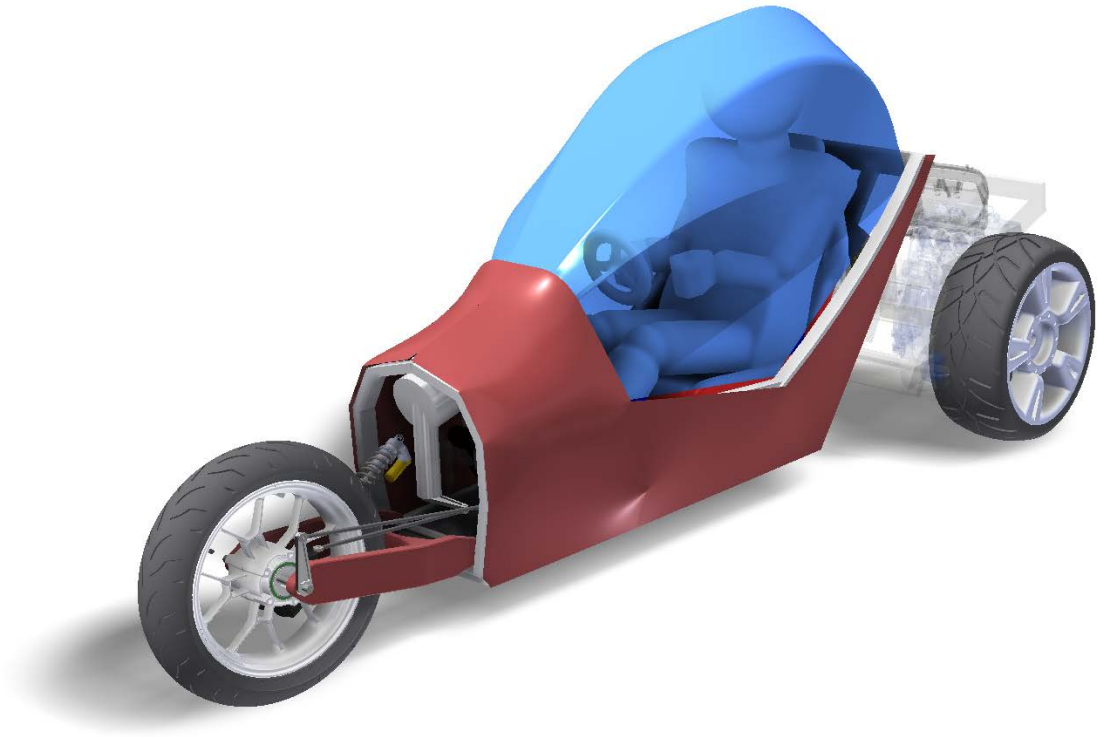
MECHENG 236: Design and Manufacture 2

Urban Transport Design Project

27 July 2020



1 Learning Objectives

- To learn to work on a real life-like design proposal.
- To extend the concept design skills learnt during the Warman Project.
- To further develop skills in working in a team-based, time-bound project.
- To gain experience in systems design.

2 Project Overview

Getting around modern cities can be very difficult. Public transport doesn't run often enough and doesn't reach all areas. Taking the car to work means an hour of sitting in traffic each way. Many people have opted to take a scooter or motorcycle to work, making use of T2 and bus lanes to avoid traffic. However, it is no secret that motorcycles are much more dangerous than cars. Without a safety 'cage', NZTA finds that riders are 21 times more likely to incur serious injury compared to drivers. The safety hazard small two wheeled vehicles present prevents large scale adoption.

Your company wishes to submit a design proposal for a solution to this problem. The tender process will close at **6 pm on Friday, 23 October 2020**. Your team of four mechanical engineers has been given the task of creating a personal urban transport vehicle. You must ensure that the mechanical design meets the specifications set and is complete and detailed enough to build confidence in your design by the clients.

