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Engineering DesingJournal

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Week 1 – Sprint 1

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Watch past Warman Challenge competition videos	COMPLETED
Complete Team Charter	COMPLETED
Complete Requirements list	COMPLETED

Progress

Attended the face-to-face Workshop, met and formed our group for the upcoming project. Set expectations and goals for the semester to come.

Were introduced to the design review, need to delve deeper into what this means and what is expected of me.

Watch videos of the 2023, 2022 and 2021 Warman's Challenge, this was a good indication of the competition. I saw what the top projects look like and what is involved in these systems, most of these teams focused on speed, specifically on being efficient with movement to result in the best times possible. Focusing on keeping the system simple and efficient will be the key to have a successful system.

Contrasting this with a video of another team from UTS from a previous year, I saw how important, and how difficult, it can be to complete the entire challenge not just completing it quickly. It will be imperative to start working hard now in the beginning of the semester, so that we can create a system that works before we start worrying about being competitive.

Key Learning

Studios are student focused learning, so it is incredibly important to stay on top of tasks and deadlines. This is something our team has promised to hold each other accountable for our work.

Reflection on Feedback:

N/A

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

N/A

Week 2 – Sprint 1

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Brainstorm Ideas for sub systems	COMPLETED
Sketch ideas of sub systems	COMPLETED
Complete Morph Table	COMPLETED
Complete Design Review 1	COMPLETED

Progress

I attended the face-to-face workshop, where we discussed the design review in more detail. We then entered the ideation phase of this project development, for the design review we what to have 3 of our strongest ideas for the challenge. As a group we spent some time pitching our initial ideas, from there we started to sketch ideas.

Following class, I did more sketching and started to complete a morph table. This continued until the morph table was complete, from there our team worked on the design review 1.

For the design exercise 1, it is a lot of CAD work, I started doing this to stay on top of deadlines.

Key Learning

For the design exercise 1, I did not know what configurations were, this allow you to make changes quickly to CAD designs and you are able to have many of them so that you are able to toggle through different configurations to see what best fits your design. I foresee this to be very helpful not only in this studio class but in my future CAD projects.

Reflection on Feedback:

N/A

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

N/A

Week 3 – Sprint 1

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Finalise 3-4 preliminary designs	COMPLETED
Sketch design sub-mechanisms	COMPLETED

Progress

This week was a week mainly spent on working the design exercise 1 and the design review 1.

We had the opportunity to present this week for the design review 1. We had prepared well, our morph table and ideation section I though was quality work, we had some really good ideas, we had some out of the box ideas, and we had a large quantity of ideas that we could choose from. Our team management section also was very detailed which I felt confident about. I requirements list really lacked, but tat is something that we know that we will have to work on.

Our presentation was a little clunky, this was down to not having practice runs. We went vastly over time and didn't get to our last section. This is ok, we had some positive feedback and know where we need to work.

The later part of the week was spent doing the design exercise.

Key Learning

Preparation is key to having good presentation, even when feeling confident it is important to practice the delivery so that the ideas are able to shine and not be diminished by bad presenting.

Reflection on Feedback:

Feedback was mainly from our presenting skills, next time we need to practice our delivery so that we do not loose track of time especially, but also so that we can deliver our point more clearly.

Besides that, there was not much technical feedback, feedback on our ideation was great, we will work on more so that we can gain more feedback when it comes to design selection.

Our requirements list was not up to standard, which we may have expected, nevertheless we will look to improve that, we understood the feedback and understand we need to elaborate a not be so vague.

Use of ChatGPT/AI resource

This week with the design exercise, there was sometimes with CAD I was stuck trying to find a specific function and what I found the most helpful was when I didn't know how to change the display between configurations. I was able to ask AI as I would a lab technician and it walked, we through the process, this saved me heaps of time not needing to shuffle through dozens of videos trying to find the answer when I

was able to ask and get an answer straight away.
https://chatgpt.com/share/c62891fe-0f2c-46ba-853d-640a7bf14d31

Resolutions for future behaviour

Practice our presentations and dedicate some time to getting the delivery right.

Week 4 – Sprint 2

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Research Components for sub-assemblies	COMPLETED
Scoring matrix for subcomponents	COMPLETED
Storyboard our first preliminary design	COMPLETED
Fix requirements list (as per feedback)	COMPLETED

Progress

Sprint 2 is where we started to put everything that we had ideated together. This week we worked together to get some preliminary designs together. We began the week fixing the requirements list together as a group which was one of the aspects of the first design review that we didn't meet the standard. This we worked on by branching out from just the rules of the Warman challenge but also t

Key Learning

I learned the importance of a comprehensive requirements list, through broadening our focus beyond just the challenge rules, we were able to identify critical design criteria that improved our preliminary designs. This approach highlighted the need for thorough planning and consideration of all project aspects early in the development process.

Reflection on Feedback:

Feedback from the first design review emphasized the need for a detailed and well-structured requirements list. Incorporating this feedback, we focused on refining our list to ensure it covered all necessary aspects. This feedback-driven improvement process reinforced the value of constructive criticism in enhancing our project outcomes.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

Moving forward, I will ensure that we continuously revisit and refine our requirements list as the project progresses. Regularly updating and validating this list against our evolving design will help maintain alignment with project goals and standards. Furthermore, I will encourage the team to adopt a more holistic approach in the initial planning stages, considering all factors that could impact the design and functionality of our project.

Week 5 – Sprint 2

Weekly Plan

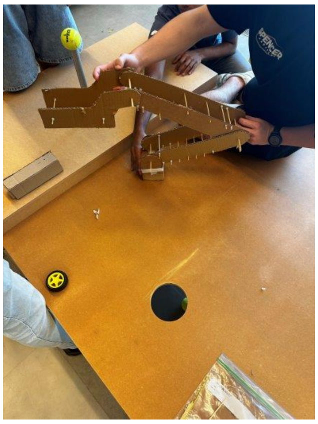
Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Finalise systems designs	CONTINUED
Prototype Robot Arm	CONTINUED
Start working on design assembles	COMPLETED
Work on Procurement plan	COMPLETED

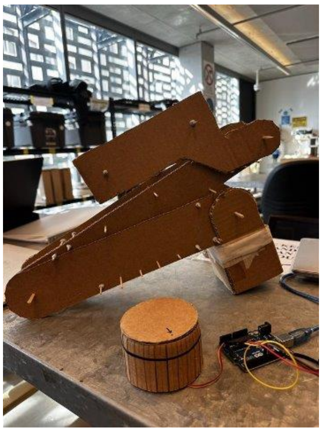
Progress

This week, I designed a low-fidelity cardboard prototype of the robotic arm. This prototype provided a scale replica of what the arm would be like, allowing us to observe important aspects such as distances, how the arm would reach the seed pods, and how it would interact in different configurations of the ball's location.

We also attempted to finalise the system design, but we were unable to conclude. Currently, we have four designs under consideration. Hopefully, we will receive constructive feedback from Design Review 2, which will enable us to make an informed decision.

For Design Review 2, I was working on the procurement plan. I divided this plan into three categories: building materials, electronics and Arduino components, and assembly tools and equipment. From here, I split the list into supplies, costs, timeline, and additional notes.





Key Learning

The creation of a low-fidelity cardboard prototype was instrumental in understanding the physical dimensions and operational dynamics of the robotic arm, providing valuable insights into how the arm would reach the seed pods and interact with different configurations of the ball's location, allowing us to observe crucial aspects such as distances and interactions. This hands-on approach to prototyping highlighted the importance of early-stage physical models in identifying potential design issues and refining the overall concept.

Attempting to finalise the system design highlighted the complexity and necessity of thorough evaluation and decision-making in the design process. The challenge of balancing multiple design options emphasised the significance of collaborative feedback and iterative refinement. This experience underscored the importance of considering various perspectives and incorporating feedback to ensure a well-rounded and effective design.

Reflection on Feedback:

Receiving feedback from Design Review 2 will be pivotal in guiding our next steps. Constructive criticism will help us identify potential flaws in our designs and provide insights that we may have overlooked these problems. We aim to use this feedback to enhance our design choices, ensuring that the final system is both functional and efficient. Embracing external input is a crucial part of the iterative design process, and we are committed to leveraging this feedback to make informed and strategic decisions moving forward.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

Based on the learnings from this week, I resolve to incorporate more iterative and rapidly prototyping in future projects to quickly identify and address design challenges. I will prioritize gathering and integrating feedback from peers and stakeholders at multiple stages of the design process. This will ensure a more robust and well-rounded approach to problem-solving and project development.

Week 6 – Sprint 2

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Finalise Systems Designs	COMPLETED
Prototype Robot Arm	COMPLETED
Start working on Design Assembles	COMPLETED
Finish Design Review	COMPLETED

Progress

This week focused on Design Review 2 and Design Exercise 2, both due this week (with Design Exercise 2 given an extension due to a public holiday). For Design Review 2, my contribution centred on the procurement plan and the cardboard prototype.

