SIMON FRASER UNIVERSITY
THINKING OF THE WORLD

Mechatronics Project
MSE 312: Mechatronics Design II

Revision History

Date	Version	[redacted]	Comments
April 19 2021	V1_1	[redacted]	New Document
May 13	V1_2	[redacted]	Updates
June 7	V1_3	[redacted]	Change to design brief assignment and mechanical report

Summary

This document outlines the project for MSE 312 students and provides further information required for successful completion of the project. It is your responsibility to read this document carefully and be aware of an update to the document. The latest document will always be available on Canvas.

Introduction

MSE 312 is being run remotely during Summer 2021 due to the Covid-19 pandemic. At all times, you must comply with the current BC requirements and recommendations with regard to social distancing and associated preventative measures. You should be aware that your situation and risk tolerance may not be the same as your group members, who could be living in a house with an immunosuppressed or elderly person, have a lower general risk tolerance or be located outside the lower mainland. You should be cognizant not to pressure your group members into situations they may not be comfortable with, even if they are within the current BC guidelines.

The Course Project is a chance to practice the teamwork skills that are particularly vital if working for a large national or multi-national company, with departments located in different physical locations. If is not uncommon to never meet your fellow team members in projects or only meet very infrequently for kick-off meetings and major milestones.

The lectures and content presented in this Course will directly feed into your main project. You will learn information regarding mechanical design and analysis, electronic / electrical design, modelling and safety and control systems. These will need to be incorporated into your final project. It is recommended you review the timetable so you know when information is provided, for example you should not be spending a large amount of time on the control system before you have virtually attended the control lectures (unless you have a large amount of prior knowledge).

Students must work in teams of three and cannot work independently. Groups will be assigned randomly – reflecting the reality of working with colleagues in a real world setting. Developing teamwork skills in an important part of training to become an engineer. Learning how to get the best out of yourself and your teammates will be an important outcome of this project course. Students have access to a Zoom account through SFU or can use BB Collaborate through canvas for remote communication.

Project: Design of a throwing arm

This project involves the design of a robotic throwing arm. You must follow and document a rigorous design process to generate, assess and demonstrate a virtual design solution that accurately models and controls a throwing arm structure. The arm structure must virtually launch a projectile to predetermined locations with high accuracy. This model must include the following systems:

- Design of an arm mechanism, including its weight, inertia and stiffness within the time domain simulation
- Design of a drive system (gears, belts, chains or other) to transmit motion from a rotational motor.
- Projectile motion analysis.
- Motor and associated operational electronics.
- Control system that provides motion control for the arm.
- A method to introduce and characterize noise or uncertainty into the simulation.

This project is computational only, there is no physical prototype requirement; however you will be asked to find, spec and cost parts for your proposed design including the fabrication of your structural elements. Your final design must cost less than $500. Everything must be specified from a parts list or fabrication center. You cannot budget to manufacture parts yourself (e.g. no 3D printed parts from your basement). You must include the specifications for your chosen parts in your simulations.

Project Requirements

Your throwing robot arm will be assessed on its ability to land a ball at prescribed locations accurately and quickly as well as the maximum height and distance – these can be in separate throws. The different steps that your project must perform are below:

1. Your arm will start at the zero position and must be stationary. The arm must begin moving when (or very shortly after) you start your simulation. You may not interact with the computer again until the simulation is completed.
2. The arm must be able to accurately launch a ball to prescribed locations within a defined field of play. You will not have the positions ahead of time. Three positions will be provided for you at demonstration time. They can be implemented in any order. Your simulation should include real time calculations to adjust the motion control of your arm mechanism to meet the defined positions. The ball must land (first impact) within 2 cm of the target position to be considered successful. You will have a maximum of three minutes once given the positions to begin your simulation.
3. You must build the following data collection into your code:
    a. A timer. Your timer must start when you first move the arm and end when the arm has returned to the start position after the last throw. The timer must output a count in seconds that is accurate to 2 decimal places, and be available for inspection after the demonstration.
    b. Ball first-impact monitor. You must build a method to identify and store the position that all three balls first impact with the ground. You can not read of these values from plots.
    c. Power use. You should record the power that your motor uses. This must be output in watts as a number to at least 2 decimal places.
4. The arm does not need to return to the start position between each of the three throws but must return to the start position at the end of the simulation to stop the timer.
5. After the accuracy test, you will be asked to demonstrate the maximum height and distance you can obtain with your design. You will have one throw for maximum height and one for maximum distance. This part of the demonstration is not timed.