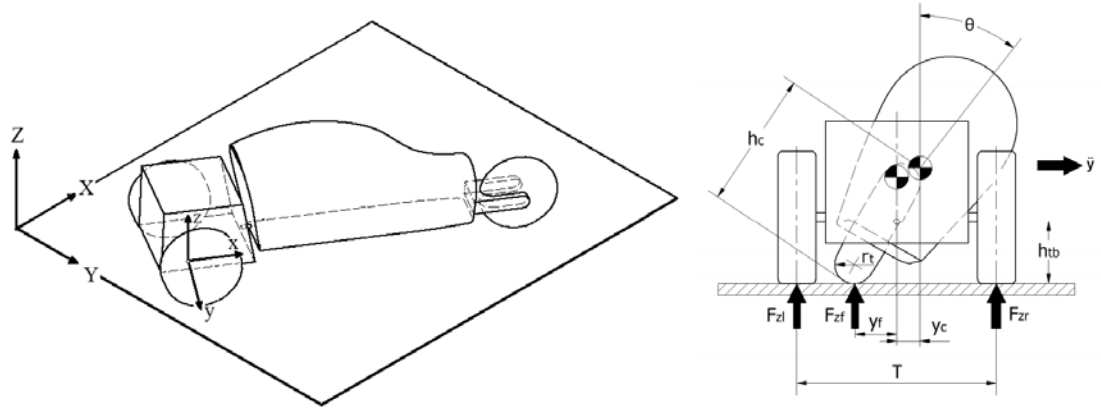


Figure 1: Vehicle diagram [Active Control of Narrow Tilting Vehicle Dynamics, James Roberts, 2014]

Your company wishes to fulfil this need by creating a three wheeled LE1[1] class vehicle, driveable on a car licence. The vehicle should be fitted with a 'shell' around the rider to protect from harm and should steer by leaning (Figure 1). The lean angle of the vehicle required for a corner is dependent on the vehicle speed, so an active steering system[2] is required for ease of drivability.

[1] Link to NZTA definition

[2] An active steering system can change the steering inputs intelligently.

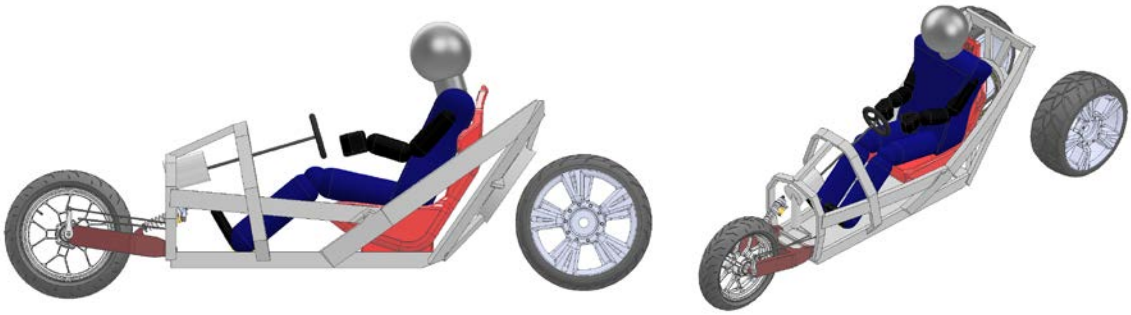


Figure 2: CAD drawing (provided)

The current design has already progressed through some of the conceptual design phase (Figure 2), and your team is expected to continue the work to finish the design. The front half of the car has already been conceptually designed, but you are free to make minor modification such as adding brackets or mounting points.

Your company has not yet determined a submarket to target the design at, and as such has left the design brief open to allow you to determine this within your design team. It is expected that the design you produce is 'tailored' to fit this submarket with appropriate justification. For example, you may choose to create an economical vehicle and market to particularly environmentally conscious customers. In your design proposal, you should discuss how your design (and the performance specifications) meet the target consumer.

Your team is required to provide a completed design proposal. You are also required to present your design to prospective investors/stakeholders through the use of AR technology. In your design proposal, you should also specify a one-page document on how to access the engine for maintenance, and which components can be maintained. Exactly which components are user accessible will be determined by your team throughout the design process.

3 Specifications

The following specifications have been collected from the clients and Australia-New Zealand automotive regulations, which your design should be conform to:

3.1 General specifications

- Must be classed as a LE 1 vehicle under NZTA law.
- Must seat 1 person.
- The leaning of the vehicle must be achieved using a hydraulic/pneumatic mechanism to allow active steering control. The steering geometry or dynamics is out of scope of this project.

3.2 Turning system

- The design must be able to lean from vertical to the maximum lean angle of 45 degrees (in either direction), within approximately 2 seconds.
- The design must be able to turn at least three, ±45 degree turning sweeps within one minute (total of 270 degrees of turning).
- The mechanism that controls the turning must exert at least 500 Nm of torque at all angles.
- The pressure system should not exceed 5 MPa.