My team met an hour before our scheduled class to finalie the PowerPoint, ensuring all necessary information was included. Based on the feedback we received from the first design review, we practiced the presentation to ensure our delivery was smooth. We received some quick feedback before presenting, made a few changes, and then proceeded with our presentation. It went well, and we received valuable feedback that we will use going forward.

We have now chosen a design. Initially, we had four robotic designs but hadn't selected one to start with. After the presentation, we returned to our room and deliberated until we decided on the robotic arm. With this decision made, we can begin developing the subsystems.

Key Learning

Practicing and refining our presentation highlighted the importance of preparation and clear communication. Incorporating feedback from the first design review improved our delivery and confidence, demonstrating the value of iterative practice.

The feedback we received before and during our presentation proved invaluable. It emphasized the importance of seeking and utilizing constructive criticism to enhance our work and guide our decision-making process.

Deliberating on the final design choice after the presentation was a critical learning experience. The process highlighted the need for thorough evaluation, discussion, and consensus in making informed and strategic decisions.

Reflection on Feedback:

We received detailed feedback highlighting areas for improvement. Notably, there was too much information on our slides, and the procurement plan was incorrect. Constructive criticism is essential for growth, as it points out both strengths and weaknesses, helping us refine our approach and enhance the quality of our work.

Our Gantt chart needed more detail for weekly tasks. We added individual tasks to the chart, providing a clearer roadmap for project progress. This detailed approach ensured better task management and accountability.
We were advised that not having a chassis prototype was a significant oversight. Whilst we had a cardboard prototype it was not the specific ply base plate that was required.

The feedback session played a crucial role in our decision-making process. The input helped us weigh the pros and cons of different robotic designs, ultimately guiding us to select the robotic arm. This decision has provided a clear path forward for developing the subsystems.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

Based on the feedback and experiences from Design Review 2, I am committed to enhancing my preparation by dedicating more time to practicing and refining presentations. I will actively seek regular feedback throughout the project lifecycle, ensuring early identification and resolution of issues. Incorporating feedback thoughtfully and promptly will be a priority, viewing it as an opportunity for continuous improvement.

Week 7 – Sprint 3

Weekly Plan

Plan	Status
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Redo Scoring Matrix Plan	COMPLETED
Redo Procurement Plan	COMPLETED

Progress

This week was challenging due to a lack of motivation caused by the public holiday on Monday, which meant we did not have class. Poor communication among the team resulted in little work being done, which I regret.

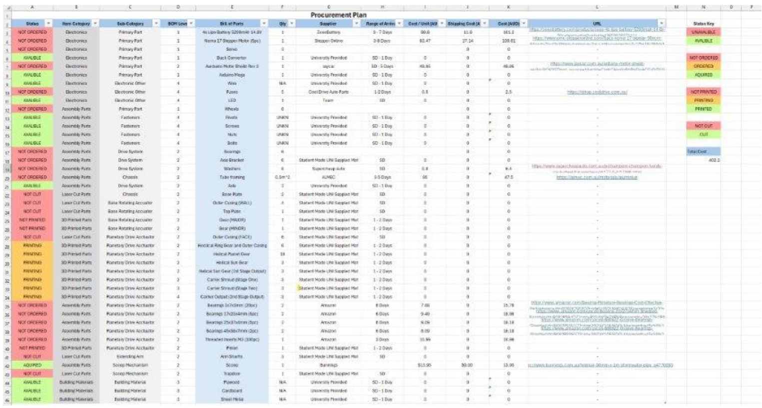
However, following the feedback from Design Review 2, I revised the procurement plan and the scoring matrix. The issue with the scoring matrix was that it was not subjective enough and lacked justification for the categories being judged, so I redefined the categories, explained why they were considered, and then recorded the results.

Scoring Matrix

	Cost	Movement Effeciency	Modularity	Manufacturability	Program Complexity	Reliability	TOTAL SCORE	Ranking
Weighting	1	3	2	1	2	3		
Crane Design	3	5	3	4	2	4		
Weighted rating	3	15	6	4	4	12	44	5
Robo Scoop Design	3	1	4	5	5	1		
Weighted rating	3	3	8	5	10	3	32	1
Encapsulating Design	2	4	2	3	3	2		
Weighted rating	2	12	4	3	6	6	33	2
Stacked ext. Design	2	3	2	2	3	4		
Weighted rating	2	9	4	2	6	12	35	3
Robo Clamp Design	3	2	4	5	5	1		
Weighted rating	3	6	8	5	10	3	35	3

Cost	The estimated cost of the system. This mainly focuses on how many motors, sensors, servos it will need as we predict that is where the majority of the cost will be related to.
Movement Effeciency	Movement Effeciency refers to specifically to time, of course the system needs to be in the 120 second time limit, however, less movement means a faster time, less chances functions running inccorectly and more time for functions to run therefore increasing the consitenicy.
Modularity	Modularity focuses on how easy is this design to take apart, if all the components are accessable and easy to fix/replace, specifically refering to complex sub systems.
Manufacturability	Manufacturability considers the time we estimate it take to build. Specifically refering to 3D printed parts asthey can take some time or laser cutting which can be completed quickly, but also the sub assembelies that need to be built, reguarding their complexity.
Program Complexity	This is an estimate on how hard the system will be to program, how many movements need to be run, how complex will this be to implement?
Reliability	Reliability refers to how the system will be run, based from the research and prototyping, what are the "unreliables"? What can happen that is out of our control, and how many of these instances will happen?

For the procurement plan, we had initially only highlighted some electronics we thought we might use without understanding what a comprehensive procurement plan or bill of materials entails. I split the plan into multiple categories: status, item category, subcategory, BOM level, bill of parts, quantity, supplier, range of arrival, cost per unit, shipping cost, and overall costs, with URLs attached. This structure allowed us to visualize the needed parts, track their status (ordered, not ordered, printed, not printed, cut, not cut), and easily access the URLs to acquire the components. This way, anyone on the team could quickly purchase the necessary parts by following the provided links.



Key Learning

This week underscored the importance of maintaining consistent communication within the team, the lack of communication and coordination, especially following a public holiday, led to significant delays and inefficiencies in our work. It highlighted the need for establishing regular check-ins and updates to keep everyone on the same page, regardless of external disruptions.

Revising the scoring matrix based on feedback taught me the value of clear justification and objectivity in evaluation criteria. By redefining the categories and explaining their relevance, I was able to create a more robust and defensible scoring system.

Updating the procurement plan emphasized the importance of a comprehensive and detailed approach. Breaking down the plan into specific categories allowed for better organization and visualization of the project needs. This detailed plan not only clarified the status of each component but also made the procurement process more accessible and efficient for the entire team.

Reflection on Feedback:

Reflecting on the feedback from Design Review 2, I recognize the importance of clarity and justification in all aspects of our project. The comments on our scoring matrix revealed that our evaluation criteria were too vague and lacked necessary explanations. By addressing these issues, I learned how critical it is to provide clear, objective, and well-justified criteria to make the evaluation process transparent and defensible.

The feedback also pointed out that our procurement plan was insufficiently detailed. This critique was instrumental in pushing us to rethink our approach, leading to the creation of a more comprehensive plan. By breaking down the procurement process into specific categories and including detailed information such as BOM levels, costs, and URLs, we enhanced our ability to manage and track the project components effectively.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will ensure regular and clear communication within the team by setting up consistent check-ins and updates, especially during weeks with interruptions like public holidays. This will help keep everyone aligned and informed.

Engaging the team in collaborative decision-making processes will be essential, ensuring diverse perspectives are considered and informed choices are made collectively. I will work on maintaining motivation and engagement within the team, fostering a supportive environment where team members feel encouraged to contribute actively.

By implementing these resolutions, I aim to enhance both my individual performance and the overall effectiveness of the team, ensuring successful and efficient project outcomes.

Week 8 – Sprint 3

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Outline tasks for Design Exercise 3 for the Team	COMPLETED
Review CAD for Design Exercise 2	COMPLETED
Review Design and Outline areas to Improve	COMPLETED
Medium Fidelity Prototypes of Assemblies	COMPLETED
Model via CAD Planetary Drive	CONTINUED
3D Print Prototype of Planetary Drive	CONTINUED

Progress

This week, following Design Exercise 2, we aimed to get a jump start on Design Exercise 3. As a team, we outlined tasks for each member. My task was the mechatronic components for the robotic arm. I began by researching the necessary electronics, focusing on motors, controllers, and batteries.

I found that stepper motors are particularly suitable for actuators because of their precision and control. They allow for accurate positioning without needing complex feedback systems, making them ideal for the robotic arm's movements. Equipped with this knowledge, I decided on the motors and controllers for our actuators.

Motors	Pros	Cons	Justification
Stepper Motor	- High precision control - High holding torque - Excellent repeatability	- Less efficient - Potential Higher Power consumption	Chosen for superior precision, holding torque, and repeatability. Ideal for applications requiring precise and consistent movements.
DC Motor	- Smooth speed control - Higher efficiency - Simpler control	- Lower precision - Requires additional mechanism for position holding (encoders)	Not chosen due to lower precision and lack of inherent position holding capability.