6. You will then be asked questions on your demonstration and software, which may include showing and explaining parts of the software and / or making and implementing changes to your software and running new simulations.

You will be assessed on:

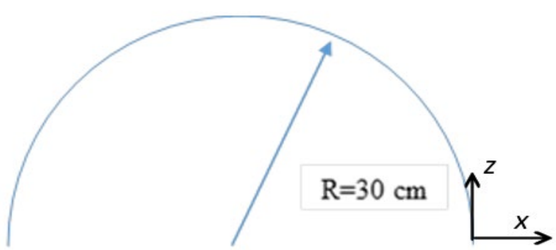
a. Your accuracy of your throw simulations, for each of the three tests
b. Performing this task with **<u>strict adhesion to the requirements stated above and the specifications given in this document.</u>**
c. The time taken between starting the simulation and returning to the start position after the third throw is complete, the fastest time as well as the consistency between the times will be noted
d. Your ability to answer questions on your simulation code and alter the code as requested.

Throwing Arm Specifications

The project involves the combination of mechanical, electrical and control design to throw a 63 mm diameter, 145 g ball (NOCSAE Standard Lacrosse Ball). The arm must start at a self-selected “start” position. The optimal design is the one that launches 3 balls to three targets the fastest and with the greatest accuracy. Maximum throw height and distance are secondary objectives. The mechanical component of the project involves the design and construction of a mechanical “arm” that satisfies the criteria outlined below.

Arm structure (including all supports):

a. Maximum vertical plane operating radius = 30 cm. The horizontal and vertical position of the ball is measured from the origin as indicated. Your structure can be positioned anywhere within the vertical operating plane, although it does need to rest on the ground (at z=0).



b. Must have passive mechanical support to hold and release the ball.
c. Maximum width of 10 cm (not including motor).
d. Ball assumed to be “automatically” loaded after each launch, from the same location within the maximum vertical plane operating radius (see a.)
e. Driven by a single motor.
f. Additional gears, pulleys, or mechanisms can be employed in the arm mechanism. No additional motor can be used.
g. Minimize the radial and axial forces on the shaft of the motor.

2) Material specifications:

   a. Can choose any material – you should select and assess at least 3 materials in your designs. You must cost your materials and fabrication method to fit within your project budget.
   b. All connections must be included in the design. Are parts welded, drilled, tapped etc?
   c. Connections to the motor shaft must be specified.

3) Integration Specifications:
   a. The maximum sampling rate of any position (including velocity and / or acceleration) sensors is 64 Hz.

Project Requirements

Deliverables

24th May	Initial Project Proposal
7th June	Design Brief and Concept Proposal 5 min presentation (week 5)
21 June	Mechanical design and analysis report
16 July	Course project related to Motion Control – details to follow
9 August	Final Report – details to follow
Week 13	Presentation – details to follow

Initial Project Proposal

All groups must submit an initial project proposal by the 24th of May. The initial project proposal should be 1 page and submitted as a PDF on Canvas. The proposal should be a formal technical document.

You must provide the following information:

- Provide your group name and the names of the group members
- Describe how you are going to distribute the different roles within the Project so that everyone contributes fairly
- Provide some information regarding your communication plan. What technology are you going to use to communicate, how are you going to store your data, and how will manage your virtual simulation to ensure everyone has access to it while implementing version control
- How will your team work together and what are your team expectations? How will you hold and organize meetings and how will you be considerate of each other
- How will you manage Covid-19 safety concerns?
- Are you planning on utilizing the MSE remote computers or will you use your own? Do you know how to download any software you may need?