3.3 Powertrain

- The vehicle must be powered by an internal combustion engine.
- The maximum force the driver can exert on the clutch pedal is 250 N.
- The vehicle must be fitted with an exhaust silencer system that operates constantly.
- The vehicle must have a range of 250 km per tank of gas.
- The vehicle should have a top speed of at least 125 kmph.
- The design must have a foot-pedal clutch.

3.4 Chassis

- A protective structure must encase the driver.
- The rider should be able to enter or exit the vehicle within 10 seconds.
- The vehicle should be easily accessible to most people and not require any heavy lifting to access.
- The vehicle should aim for a design lifetime of 10 years at 10,000 km per year.

3.5 Brakes

- The vehicle must use a foot actuated brake system.
- Brake friction material thickness should be visible without disassembly, or when it's not visible, wear shall be assessed by means of a device designed for that purpose.
- The maximum force the driver can exert on the brake pedal is 400 N.
- The vehicle must have a stopping distance of </= 33 m from a speed of 60 kmph in wet & dry conditions.
- The brake pressure should have a maximum operating pressure not exceeding 7 MPa.

4 Submissions and Due Dates

This project requires the following submissions:

4.1 First submission - 6 pm, 10 August 2020.

Your Design Office Manager will require a **Product Design Specification (PDS)**, an **Objectives Tree**, and a **Plan of Work,** scheduling the main tasks to be completed, before the start of the project. These documents should be no longer than one A4 page each and compiled into a single PDF file. One team member must upload the submission to Canvas by the specified date and time. Your tutor will provide feedback.

4.2 Second submission - 6 pm, 24 August 2020.

You must individually submit a concept design process for your subsystem responsibility. A few promising concepts should be discussed within each subsystem. These should be markedly different ideas rather than minor variations. Further instructions can be found in Section 6.

4.3 Design checkpoint - 1 pm, 28 September 2020.

By this date you should finalise the main parts of the design. You may make minor adjustments such as small variations in position and sizing of components, aesthetics and such like. However, major design decisions such as the choice and layout of major components must be fixed and not changed after this date. This is to ensure that you do not push major decisions too late and run out of time.

4.4 Third submission - 6 pm, 23 October 2020.

Two submissions are required at this time:

a) Your team must submit a single team proposal with drawings. Compile all your files into a single PDF document. One team member must upload the PDF file to Canvas by the specified date and time.
b) Your team must also submit your individual workbooks. Place all your team's workbooks into a single A4 envelope. Write your names and University email addresses, your tutor's name, and the words "ME 236: Project Workbooks" on the front. Submit the envelope at the SSS.

4.5 Model presentation (two stages):

(a) Management meetings - Week 8 (28 Sept. - 2 Oct. 2020).

You must present your design (CAD model demonstrated in AR) at the design team meetings with the project's managers.

(b) Design expo - 2 pm, 30 October 2020.

Your team will attempt to sell your design (CAD model demonstrated in AR), along with other teams, to prospective investors.

For more information on content of the submissions, refer to Section 6.

5 Assessment

You will be assessed on the quality and communication of design intent of your submissions. The project is worth a total of 38 marks, out of the course total of 100 marks. The breakdown of marks for the project is as follows:

PDS, objectives tree and plan of work	**6 marks**
Product Design Specification	3 marks
Objectives Tree	2 marks
Plan of work	1 mark

Individual design concept	**5 marks**
Team design proposal with drawings	**18 marks**
Proposal	10 marks
Maintenance instructions	3 marks
Engineering drawings	5 marks
Individual workbook	**4 marks**
Content and clarity	2 marks
Evidence of individual contribution and understanding	2 marks
Design expo presentation	**5 marks**

Note that penalties will be applied to late submissions.

6 Expectations

You are strongly advised to **read this section very carefully** and be sure to address all the points as you work through the project. You are also advised to study the detailed rubric, which will be provided as a separate document. The rubric will show how your design proposal with drawings will be assessed.

6.1 Overall project

The project will entail the creation of an individual concept or concepts, brainstorming, teamwork, morphological analysis, and so on. You are expected to follow a systematic process of design, following what you studied in MECHENG 235. Concepts will need to consider aesthetics, safety, maintenance, reliability, and other factors you deem fit. The team must select one of the concepts for further development as the subject of the final design proposal to the client. You should consider relevant usability issues. These include consideration of how the driver will interact with the vehicle, inspect it and maintain it.