Controllers	Pros	Cons	Justification
Digital Controllers	- Support for complex control	- More complex	Not chosen due to the simplicity

	algorithms - Easier programmability - Greater flexibility	implementation - Potentially slower response times due to processing delays	and fast response required for the robotic arm.
Analog Controllers	- Simpler implementation - Faster response time - Greater reliability in harsh environments - Cost effective	- Limited to simpler control tasks - Less flexibility and adaptability	Chosen for simplicity, faster response time, and reliability. Suitable for the straightforward control requirements of the robotic arm.

After discussing with the group and a mentor, we considered using stronger motors to avoid needing gearboxes. However, due to budget constraints and weight considerations, we chose a hybrid approach. We selected a NEMA 23 motor for the base actuator, as it can handle higher torque and stress, despite being heavier. For the other three actuators and the rotating base, we opted for NEMA 17 motors, which are lighter and sufficient for the torque requirements along the arm.

For the controllers, we chose A4988 controllers for the stepper motors. These are simple, cost-effective, and compatible with the NEMA 17 motors, making them an excellent choice for our project.

In a team discussion, we decided to scrap the robot's drive system due to concerns about wheel synchronization and potential course deviations. Instead, we opted to make the arm stationary, capable of reaching all parts of the track, which we believe is a more reliable design.

After further discussions, I decided to change my artifact to focus on a planetary gear drive actuator. Initially, I created a low-fidelity prototype using typical spur gears to visualize the concept in CAD. For the second iteration, I used a 4:1 ratio for testing, calculated the necessary teeth, and generated helical gears in SolidWorks. I then created a ring gear and a basic carrier to test the movement. I got inducted into ProtoSpace and printed the second iteration of the planetary gearbox design on Friday.

Key Learning

This week highlighted the importance of early planning and task delegation. By outlining tasks for each team member at the start of the week, we set clear objectives and responsibilities, which streamlined our efforts towards Design Exercise 3.

Researching and selecting the appropriate mechatronic components reinforced the value of due diligence. Understanding the advantages of stepper motors for precise control and the necessity of choosing suitable controllers and motors based on weight and torque requirements was crucial, This deep dive into component selection emphasized the need for informed decision-making to balance performance and budget constraints.

Reflection on Feedback:

The discussions about motor selection and the potential elimination of gearboxes brought to light the importance of balancing performance with practical constraints such as budget and weight. The feedback from our mentor about considering the torque-to-weight ratio and the overall cost effectiveness guided us to a more feasible solution that aligned better with our project's goals.

The decision to make the robotic arm stationary instead of using a drive system was heavily influenced by feedback regarding our team's lack of experience with complex sensor-based control systems. This feedback helped us acknowledge our limitations and choose a simpler, more reliable design approach. It reinforced the idea that sometimes the best solution is the one that aligns with the team's current capabilities and resources.

Furthermore, the iterative design process for the planetary gear drive actuator benefited greatly from feedback on my initial prototype. Constructive critiques of my spur gear design encouraged me to explore helical gears and more precise calculations, ultimately leading to a more refined and functional prototype. This iterative approach, fuelled by ongoing feedback, highlighted the value of continuous improvement and adaptability in engineering design.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will conduct comprehensive research on all components, balancing performance, cost, and practical constraints. This approach will ensure informed choices that align with our project goals, such as considering torque-to-weight ratios and budget limitations.

I will prioritize design solutions that match the team's current capabilities and resources. Avoiding overly complex systems in favour of more reliable and manageable designs will lead to more successful project outcomes.

I will foster better communication and collaboration within the team. Regular check-ins, clear task delegation, and open discussions will ensure everyone is aligned and working towards common objectives.

I will embrace an iterative approach to design and prototyping. By continuously seeking feedback and making incremental improvements, I can develop more refined and functional solutions.

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Weekly Plan

Plan	Status
Attend the Makeup session	ONGOING
Model via CAD Planetary Drive	CONTINUED
3D Print Prototype of Planetary Drive	CONTINUED

Progress

I attended the makeup session this week primarily because I had initiated a 3D print for the planetary gear drive test the previous week. I learned the importance of checking the parameters of 3D prints before starting them, as incorrect settings and calculations can lead to costly time wastage. This was evident in my planetary gear drive prototype, where the gears did not fit properly, preventing the planetary aspect from functioning as intended. However, I was able to observe the gear teeth fitment and the interaction between the helical gears, which was positive. This confirmed that the dimensions, pitch angle, and module could be used in the next iteration.

After performing torque calculations, I realized that the current design required more holding torque for the gearbox. Changing the gear reduction to a suitable level would necessitate very small gears or a significantly larger actuator. This led to a shift from a standard planetary gear drive gearbox to a stacked planetary gear drive gearbox, which offers high reduction ratios in a compact space. We achieved a 16:1 gear reduction, making the overall actuator smaller than the current design.

Torque calc

I conducted further research and watched various YouTube videos on stacked planetary gearboxes. This prepared me to design my own. I decided to use a square outer casing to allow room for fasteners, as the actuator needs to be attached to the robotic arm. I moved away from using SolidWorks toolbox helical gears and, after watching a SolidWorks tutorial, created my own helical gear design. This new design served as a template for the sun gear, planet gears, and ring gears.

The stacked planetary gearbox works as follows: the stepper motor is attached to the sun gear, which moves the planet gears around the ring gear at the desired reduction ratio. The planet gears are connected to a carrier that produces an output, which then feeds back into another set of planet gears and onto another carrier, creating a two-stage reduction. This final output connects to the robotic arm.

This process took up most of my week, but I set a deadline for Friday to print a test actuator. On Friday, I tested the fitment of the gearbox components by printing a 15mm thick version of the planetary gear design. The test print was successful, so I proceeded to print the entire gearbox, which took about 14 hours. I monitored the initial layers to ensure there were no issues with the print.

Key Learning

This week highlighted the critical importance of thorough planning and parameter checking before starting 3D prints. Incorrect settings can lead to significant time wastage, as seen with my initial planetary gear drive prototype, where improper fitment prevented proper function.

The experience reinforced the need for accurate torque calculations and informed component selection. Realizing the limitations of the standard planetary gear drive gearbox led to the adoption of a stacked planetary gear drive design, which offers high reduction ratios in a compact space. This shift was crucial in balancing performance requirements with size constraints.

I learned the value of hands-on research and iterative design. Watching instructional videos and tutorials enhanced my ability to create custom helical gears in SolidWorks, which improved the precision and functionality of my design. This iterative approach, from conceptual design to test printing, demonstrated the importance of prototyping and testing in the development process.

Reflection on Feedback:

The feedback on my initial 3D print highlighted the importance of thorough parameter checks and accurate calculations before starting a print. This was a valuable lesson, as it underscored the need for meticulous preparation to avoid costly time wastage and ensure that all components fit and function correctly.

The suggestions regarding the torque requirements for the gearbox were particularly impactful. They prompted a shift from a standard planetary gear drive to a stacked planetary gear drive, which allowed for higher reduction ratios in a more compact space. This feedback was crucial in guiding me towards a more efficient and practical design solution.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will ensure all parameters and calculations are thoroughly checked before starting any 3D prints. This will prevent time wastage and ensure proper fitment and functionality of components.

I will conduct detailed research and use precise calculations for all design elements. This includes selecting the most suitable gear types and reduction ratios to meet performance requirements efficiently.

I will adopt an iterative approach to design and prototyping, continuously testing and refining components to achieve the best results. This includes utilizing custom designs when pre-made components do not meet project needs.

I will set clear deadlines and closely monitor progress to ensure timely completion of tasks. This disciplined approach will help in managing project timelines effectively and overcoming any challenges promptly.

Week 9 – Sprint 3

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Model via CAD Planetary Drive	COMPLETED
3D Print Prototype of Planetary Drive	CONTINUED
Design Review 3	CONTINUED
Design Exercise 3	COMPLETED

Progress

This week, I printed out the test prototype for the high-fidelity planetary gearbox. The print came out very well, and I was extremely pleased with the result. The fitment was excellent, and we could see how the gear reduction would work. Functionally, it worked perfectly, requiring only small changes for the next iteration before printing the final gearboxes. However, this prototype didn't account for certain components, such as the placement of bearings, links, and specific screws. The next iteration will need to be designed around these specific parts to mass-produce functional gearboxes, not just prototypes. Nonetheless, it was exciting to see the gearbox actually function, and I was able to present this prototype for Design Review 3.



Design Review 3 was a significant improvement over the previous two reviews. We better addressed the rubric points and incorporated feedback more effectively. Our overall presentation was strong, with better delivery and more visually appealing slides that focused on images rather than large blocks of text. Based on feedback and consultation with our mentor, we realized our procurement plan was initially inadequate. I was tasked with revising it, and the feedback on these changes was very positive, though I need to add subcategory costs in the future.

Our biggest mistake in this design review was not having a properly done chassis according to the rubric. We had prototypes, but without a base plate for the chassis, we couldn't achieve a higher rating than "Not Yet Novice." This is a mistake we can easily correct by ensuring we fully understand and meet the rubric's minimum requirements in future reviews. I received positive feedback on the CAD design of the planetary gearbox, with no negative comments, which was validating. However, I will seek constructive feedback from mentors in class to further improve.