Design Brief and Concept Generation

The Design Brief and Concept Proposal is split into two requirements. A 4 minute "elevator pitch" presentation where you present your Design Brief and Proposed solution; and a more comprehensive short report.

4 Minute Presentation – Time slot in Week 5

Your 4-minute presentation should include the following information:

- Design Specifications – what are the measurable requirements for your solution?
- 3-5 generated solutions – what are your best ideas to solve this?

This will be followed by a brief (<5 min) question and answer session.

Mechanical Project Description

The write up and deliverables for the mechanical section of MSE 312 must include four critical elements – 1) three design options for your mechanical element, 2) analytical (hand) calculations for the structural (stiffness and deflection) and dynamic (inertia and kinematics) characteristics of your design, 3) simulations to determine the detailed structural characteristics, 4) costing of your raw materials and fabrication methods, and 5) discussion of your different mechanical analysis components and an evaluation of your mechanical designs to select the best design.

General design objectives

1) Design a mechanical system that will not fail for the anticipated loading requirements.

2) Balance the mechanical stiffness (minimize deflection) of the system with inertia (rapid acceleration)

3) Assess the value of different calculation approaches and understand their role and value in the design process.

4) Format equations to determine the launch position and velocity required to hit specific position targets.

Mechanical Project Deliverables

1) Solidworks model of your selected mechanical design.
2) Simulation of your mechanical design.
3) Brief Mechanical Design Report (maximum 6 pages of text – double spaced, 12 pt, 1” margins) **should be uploaded to Canvas.** The report will be evaluated out of 100 pts and must include

Grading rubric posted to Canvas.

Time Frame (To be finalized)

Weeks	Date	Content
Week 1	13-May	Project Introduction and Teamwork Tools. Remote working and team strategies
Week 2	20-May	Design Process
Week 3	27-May	Kinematics and Kinetics of mechanisms
Week 4	03-Jun	Analysis of mechanical systems
Week 5	10-Jun	Electrical/Electronic Interface Circuit Design
Week 6	17-Jun	Electrical/Electronic Interface Circuit Design
Week 7	24-Jun	Protection and start/stop circuitry
Week 8	1-Jun	Electronic Project
Week 9	08-Jul	Control Design and Implementation
Week 10	15-Jul	Implementation of a position control system using Arduino board and DC motor
Week 11	22-Jul	Integration
Week 12	29-Jul	Safety and Risk
Week 13	05-Aug	Demonstration of Integrated Project

Assessment

Evaluation Component	Proportion of overall mark
Mechanical Design and Analysis Mechanical Design and Analysis report	20%
Electrical/Electronics	20%
Controls	20%
Final Project	40%

Teamworking and Assessing Teamwork

Teamworking is a vital part of this project and will be directly assessed using the following methods.

1) Peer Review
2) TA review
3) Contributions page
4) Team working sections within Deliverables

Peer Review

At regular intervals you will be asked to evaluate your group members team working skills alongside your own. You will be asked to split a fixed number of points between members of your group in the following categories. Due to the small teams within MSE 312, the results from the peer review will not be released to your fellow group members, although it will be accessible to the instructors to TA's. The instructors and TA's may discuss the overall results of this evaluation to aid future teamworking but will not release individual scores. An overall mark, available at the end of the semester will be provided.

Contribution to the project. This includes if the person actively participates and accepts a fair share of the work. That the person works skillfully on assigned tasks and completes them on time, as well as giving timely and constructive feedback to other group members.

Communication skills: The person communicates actively and constructively while encouraging all perspectives to be considered and acknowledges the contribution of others. They report to the term on their progress and where required, clarify the goals and plans for their work.

Team building skills: The person acts with consistency and coherence. They facilitate contributions from others and fosters a team climate. They display appropriate assertiveness (neither dominating, submissive or passive aggressive) and contributes to healthy debates while managing conflict constructively. The person takes on an appropriate role within the group (leader, note taker, specialist).

If it is believed that a student is deliberately "playing the system" to artificially increase their mark from the peer review, then their peer review submission may be altered.