6.2 Project management

The project has four main sections, or subsystems; powertrain, chassis, brakes, and turning system. It is advised that within your group of four[3], each member picks a subsystem that they specialize in, and take responsibility for. *This does not limit team members to working only on their own subsystem – you are still expected to work as a team, and help in other subsystems, as each section has varied workloads.*

Further details can be found in the "Team Structure Guide" on Canvas.

6.3 PDS and Objectives Tree

Your PDS should include a short foreword/introduction laying out the context for the design and summarising the high-level objectives. The detailed performance requirements should include all significant performance requirements; quantify any requirements that are vague or ill defined. In addition, you must state any regulatory requirements that apply to your design. The Objectives Tree should ideally have four levels of hierarchy. However, for some parts only three levels may be

[3] Groups of three should still 'focus' on one subsystem and split the fourth subsystem's workload equally between members. If there is a group of 5, one person can be the team manager, and take responsibility for the overall project. If you are in these situations, please discuss the work to be done with your tutor.

appropriate, whereas for others five might be needed. The Objectives Tree should cover all significant objectives and sub-objectives relevant to this part of your design.

6.4 Individual design concept

Within the subsystem you are responsible for, you should develop ideas on several design concepts by following a systematic design process. You should identify the best few ideas you had created and develop them into potential concepts for your subsystem.

The concepts for your subsystems should *not* be developed independently of your team. Instead, you should develop your concepts with your team, and comment on the **compatibility** with other concepts your team has created for the other subsystems.

It is very important that you ***collaborate*** with your team – otherwise you may find that what you design is not compatible with the rest…

Following the design process techniques shown in MECHENG 235, you should determine the best overall vehicle concept, and present your subsystem "piece" of that concept. Each submission should be no longer than three pages, including drawings.

Deliverables for submission:

- Create a handful of promising subsystems concepts. You should provide a diagram/sketch, brief description, pros/cons and note down compatibility with other team member's subsystem concepts.
- Provide an overview of the overall vehicle concept selection. You may reuse tables/diagrams created by the team between team members, but the evaluation and comments should be your own.
- Make it clear which of the subsystem concepts made the best overall car concept.
- You do not need to discuss at present (i.e. in this submission), the proposed final full vehicle concept. It is enough to state which one of the concepts from the morphological analysis was selected, and why.

6.5 Content of the proposal

Unlike previous design projects, you are required to write a proposal for your design to the clients, rather than a technical report read by other engineers. Therefore, the main body of the proposal should place emphasis on features of the vehicle in adequate detail and depth for clients and other senior engineers. It should also briefly communicate your design process. It should communicate your design solution through written descriptions, sketches and technical drawings. It should establish that the solution meets the specifications, and that all parts are appropriately sized.

Finally, it should include **up to one page of reflection.** Reflection should discuss what worked well, what did not, what you have learned and what you would do differently next time. It should also discuss the extent of iterations and design changes that were required during the design process. (Note that the section on reflection is included here as this is a classroom exercise. A real-life design proposal would not include this part, though in that situation you may keep reflections in your workbook or notes for future use). The proposal must include in its appendix written service instructions for accessing the engine bay for maintenance.

6.6 Format of the report

Your proposal should be set out on A4 paper in 11-point Times New Roman or similar font, with 2.5 cm margins on all sides. It should be properly structured with a title page, a contents page, a main

body, a conclusion, and appendices if necessary. Appendices may include (for example) calculations, mechanical engineering drawings, and suchlike. Length should be appropriate to content, but the report must be no longer than fifteen (15) pages maximum, excluding the title page, contents page and appendices. As the proposal is for clients, it is expected that it is professionally presented, i.e. images and so on are legible, and calculations are neatly presented, avoiding handwritten text.

6.7 Manufacturing and assembly

Designing for manufacture is an important aspect of design and should be considered throughout the design process. Designing a part and then figuring out how it can be manufactured at the final stages of the design process leads to a part that is unlikely to be easy or cost effective to produce. Instead, you should determine the overall manufacture method at the start of the design process. The features you design in the part should reflect the manufacturing process you have chosen.