Key Learning

This week emphasized the importance of detailed prototyping and iterative improvement. Printing the high-fidelity planetary gearbox prototype taught me that while initial fitment and functionality can be promising, it's crucial to consider all components, such as bearings and screws, in the design. This comprehensive approach will ensure that future iterations are not just functional prototypes but fully operational gearboxes ready for production.

Understanding and adhering to the rubric's requirements proved to be essential. Our oversight with the chassis prototype underscored the importance of thoroughly reading and comprehending the evaluation criteria. Ensuring that all minimum requirements are met will be a priority moving forward to avoid easily correctable mistakes.

Reflection on Feedback:

The positive reception of the high-fidelity planetary gearbox prototype was encouraging, as it highlighted the value of detailed and precise design work, reinforcing the importance of thorough prototyping to validate functionality and fitment. This feedback confirmed that our approach to creating the gearbox was on the right track, but also pointed out the need to consider all components, such as bearings and screws, in future iterations.

Feedback on our presentation emphasized the importance of clarity and visual engagement. The improved slides, focusing more on images than text, were well-received, illustrating the effectiveness of visual aids in communicating complex ideas. This insight will guide our future presentations, ensuring we continue to enhance our delivery and make our presentations more impactful.

The critique regarding our procurement plan was particularly valuable. Realizing that our initial plan was lacking and receiving positive feedback on the revised version. This feedback has motivated me to be even more meticulous in future procurement plans, ensuring all aspects, including subcategory costs, are well-documented.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will ensure all aspects of a design, including minor components like bearings and screws, are considered in initial prototyping stages. This will lead to more complete and functional prototypes.

I will focus on improving the visual aspects of presentations by using more images and fewer blocks of text. This will make our presentations more engaging and effective in communicating complex ideas.

I will create more detailed and comprehensive procurement plans, including all necessary subcategory costs. This will ensure thorough documentation and better project planning.

I will thoroughly review and adhere to all rubric requirements for future evaluations. Ensuring that all minimum criteria are met will help avoid easily correctable mistakes and improve our overall project outcomes.

I will actively seek constructive feedback from mentors and peers, using it to continuously refine and improve our designs and processes. This proactive approach will enhance the quality and functionality of our final products.

Week 10 – Sprint 4

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
3D Print Full Planetary Gearboxes	COMPLETED
Design Final Iteration of Gearbox	COMPLETED
Adjust Gearbox for Bearings and Screws	COMPLETED
Assemble Gearbox	CONTINUED

Progress

This week wasn't as productive as I would have liked. I was preoccupied with other commitments and missed the Monday class due to illness, although I did some work from home. Seeing other teams with fully assembled robots while we have basic prototypes indicates that we need to step up our efforts if we want to complete our robot on time.

On Friday, I went into 3D print the full planetary gearboxes. For this final iteration, I kept most of the main components the same but made minor changes to accommodate components like bearings and specific screws. Previously, my designs were more proof-of-concept; now, this iteration focused on making the gearboxes functional and attachable to the robot.

I used Bolt Master's website to order specific screw lengths and types, such as countersink screws to ensure they were flush with the surface. I obtained three types of screws: 16mm, 20mm, and 30mm, which would meet the gearbox's needs. I also adjusted the internal gears to protrude 7mm out of the casing to accommodate laser-cut acrylic faces, adding 4mm spacers on each side to fit the 3mm acrylic.

I ordered bearings from Amazon, which arrived next day and were of surprisingly good quality for the price, much cheaper than other suppliers. Choosing Bolt Master over Bunnings for screws was also a no-brainer due to the significant cost difference.

My main source of 3D printing is the DIY UTS printers at ProtoSpace. Only being able to print once a week has been challenging, causing delays in completing this part due to the need for multiple iterations. However, I was able to secure two printers after someone didn't show up, and set them to print the designs, which had an estimated time of 56 hours. There is a concern about print quality over long durations, but it's a risk we have to take if we hope to assemble next week.

Key Learning

This week highlighted the importance of time management and prioritization. Balancing other commitments with project tasks is crucial to maintaining steady progress, especially when unexpected events like illness occur.

I learned the value of sourcing materials cost-effectively without compromising quality. Ordering bearings from Amazon and screws from Bolt Master demonstrated that thorough research and comparison can lead to significant cost savings while still obtaining high-quality parts.

The challenge of limited 3D printing access at ProtoSpace underscored the importance of efficient resource use and planning. Securing printers and managing long print times effectively are critical to meeting project deadlines.

Reflection on Feedback:

Feedback on the need for better time management and resource allocation, especially concerning 3D printing, has underscored the importance of efficient planning. Limited access to printers at ProtoSpace requires careful scheduling and prioritization to meet deadlines. This realization has prompted me to be more strategic in managing print jobs and leveraging available resources effectively.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will ensure meticulous planning and precise design modifications, including all necessary components like bearings and screws, from the outset. This will help avoid functional issues and ensure ease of assembly.

I will prioritize efficient time management and resource allocation, especially concerning 3D printing. Careful scheduling and prioritizing print jobs will be crucial to meet deadlines and make the most of limited resources.

I will continue to conduct thorough research to find quality materials at competitive prices, ensuring cost-effective procurement without compromising on quality. This strategy has proven beneficial and will remain a focus.

I will adhere closely to all rubric requirements in future reviews, ensuring that all minimum criteria are met to avoid easily correctable mistakes. This includes thorough preparation and understanding of evaluation criteria.

I will actively seek and incorporate constructive feedback from mentors and peers, using it to refine and improve our designs and processes continuously. This proactive approach will enhance the quality and functionality of our final products.

Week 11 – Sprint 4

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Assemble all planetary gearboxes	COMPLETED
Clean up all 3d printed parts	COMPLETED
Design bracket to enclose bearing	COMPLETED
Prepare Presentation for Design Review 4	COMPLETED
Update Procurement Plan with Pivot Tables	COMPLETED
Improve Scoring Matrix and Feedback Section	COMPLETED
Conduct stepper motor testing	COMPLETED
Finalise Prototype Assembly	CONTINUED
Review and align with rubric requirements	CONTINUED
Finalise CAD designs for presentation	CONTINUED
Prepare interactive and engaging slides	CONTINUED

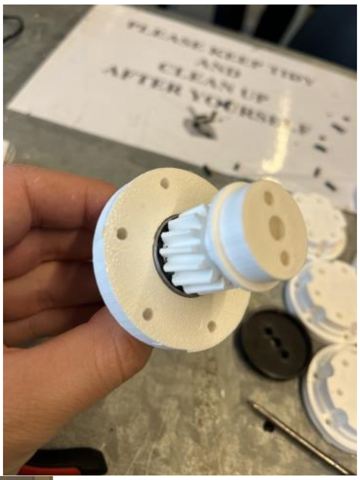
Progress

This week, I assembled all the planetary gearboxes. I had two printers running over the weekend, producing the necessary parts for the full planetary gearboxes. The first step was to clean up all the 3D printed parts, which had a lot of brim. This process took almost an entire day as I used small long-nose pliers to meticulously remove the excess material, especially from the gears.




Once the parts were cleaned, I began assembling the gearboxes. I used specific screws from Bolt Master, which were the exact sizes needed and countersunk to be flush with the surface. I opted for threaded inserts instead of nuts because they are very effective in 3D printed parts. The two faces of the gearboxes were laser-cut from acrylic, mainly for cosmetic purposes and to allow visibility into the gearbox for troubleshooting.






A problem I encountered was that the internal gears were not secured inside the gearbox, causing some carriers to slide in and out. This could lead to frictional forces causing wear in unintended places. To solve this, I designed a bracket to enclose the bearing inside the gearbox, preventing it from translating out of the casing while still allowing the bearing to move freely.

This week was crucial as it was the week before the graded design review. In previous design reviews, I felt we missed the mark, but Design Review 3 showed improvement. I emphasized doing well in the upcoming review by focusing on presentation skills and ensuring we met the rubric points. I was responsible for the procurement plan, the scoring matrix, and the feedback section. I oversaw the prototype section, showcasing the gearboxes I designed and built, along with videos of stepper motor testing.

To address previous feedback, I included subcategory costs in the procurement plan using pivot tables in Excel. This allowed us to see a detailed breakdown of costs for each category and subcategory. We also made our presentation more engaging by using interactive screens with fewer words and more images, improving our ability to convey points effectively.

Key Learning

This week emphasized the importance of meticulous assembly and post-processing in 3D printing. Cleaning up the printed parts was a time-consuming task, but it was essential for ensuring proper fitment and functionality. This taught me the value of patience and attention to detail in preparing components for assembly.

I learned the necessity of considering all components during the design phase. The issue with the internal gears not being secured highlighted the importance of comprehensive design reviews to foresee potential problems. Designing and implementing a bracket to enclose the bearings was a practical solution that reinforced the need for adaptability and problem-solving in engineering.

