electrical CAD should be complete by the end of this week except for specifics regarding some component selection as sections should expect to reiterate their designs throughout the Design JAM Mechanical team should have rough car specifications (weight, dimensions, steering and drivetrain mechanisms) ready to be discussed with the rest of the team
Design JAM (Exam 1) *27/5 - 2/6*	Monday	Motor and motor controller selection. Battery specifications. High-level system diagram for the software. Start with software programming and adapt it to the smaller model. Order any 100% confirmed components	Anywhere	This week, teams should aim to present their ideas to other sections in full and get feedback to ensure specifications/designs are realistic. Outline of what each section is expected to deliver. This is where specifications of the system need to be set. All sections are required to work together.
	Tuesday	Wiring diagrams for electrical systems. MCU and motor controller wiring diagrams Order any 100% confirmed	Anywhere	Get the system diagram from all sections.

		components		
	Wednesday	Continue with Chassis CAD, making modifications for what other sections need. Develop an embedded programming structure and program flow. Finalise a rough bill of materials covering the most critical components. Order any 100% confirmed components	Anywhere	
	Thursday	Begin design presentation and justify everything. Each section should be around 20 minutes including QnA. Implement any feedback and finalise the bill of materials. Order any 100% confirmed components	Anywhere	Presentations are to be done to update the rest of the team on what has been worked on and how it’ll be integrated.
	Friday	Finalise the CAD model, wiring diagrams and software/embedded program flow.	Anywhere	Re-tweak goals and set updated goals for the next week.

		Order any remaining components. Update section cost reports Team dinner to celebrate the end of the design phase.		
Refinement and Purchasing Lead Times (Exam 2) *3/6 - 9/6*	(During Section Meetings)	Design Review and Refinement Assembly and integration plans. Begin embedded and software programming.	Anywhere	As the team will be waiting for parts to arrive and completing any final/last minute orders, they should be shifting their focus towards how they will integrate their components with the rest of the car.
Fabrication and Integration JAM *10/6 - 16/6*	Monday - Friday	Induction [**IMPORTANT**]	Mechatronics Lab	Lab supervisor to induct members who have not been in the space. Everyone needs to be here on the first day.
		Construction	Mechatronics Lab	Mechanical team to assemble the chassis and other mechanical components
		Embedded Programming	Mechatronics Lab/Office	Embedded team to program the controllers and test
		Electrical wiring	Mechatronics Lab	Embedded/electrical team to wire up the robot and test using power supplies (NO BATTERIES)
		Software Integration	Mechatronics Lab/Office	Integrate the high-level software with the embedded CAN network.
		Media	Mechatronics	Take photos and create promotional content.

			Lab/Office/iHub	Potential Vlogging → give 3 members a vlogging camera to vlog their team's day: Long, Morgan, Quan, Adesh and Kat. Mic → Cam up for the days of the challenge Day 1 - Introduction to the Challenge Day 2 - Focus on Mechanical Day 3 - Focus on Embedded Day 4 - Focus on Software Day 5, 6, 7, - End phases of the challenge
		Start Final Design Reviews	Office/iHub	Towards the end of the week if people cannot make it on the weekend the Design Reviews can start early.
	Saturday	Final Design Reviews + Reflection	iHub	Each section to present their work and final presentation.
	Sunday	Finish of Design Reviews/Buffer	iHub	Finish of Design Reviews and complete any activities that may have been missed during the week.

Appendix A: Risk Assessment

GENERAL RISK ASSESSMENT: UTS Motorsports Autonomous Design Challenge

Work area/operation	CB11.10.403 Mechatronics Lab	**Assessor's name**	Thein Tran, Morgan Sheather-Reid, Cameron Chalmers		
Other persons consulted			**Date of safety assessment**	23.04.2024	
Lab Supervisor's Name	Ricky Ha				