As a rule of thumb, off the shelf components are much cheaper than custom made components. Therefore, it is advisable to use/modify off the shelf components and standard material sizes wherever possible, and only make a custom part if absolutely required.

6.8 Engineering drawings

Engineering drawings are essential in communicating your design. They need to be accurate and clear, otherwise you may risk receiving manufactured parts that aren't what you designed! You are advised to carefully review the drawing checklist used in MECHENG 235. It is expected that critical dimensions have an appropriate tolerance applied.

A drawing template will be provided to you on Canvas. If you have any questions regarding engineering drawings, a good place to look is "Technical drawing for students" (SAA/SNZ HB 1:1994). Key requirements will be listed here as well, and your drawings must:

- Include a complete Bill of Materials (BoM) with enough information to allow the client/contractor to order all the parts required, produce the custom manufactured or modified items, and assemble the vehicle.
- Each member of the team must sign and date the drawing once they have determined that the drawing is of acceptable quality.
- Clearly identify the team member's name responsible for that drawing.
- Include a brief description on how to either manufacture or assemble the part.

Whatever drawings are produced are expected be of high quality and complete. They should be easy to read, with complete dimensions that are appropriately laid out, and with appropriate tolerances specified. Note that you do not need to draw purchased machine parts like electric motors or chains in detail; simple shapes to show the outline or envelope of the part are acceptable.

It is important that the **drawing workload is equally distributed between team members** such that each team member contributes equally towards drafting engineering drawings. The amount of effort spent by each team member should be similar; in other words, one team member creating 5 simple drawings and another creating 5 complex drawings is not an equal workload. Having a single team member do all the drawings is *not acceptable.*

Drawing scope:

- Standard off the shelf components do not need to be drawn, but it should be clear where these parts are positioned through an assembly drawing.

- You should provide at least one assembly and one subassembly drawing, showing how all the parts assemble. You should have enough subassembly drawings (and/or exploded views) to clearly display your design intent.
- The components in the CAD drawing provided do not need part or assembly drawings.
- There will be an upper limit of 5 part drawings, and 2 assembly/subassembly drawings per student. You should make drawings for the most critical parts, and you may ask your tutor for advice.

6.9 Management meeting

Your project managers want to make sure that the project is on-track and will require an approximately 20-minute long face-to-face meeting with your team to evaluate your design (in week 8). You will be expected to present your design in its current state and address their concerns. The design you present should have all the major components and higher-level concept decisions finalized. Be prepared to amend your design to consider any suggestions that are useful, or any criticisms that are valid.

You will present your concept and the design process your team followed, using **AR technology**, for the first 5-10 minutes, which will be followed by a discussion on points the managers deem fit. All team members must be present. You are expected to record the minutes of the meeting and demonstrate in the proposal that the concerns have been addressed.

This meeting will not be graded directly and is primarily a learning experience; however, how you address comments in your design proposal is assessable.

6.10 Design expo

At the completion of your design, you will need to secure funding. Fortunately, an automotive design expo is about to occur, and by attending, you could secure funding from a potential investor. Other teams will also be present at the expo.

In preparation, your team should:

- Finalize your AR model demonstration
- Create a 2-minute sales pitch. You may include things such as:
  Who are your product's customers, why them, and how your design will appeal to them.

You will be graded based on your business case, sales pitch, and design presentation. The presentation quality of the AR model, and therefore the CAD model you generate, *is assessable.*

Once you have presented your design, you will be free to check out designs other teams have created. You may vote on your favourite design, and there may be a 'student choice' prize up for grabs.

6.10.1 AR model demonstration:

The demonstration of your model is achieved through AR technology. Your CAD model can be converted into a format that is viewable on a tablet, which will be presented in the meeting. You may wish to show the model in multiple configurations to demonstrate your design better. Instructions on how to achieve or perform this conversion will be released closer to the presentation time.

7 Peer Assessment

An **optional** peer assessment will be done at the end of the project. Details will be given out through Canvas announcements towards the end of the project.

8 Feedback

This is a new MECHENG 236 project and the first year it has been implemented. Inevitably, problems may arise, and in those cases, you should talk to your tutor – amendments to the project will be made if required.

You are free to leave comments which will be used to improve the project for future years. A link to an anonymous survey will be sent to your email, or you may click on this hyperlink.

Happy designing!

The MECHENG 236 Teaching Team