The process of updating the procurement plan with pivot tables in Excel proved to be a valuable skill. It provided a clear breakdown of costs and enhanced our ability to manage and plan the project's financial aspects. This experience highlighted the importance of effective documentation and financial planning in project management.

Improving our presentation skills by making slides more visual and interactive showed the impact of clear and engaging communication. Ensuring that our presentations are not just informative but also engaging is crucial for effectively conveying our ideas and progress.

Furthermore, the ongoing challenge of managing 3D printing resources underscored the importance of efficient resource allocation and time management. Securing and managing long print times effectively are critical for meeting project deadlines and ensuring steady progress.

Reflection on Feedback:

Reflecting on the feedback received this week, several key insights have emerged that are crucial for our project's development.

Firstly, the positive feedback on the assembled planetary gearboxes validated our approach and reinforced the importance of thorough post-processing. The detailed cleaning and precise assembly were recognized as essential steps in ensuring the functionality and reliability of the gearboxes.

The constructive comments regarding the procurement plan and the use of pivot tables in Excel were particularly enlightening. The feedback highlighted the effectiveness of this approach in providing a clear and detailed breakdown of costs. This has motivated me to continue using such tools for better financial planning and project management.

Feedback on our presentation skills underscored the value of making slides more visual and interactive. The positive response to our more engaging presentation style demonstrated the importance of clear and concise communication. This insight will guide our future presentations, ensuring we continue to enhance our delivery and make our presentations more impactful.

The issue with the internal gears not being secured was a critical learning point. The feedback prompted me to consider all components more thoroughly during the design phase and to anticipate potential problems. Designing a bracket to secure the bearings was a practical solution that addressed the feedback effectively.

Furthermore, the feedback on our overall progress and resource management highlighted the need for efficient time management and prioritization. The challenge of managing 3D printing resources and scheduling print jobs emphasized the importance of strategic planning to meet project deadlines and ensure steady progress.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will ensure thorough post-processing of 3D printed parts, dedicating the necessary time and attention to detail to guarantee proper fitment and functionality. This will improve the overall quality and reliability of our assemblies.

I will incorporate comprehensive design reviews to anticipate and address potential issues with components. This includes considering all aspects of the design, such as securing internal gears, to prevent functional problems during assembly.

I will continue using pivot tables and other effective documentation tools in Excel for financial planning and project management. This will provide clear, detailed breakdowns of costs and enhance our ability to manage project finances effectively.

I will prioritize making our presentations more visual and interactive. By focusing on clear and engaging communication, we can convey our ideas and progress more effectively and make a stronger impact during reviews.

I will improve my time management and resource allocation strategies, especially concerning 3D printing. Efficient scheduling and prioritizing print jobs will be essential to meet project deadlines and ensure steady progress.

By implementing these resolutions, I aim to enhance both my individual performance and the overall effectiveness of our team, ensuring successful and efficient project outcomes.

Week 12 – Sprint 4

Weekly Plan

Plan	Status
Attend the face-to-face session	ONGOING
Attend the face-to-face session	ONGOING
Read through Canvas	ONGOING
Complete Canvas modules (prework)	ONGOING
Finalise presentation for graded design review	COMPLETED
Correct errors and format presentation slides	COMPLETED
Add design process pictures to presentation	COMPLETED
Ensure presentation delivery and rubric alignment	COMPLETED
Test stepper motors individually and synchronously	COMPLETED
Seek guidance on homing device implementation	COMPLETED
Test planetary gearboxes	COMPLETED
Assemble final prototype components	CONTINUED

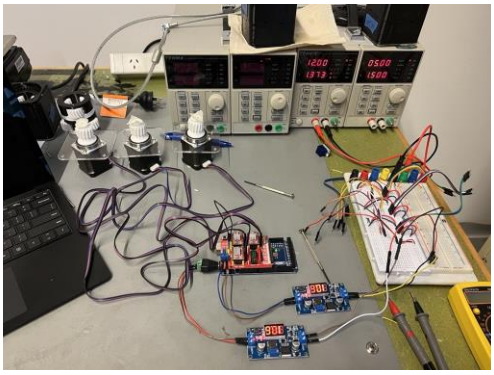
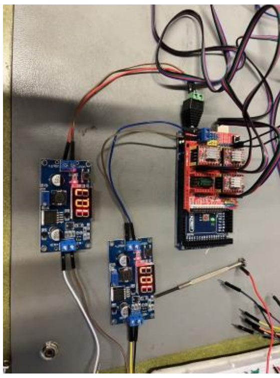
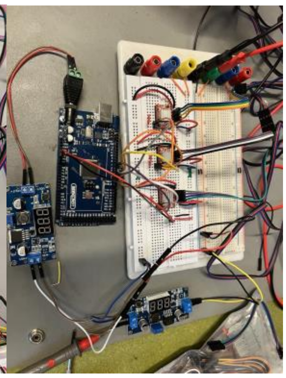
Progress

The graded design review was this week, so our team focused a lot of time on getting the presentation right, as it affects our final grade. We spent the majority of Monday correcting any errors and addressing problems with the current presentation. My primary task was formatting and adding pictures to the slides showing the design process from initial prototypes to the final version. Since most of my work on the design review was completed last week, we spent additional time ensuring our delivery was correct and that we were hitting the design rubric points to achieve good marks.

The presentation went well, and we received a distinction, which we were pleased with. However, we were slightly disappointed that we didn't have a fully assembled final prototype. We had all the components, but the arm wasn't correctly attached to the base, resulting in essentially two prototypes: the base and chassis with electronics, and the arm. Compared to other groups, our animation, completed by Will, and our CAD models were quite impressive.

Following the presentation, I focused on the planetary gearboxes during the drop-in sessions. This week, I concentrated on testing the mechatronics and how they interact with the gearboxes. I began by testing the stepper motors individually and together. The initial goal was just to control the stepper motors, and then to synchronize them. I managed to get them to move in a synchronized motion, but faced issues with starting from a zero position since the stepper motors are open-loop and lack sensors to determine their zero position.

To address this problem, I sought guidance from a mentor. We discussed implementing a homing device with limit switches. The idea is that the stepper motor would rotate until it hits a limit switch, then move to its home position, allowing it to rotate with a known zero position. This would greatly improve consistency in our demonstrations, as we wouldn't need to manually home the robot before each run.

https://youtu.be/57JuzCJEyQE
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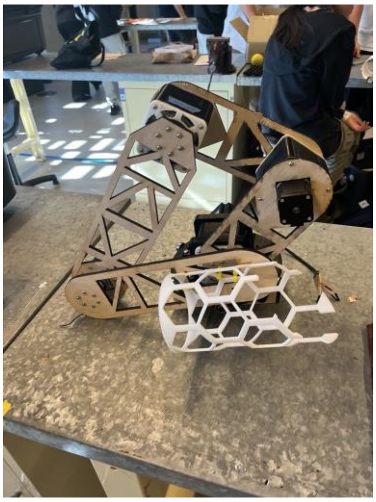
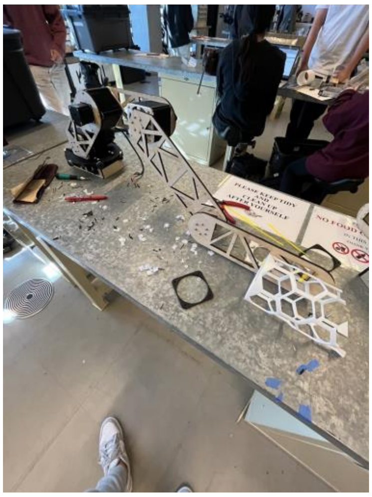
After this, I tested the gearboxes. I only tested one due to a lack of silicone grease and concerns about the PLA potentially damaging itself. However, the test was successful, and the gearbox worked smoothly without grease, giving me confidence that all the actuators would function correctly. The Arm was also assembled this week, I was waiting on the arms but they were completed.

Key Learning

This week highlighted the critical importance of teamwork and detailed preparation. Coordinating with the team to finalise the presentation for the graded design review underscored the value of collective effort and effective communication. Ensuring that our presentation aligned with the rubric points was essential for achieving good marks.

The experience of assembling the planetary gearboxes reinforced the necessity of thorough post-processing for 3D printed parts. Spending considerable time cleaning and preparing the components ensured proper fitment and functionality, which is vital for the overall success of the assembly.

Testing the stepper motors individually and in synchronized motion taught me about the challenges of working with open-loop systems. The lack of sensors for zero position highlighted the need for components, such as limit switches, to improve accuracy and consistency in motor control.

Seeking guidance from a mentor on implementing a homing device was invaluable. This solution will not only enhance the performance of the stepper motors but also improve the reliability and consistency of our robot's movements, making future coding and demonstrations more efficient.

Overall, this week emphasized the importance of meticulous preparation, effective teamwork, and continuous learning. These lessons will be instrumental in driving the project forward and ensuring its success.

Reflection on Feedback:

Reflecting on the feedback received this week, several important insights have emerged that are crucial for our project's development.