ACTIVITY - Describe hazardous activities related to the work area or operation.	**ASSOCIATED HAZARDS**	**INHERENT RISK** - Harm that could occur from these hazards if controls fail or are not in place.	**EXISTING CONTROL MEASURES**	**PROPOSED CONTROL MEASURES** - Proposed action to minimise risk to an acceptable level.	**TARGET DATE** - To implement proposed controls	**RESIDUAL RISK LEVEL** (H, M,L)
Electrical Cables Plugged Incorrectly	Electrical Short Circuit due to misplacing connections	Excessive heat generation and damage to equipment and electrical components	High current connectors such as XT60 connectors are used. Can only be plugged in the correct way so short circuit should not occur.	Have multiple people check over electrical connections before powering on power supply. Have current limit set on power supply, have some ready to switch of power supply, fuse electrical components to prevent damage due to short circuit.	On the day of activities	L
Robot not secured correctly when on the test bed or when testing electrical components	Robot/components, e.g. motors, can move during testing and can cause harm or short circuits	To ensure everything is secured properly before testing. In case of fault, ensure someone is ready to cut the power or set over current and voltage protection.	Short circuit trips the circuit breaker in the room.	Have the lab supervisor and other lab attendees aware of the testing procedures and check over the setup and wiring. Ensure that over current and voltage protection are set on the power supply.	On the day of activities	L
Moving Electrical-Mechanical components	Work Environment – moving objects such as motors, wheels, gears.	Damage to equipment. Could cause harm when collision occurs with person at high speed or hands get caught in mechanism.	Torque and current limitations to motor. Fully enclosed shoes to prevent falling on feet causing damage.	Keep hands away from moving components. Ensure moving components are securely fastened to workbench. Stand away from working area where possible. Where safety glasses at all times.	On the day of activities	L
Sharp Edges	Material which is cut can often have sharp edges	Stabs or cuts to hands if handled	Corners are smoothed out where possible.	Sand down or deburr edges, inspect component for any sharp edges which are unable to be removed and pick up components from areas free from such sharps.	On the day of activities	L

Wires Disconnecting During Testing	The wires could get caught in the robot arm and pulled out of place	Damaged wires and connectors, creates more potential for shorts and/or robot malfunction	Route wires up and through the sides of the base and arm. Tape them down or use wire guides.	Route wires carefully to ensure they do not get caught. Use secure connectors such as terminal blocks and wago connectors where possible. Keep enough slack in the wires so they can freely move a little bit. Ensure fuses are used in the event of a short circuit due to a disconnected or lose wire.	On the day of activities	L
Working in the lab environment with hand tools and heavy/ large objects	Tripping on or knocking over loose objects, and incorrect equipment usage.	Causing bodily harm or damage to components and/or equipment.	Online and in person Lab inductions.	Morgan and Thien to perform in person inductions on day of activities as advised by Ricky. Supervisors must ensure team members are operating equipment safely as described in induction material. Supervisors to always remain in the lab. No one is to enter or be in the lab without a supervisor present.	Lab supervisor organised prior to the day of activities. Other control measures implemented on the day of activities.	L
Number of people in the Lab	Collisions with other people working in the lab or leg strain due to standing for long periods of time	Can cause bodily harm from colliding with people. Long term strain to legs resulting in soreness.	Seating at each bench and frequent breaks. Evaluating your surroundings.	Lab supervisors should ensure people are spaced appropriately in the lab and outside the safety envelope of people operating machinery. Lab supervisors to ensure people take frequent breaks from working and ensure there are plenty of seating.	On the day of activities.	L
Soldering iron	Hot tip that can cause burns and harmful fumes.	Burns and possible illness from inhaling toxic gasses	Safety inductions for soldering iron. Ensure safety glasses are worn.	If user of soldering iron is inexperienced have the lab supervisor show them how to solder and use fume extraction correctly.	On the day of activities.	L
Laser cutter	Blindness and harmful fumes.	Can cause lung irritations when inhaling fumes. Looking at the laser can cause blindness.	Safety inductions for laser cutter.	Only cut materials that are approved by technical staff.	On the day of activity.	L

Approval of assessment	I am satisfied that the residual risk with existing controls is acceptable X Yes ☐No OR I am satisfied that that the proposed controls will reduce risk to an acceptable level. X Yes ☐No	**Signature:** Long	Date: 23/04/2024