The feedback on our presentation was positive, highlighting the importance of thorough preparation and attention to detail. Ensuring our slides were well-formatted and visually engaging, with clear alignment to the rubric points, proved to be effective. This experience underscored the value of investing time in refining our presentation skills and ensuring we meet all evaluation criteria.

Receiving a distinction was gratifying, but the feedback regarding our prototype assembly highlighted a critical area for improvement. The fact that we had all components but failed to fully assemble the prototype due to the arm not being attached to the base was a significant oversight. This taught us the importance of comprehensive assembly and testing before presentations to ensure all components are functional and integrated.

The guidance on implementing a homing device for the stepper motors was particularly valuable. The feedback pointed out the limitations of our current open-loop system and the need for components, such as limit switches, to improve accuracy. This insight has guided us towards a more reliable and consistent motor control solution, which will enhance the overall functionality of our robot.

Testing the planetary gearboxes and receiving feedback on their performance without silicone grease was also insightful. The positive response to the smooth operation, even without lubrication, gave us confidence in our design and assembly processes. However, it also highlighted the necessity of using appropriate materials and components to ensure long-term durability and performance.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will ensure all components are fully assembled and tested before presentations. This will prevent oversights and ensure that all parts are functional and integrated, improving the overall quality of our prototypes.

I will focus on thorough preparation and attention to detail in all aspects of our presentations. Ensuring our slides are well-formatted, visually engaging, and aligned with rubric points will enhance our performance in future design reviews.

I will incorporate components, such as limit switches, to improve the accuracy and consistency of our motor control systems. This will address the limitations of our current open-loop system and enhance the reliability of our robot's movements.

I will continue to seek guidance and feedback from mentors and peers to identify areas for improvement and implement effective solutions. This proactive approach will support continuous learning and development.

I will ensure the use of appropriate materials and components to guarantee the long-term durability and performance of our designs. This includes using silicone grease for gearboxes and selecting high-quality parts for critical components.

By implementing these resolutions, I aim to improve both my individual performance and the overall effectiveness of our team, ensuring successful and efficient project outcomes.

STUVAC

Weekly Plan

Plan	Status
Develop and test separate code sections	COMPLETED
Integrate code sections into one cohesive program	CONTINUED
Test stepper motors individually and synchronously	COMPLETED
Address torque issues with base and first actuator	COMPLETED
Consult with peers and tutors about efficiency issues	COMPLETED
Redesign the robot to reduce weight and improve efficiency	COMPLETED
Redesign the stack planetary gearbox to reduce weight	COMPLETED
Redesign the Bowden actuator for proper function	COMPLETED
Relocate and reorganise electronics on new chassis	COMPLETED
Print and assemble redesigned gearboxes	COMPLETED
Test and lubricate redesigned gearboxes	COMPLETED
Implement homing device with limit switches	COMPLETED
Prepare for next week's demonstration	CONTINUED

Progress

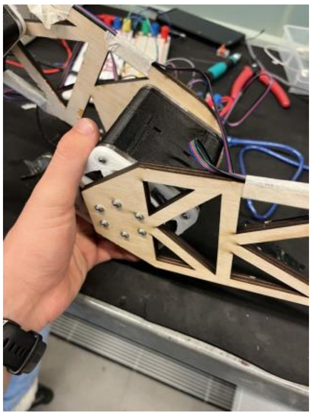
My main focus this week was programming. As the only mechatronics student in my group, I was responsible for developing the code. Instead of creating one large code, I started by writing separate sections for different functions: an angle function, a sliding function (for the scoop to slide over and pick up the ball), a retract function, and a deposit function. These functions would be integrated to work cohesively. I mainly worked from home on this, as I did more hands-on work when at university.

We were behind schedule, so the entire team worked intensively to finish the mechanical and mechatronics components for real testing this week, knowing that if we didn't test now, we'd be in a difficult position for next week's demonstration. When I attempted to run a code to move the entire arm, I encountered a significant problem. The base and first actuator couldn't lift the arm due to insufficient torque, despite my calculations being seemingly correct. Discussions with peers and tutors revealed that the stepper motors were working at less than 50% efficiency at the current voltage, which was not accounted for in my calculations. This inefficiency might also stem from the controllers not working at full efficiency without an extra cooling system.

To address this, I considered several solutions. One was to increase the current through the controller, but this risked frying the controllers. Another was to use a bigger LiPo battery, but the voltage increase from

12V to 15V was not significant enough. After consulting with tutors and peers, we decided to redesign the robot.

Reasons for Redesign



The main goal of the new design was to dramatically reduce weight and improve efficiency. The current robotic arm was too heavy, with four actuators weighing a total of 3.7 kilograms. We considered using lighter materials like cardboard for parts of the chassis that didn't need extra strength, but this was not sufficient to solve the weight issue. The excess weight was causing problems with the torque and efficiency of the motors, as they couldn't lift the arm properly.

The overall design was too bulky, especially the actuators, which were large due to the high stress on the longer arm. By reducing the length of the arm and simplifying the design, we aimed to reduce both weight and mechanical stress. We also decided to implement a drive system, which would allow the robot to move across the track rather than having a long arm reach out. This approach would significantly reduce the arm length and the number of actuators needed.

Stack Planetary Gearbox Redesign

Redesigning the stack planetary gearbox was a significant task. The original design used gears with a 1.5 module, which were too large and added unnecessary weight. I decided to test smaller module sizes, specifically 1.0, 0.75, and 0.85. After testing, I found that a 0.85 module provided the best balance of strength and size reduction. The smaller module size cut down the overall diameter by about 30mm.

To further reduce weight, I changed the gearbox shape from square to hexagonal. The hexagonal shape reduced the surface area of the faces, cutting out unnecessary material while still allowing for the addition of fastener holes. This shape also brought the design closer to a circle, which is generally more efficient in terms of space usage.

I eliminated the carrier in the internal gears to save space and weight. Instead, I fastened the screws directly onto the bearings. This design ensured that the gears still spun freely while reducing internal space. I optimized the fitment by tightening tolerances to 0.5mm, ensuring that everything was very tight and compact.

Another critical change was in the wall layers of the 3D printed parts. To maintain strength while reducing weight, I reduced the infill to 7.5% but increased the number of wall layers to three. This approach made the gears almost solid plastic, providing the necessary strength without the additional weight.

For the internal gears, I replaced the traditional carrier with a simpler design where the screws were fastened directly onto the bearings. This not only saved space but also reduced weight significantly. The hexagonal shape allowed me to add fastener holes while reducing the surface area of the faces, making the design more efficient.

These changes resulted in a weight reduction of over 100 grams, which is nearly half the weight of the previous iteration. I addressed previous issues such as bearing slippage by enclosing the bearings in spacers to prevent movement.

Lastly, to ensure the planetary gearbox fit perfectly with the rest of the design, I integrated the bracket for the NEMA 23 motor into the gearbox itself. This integration made for a stronger connection and reduced the likelihood of mechanical failure. By making these detailed adjustments, I was able to create a more efficient and lightweight gearbox that met all the necessary requirements.

https://youtu.be/5RvNctKpYfA

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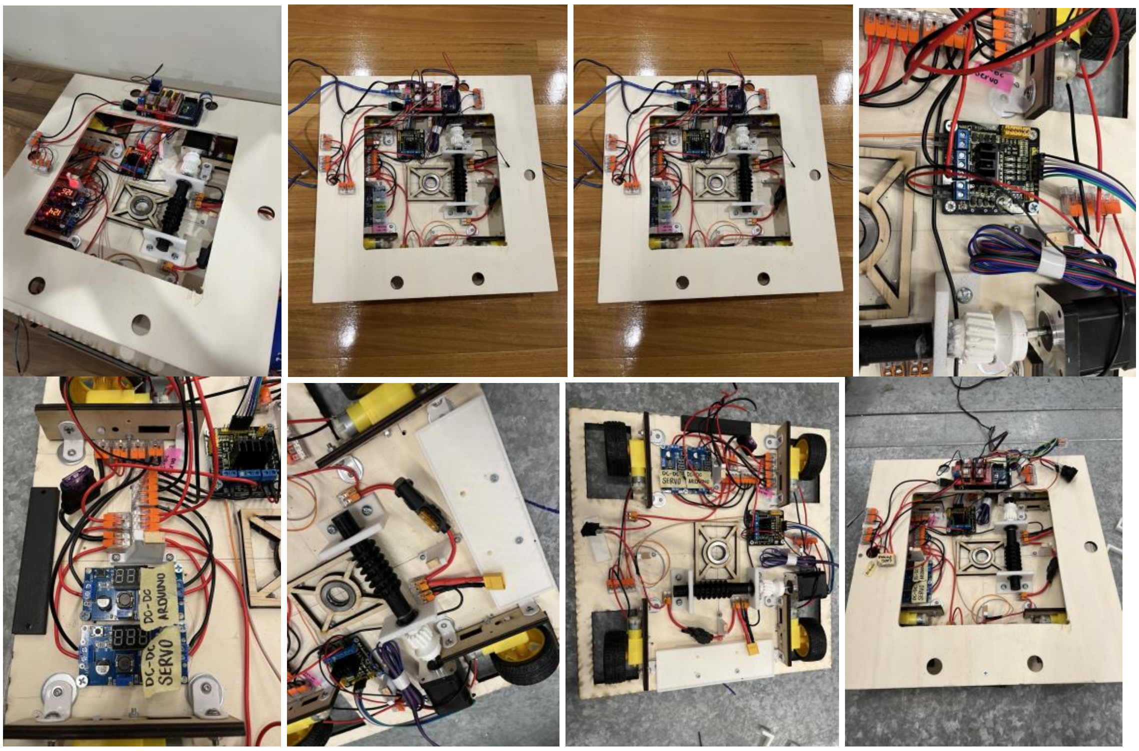
Bowden Actuator Redesign

Deegan's initial iteration of the Bowden actuator needed adjustment, so I redesigned it to ensure proper function. The original design fastened the pulley to both the scoop and the arm, which would not have allowed it to spin properly. I separated the bracket that held the pulley to the scoop and the arm, adding a washer-like bracket to hold the bearing in place. This allowed the scoop to orient correctly when the pulley was pulled.

Chassis and Electronics Redesign

The redesign of the chassis required relocating the electronics, which was not a straightforward swap. The new chassis featured four wheels with cutouts on the bottom level and an integrated top level for housing electronics. This setup ensured better cable management and minimized the risk of disconnections when the arm was fully extended. The basic flow of the wiring involved an XT60 connector to a fuse, then to an isolator switch, and then to terminals that split off in five directions: to the Arduino, buck converter, servo driver, and CNC machine.



Detailed Redesign Process

Despite redesigning major components in a night, there were some issues. We reverted to threaded inserts due to fitment problems with nuts and made slight changes to the gearbox stacking stages to make them more modular. This included increasing the tolerance for the bearings to ensure a proper fit.

Once the gearboxes were reprinted, they were assembled without problems. I integrated the bracket for the NEMA 23 motor into the gearbox design, making for a stronger connection that reduced the likelihood of mechanical failure. The original stack planetary gearbox had taken weeks to design, so this redesign focused on cutting weight while maintaining strength.

https://youtu.be/jnH0Sp74jCI

Key Learning

This week underscored the importance of thorough preparation and flexibility in engineering projects. The initial programming tasks highlighted the value of breaking down complex problems into manageable sections, testing each function individually before integration. This approach ensured that each part of the code worked correctly and made troubleshooting easier.

The issues with the torque of the stepper motors revealed critical insights into the efficiency and power requirements of our design. Realizing that the stepper motors were operating at less than optimal efficiency due to voltage constraints emphasized the need for precise calculations and consideration of all operational factors, including the efficiency of controllers and the impact of different voltages.

The decision to redesign the robot to reduce weight and improve efficiency was a pivotal learning moment. It taught us the importance of adaptability and the willingness to undertake significant changes, even when under tight deadlines. The redesign process highlighted the necessity of considering the overall system's weight and its impact on performance, reinforcing the importance of iterative design and testing.

Redesigning the stack planetary gearbox provided valuable lessons in optimizing mechanical components for both weight and strength. The iterative testing of different module sizes and shapes showed the benefits of detailed design adjustments. The integration of the bracket for the NEMA 23 motor into the gearbox design was a practical solution that strengthened the connection and reduced mechanical failure risks.

Implementing the Bowden actuator and redesigning the chassis and electronics layout emphasized the need for effective teamwork and communication. Each team member's focused contributions were crucial in managing the redesign within a short timeframe. This experience highlighted the importance of clear task delegation and collaboration in achieving complex project goals.

Overall, this week reinforced the significance of meticulous preparation, detailed design, and effective team collaboration. These key learnings will be instrumental in guiding our future efforts and ensuring the successful completion of our project.

Reflection on Feedback:

The feedback on our programming approach was positive, validating the decision to break down the code into separate sections for testing before integration. This approach ensured that each function worked correctly and made the final integration smoother. This feedback reinforced the importance of modular design and incremental testing in complex projects.

The constructive comments on the torque issues with the stepper motors were particularly enlightening. They highlighted the need to account for efficiency variations at different voltages and the impact of controller efficiency. This feedback pointed out a critical oversight in our initial calculations and emphasized the necessity of considering all operational factors in our designs.

Receiving guidance on the robot redesign was invaluable. The mentors and peers encouraged us to focus on weight reduction and efficiency improvements, which led to a significant overhaul of our design. This feedback underscored the importance of adaptability and reinforced the idea that substantial changes can lead to better outcomes, even under tight deadlines.

Feedback on the Bowden actuator and the chassis redesign emphasized the importance of proper function and effective cable management. The comments highlighted the need to ensure all components work seamlessly together and that the overall system is robust and reliable. This feedback was crucial in guiding the final adjustments and ensuring the redesigned components met all functional requirements.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will continue to break down complex tasks into smaller, manageable sections and test each part individually before integration. This modular approach ensures thorough testing and smoother integration, reducing the risk of errors.

I will account for all operational factors in my designs, including efficiency variations at different voltages and controller efficiency. This comprehensive consideration will improve the accuracy of my calculations and the overall reliability of our projects.

I will remain adaptable and open to significant changes, even under tight deadlines. Embracing flexibility allows for better outcomes and demonstrates the importance of iterative design and continuous improvement.

I will focus on optimizing mechanical components for both weight and strength. Detailed design adjustments and iterative testing will ensure our components are efficient and reliable, contributing to the overall success of the project.

I will prioritize effective teamwork and communication. Clear task delegation and collaboration are essential for managing complex projects within tight timeframes, ensuring all team members can contribute effectively to our goals.

By implementing these resolutions, I aim to enhance both my individual performance and the overall effectiveness of our team, ensuring successful and efficient project outcomes.

Exam Period – Demonstration Week

Weekly Plan

Plan	Status
FINISH	DONE

Progress

In three days, we completely redesigned our robot, but a major challenge was that we only had seven hours to test it. None of us had slept, and we were running extremely low on energy. As the head programmer, I tested each component of the robot separately as it was being built. The wheels drove forward synchronously, and the actuators held well against the torque. This was likely due to the significant weight reduction and possibly an over-engineered gear ratio, which, while not ideal, was preferable to having too weak a system. The rotational base did spin; however, problems arose when we brought the entire system together.

We encountered a major mechanical failure with the rotating base. The team member responsible for this part did not correctly integrate the motor and the worm gear design, and under load, the motor failed to function properly. This issue should have been identified and fixed earlier, highlighting the need for better peer review and collaboration within the team.

Despite this, when we held the part together, we did have a working robot. The code allowed us to input positions, and the robot would move to set positions. The plan was to have a program with hardcoded angles for each stepper motor, a slide function, and a deposit function for the three balls once they were collected. However, we encountered problems with the angle code. As time ran out and there was no hope for fixing the rotational base, we had to accept the consequences despite our best efforts.

On the track, the robot was disappointing. For the amount of time and effort put into it, the performance was somewhat embarrassing. The Bowden tube actuator failed, and the rotation base malfunctioned, preventing the arm from picking up seed pods or rotating to face other pods. It could only move in one specific direction. However, the planetary gearboxes worked well, performing as expected. Seeing this part of the design succeed, despite doubts from many, was a small consolation.

Now that the demonstration is over, all attention focuses on the portfolio.

https://youtu.be/2dGo_XJyMJ0

Key Learning

This final week underscored the critical importance of thorough testing and teamwork. The lack of sufficient testing time, combined with sleep deprivation, significantly impacted our ability to troubleshoot and solve problems effectively. Ensuring adequate testing time in future projects is essential to identify and rectify issues before critical deadlines.

The failure of the rotating base highlighted the necessity of rigorous peer review and collaboration. Every team member's work should be cross-checked to ensure integration issues are caught early. This experience has taught me the value of regular team check-ins and collaborative reviews to maintain high standards and functionality across all components.

The success of the planetary gearboxes, despite other failures, reinforced the importance of detailed design and iterative testing. The gearboxes performed well under stress, validating the extensive testing and adjustments made during their development. This outcome demonstrated that thorough preparation and meticulous design can yield reliable components.

The disappointing performance on the track was a humbling reminder of the challenges in real-world applications. Despite theoretical correctness and isolated component success, the overall system integration and real-world conditions can reveal unexpected issues. This experience emphasized the need for holistic testing and validation under realistic conditions.

Lastly, this week highlighted the resilience and determination required in engineering projects. Despite setbacks and disappointments, maintaining a focus on learning and improvement is crucial. The shift of focus to the portfolio now provides an opportunity to reflect on these experiences, document lessons learned, and apply them to future endeavours.

Reflection on Feedback:

The feedback on our testing approach highlighted the need for adequate testing time and better time management. This underscored the importance of planning and allocating sufficient time for both component and system-level testing. Ensuring thorough testing before critical deadlines will be a priority moving forward.

The feedback on the overall system performance was humbling but valuable. It highlighted that theoretical correctness and isolated successes do not guarantee overall functionality. This experience emphasized the need for holistic testing and validation under realistic conditions, ensuring that the entire system operates as intended.

Use of ChatGPT/AI resource

N/A

Resolutions for future behaviour

I will ensure adequate testing time for all components and the integrated system in future projects. Proper scheduling and time management will help identify and address issues before critical deadlines, reducing the risk of last-minute failures.

I will prioritize rigorous peer review and collaboration within the team, regular check-ins and collaborative reviews will ensure that each team member’s work is cross-checked, preventing integration issues and maintaining high standards across all components.

I will continue to focus on detailed design and iterative testing, the success of the planetary gearboxes demonstrated the value of this approach, and I will apply it consistently to ensure the reliability and performance of all components.

I will incorporate holistic testing and validation under realistic conditions, understanding that theoretical correctness and isolated component success do not guarantee overall system performance, I will emphasize comprehensive testing to uncover and address unexpected issues.

I will maintain resilience and determination, focusing on continuous learning and improvement, despite setbacks, I will use every experience as an opportunity to grow and enhance my skills. Documenting lessons learned and applying them to future projects will be a key part of my approach.

By implementing these resolutions, I aim to improve both my individual performance and the overall effectiveness of our team, ensuring successful and efficient project outcomes.

Abstract

Scoring Matrix

	Compactablity	Weight	Modularity	Complexity	High Torque	TOTAL SCORE	Ranking
Weighting	**3**	**3**	**1**	**1**	**2**		
Planetary Gear Drive	1	2	1	4	1		
Weighted rating	3	6	1	4	2	16	1
Hydraulic Drive	4	4	4	4	1		
Weighted rating	12	12	4	4	2	34	4
Cylindrical Drive	2	2	2	2	2		
Weighted rating	6	6	2	2	4	20	2
Worm Gear	3	3	2	2	2		
Weighted rating	9	9	2	2	4	26	3

Torque calculations

To determine the torque required for each actuator, we can use the following approach:

1. Calculate the torque for the base actuator (BA), which supports the entire arm.
2. Calculate the torque for actuator A, which supports the distal arm and any components attached to it, including the scoop.

- $m(BA)$ as the mass of the base actuator
- $m(A1)$ as the mass of the first arm segment
- $m(A2)$ as the mass of the second arm segment
- $m(A)$ as the mass of actuator A
- $m(S)$ as the mass of the scoop
- $A1$ as the length of the first arm segment
- $A2$ as the length of the second arm segment

The torque calculations for each actuator can be derived using the following general formula for torque (τ) due to a force (F) acting at a distance (r) from the pivot point:

$$\tau = F \cdot r \cdot \cos(\theta)$$

For simplicity, we'll assume that the angles (θ) at which forces are applied are perpendicular (i.e., $\cos(\theta)$ = 1).

Torque for Base Actuator (BA)

The base actuator needs to support the weight of the entire arm, including actuator A and the scoop. Therefore, the torque required for the base actuator is the sum of the torques due to each segment's weight.

$$\tau_{BA} = (m(A1)\cdot g\cdot\frac{A1}{2})+(m(A2)\cdot g\cdot(A1+\frac{A2}{2}))+(m(A)\cdot g\cdot(A1+A2))+(m(S)\cdot g\cdot(A1+A2))$$

Given:

- $m(A1)$ = 0.040kg
- $A1$ = 300mm = 0.3m
- $m(A2)$ = 0.040kg

1

- $A2$ = 300mm = 0.3m
- $m(A)$ = 0.552kg
- $m(S)$ = 0.150kg
- $g = 9.81\text{m/s}^2$

Substituting the values:

$$\tau_{BA} = (0.040\cdot 9.81\cdot\frac{0.3}{2})+(0.040\cdot 9.81\cdot(0.3+\frac{0.3}{2}))+(0.552\cdot 9.81\cdot(0.3+0.3))+(0.150\cdot 9.81\cdot(0.3+0.3))$$

$$\tau_{BA} = (0.040\cdot 9.81\cdot 0.15)+(0.040\cdot 9.81\cdot 0.45)+(0.552\cdot 9.81\cdot 0.6)+(0.150\cdot 9.81\cdot 0.6)$$

$$\tau_{BA} = 0.05886 + 0.17658 + 3.24672 + 0.8829$$

$$\tau_{BA} \approx 4.36\text{Nm}$$

Torque for Actuator A

Actuator A supports the distal arm segment and the scoop. Therefore, the torque required for actuator A is the sum of the torques due to the weight of actuator A and the scoop.

$$\tau_A = (m(A2) + m(A) + m(S)) \cdot g \cdot A2$$

Given:

- $m(A2)$ = 0.040kg
- $A2$ = 300mm = 0.3m
- $m(A)$ = 0.552kg
- $m(S)$ = 0.150kg
- $g = 9.81\text{m/s}^2$

Substituting the values:

$\tau_A = (0.040 + 0.552 + 0.150) \cdot 9.81 \cdot 0.3$ $\tau_A = 0.742 \cdot 9.81 \cdot 0.3$ $\tau_A \approx 2.18Nm$

Planetary gear calculations

Desired Gear Ratios

We need two 4:1 gear ratios to achieve a combined reduction of 16:1. The overall gear ratio (R_{total}) for stacked stages is the product of the individual gear ratios:

$$R_{total} = R_1 \times R_2$$

Since we need both stages to have the same ratio:

$$R_{total} = 4 \times 4 = 16 : 1$$

Calculating Gear Teeth

The gear ratio (R) for a single planetary gear stage can be calculated using the following formula:

$$R = 1 + \frac{N_R}{N_S}$$

where:

- N_R is the number of teeth on the ring gear.
- N_S is the number of teeth on the sun gear.

Given the desired gear ratio ($R = 4$) for each stage:

$$4 = 1 + \frac{N_R}{N_S}$$

Solving for N_R:

$$4 - 1 = \frac{N_R}{N_S}$$

$$3 = \frac{N_R}{N_S}$$

$$N_R = 3 \cdot N_S$$

Determining the Number of Teeth

Let's choose the number of teeth for the sun gear (N_S):

- Let $N_S = 20$

Then the number of teeth for the ring gear (N_R) is:

$$N_R = 3 \cdot N_S = 3 \cdot 20 = 60$$

Verifying the Planet Gear

The planet gear must fit between the sun and ring gears. The number of teeth for the planet gear (N_P) can be calculated by ensuring it meshes properly:

$$N_P = \frac{N_R - N_S}{2}$$

Given $N_R = 60$ and $N_S = 20$:

$$N_P = \frac{60 - 20}{2} = \frac{40}{2} = 20$$

Arduino Code

Basic Control Robot arm

```
#include <AccelStepper.h>
#include <MultiStepper.h>

AccelStepper newStepper(int stepPin, int dirPin, int enablePin) {
  AccelStepper stepper = AccelStepper(stepper.DRIVER, stepPin,dirPin);
  stepper.setEnablePin(enablePin);
  stepper.setPinsInverted(false,false,true);
  stepper.setMaxSpeed(800);
  stepper.setAcceleration(2000);
  stepper.enableOutputs();
  return stepper;
}

unsigned long time;

AccelStepper steppers[5];

int incomingByte = 0; // for incoming serial data

MultiStepper msteppers;

long stepperPos[5] = {0, 0, 0, 0, 0, };
long stepsPerFullTurn[5] = {4000, 3200, 3200, 3200, 3200};


void setup() {
  Serial.begin(9600);
  // init steppers based on RAMPS 1.4 pins
  steppers[0] = newStepper(40,41,31); // Don't know the pins
  steppers[1] = newStepper(2,5,32);
  steppers[2] = newStepper(3,6,33);
  steppers[3] = newStepper(4,7,34);
  steppers[4] = newStepper(12, 13, 35); // Don't know the pins

  msteppers.addStepper(steppers[0]);
  msteppers.addStepper(steppers[1]);
  msteppers.addStepper(steppers[2]);
  msteppers.addStepper(steppers[3]);
  msteppers.addStepper(steppers[4]);

  int tokenPos=0;
  char token[10];

  char whichAxis = NULL;
```

```
  int ctoi(int c) {
      return c - '0';
  }

  void moveDegrees(int stepper,double degrees) {
    double stepPos = stepsPerFullTurn[stepper] * degrees / 360.0 ;
    stepperPos[stepper] = (long)stepPos;
  }

  void readSerial() {
  if (Serial.available() > 0) {
    // read the incoming byte:
    incomingByte = Serial.read();

    if (incomingByte!=' ' && incomingByte!=10) {
      if (whichAxis == NULL) {
        whichAxis = incomingByte;
      } else {
        token[tokenPos++]=(char)incomingByte;
      }
    } else {
      token[tokenPos]=NULL;
      double distance = atof(token);
      int stepper = ctoi(whichAxis);
      moveDegrees(stepper, distance);

      whichAxis = NULL;
      token[tokenPos]=NULL;
      tokenPos=0;
    }

    if (incomingByte==10) {
      msteppers.moveTo(stepperPos);
    }
  }
}

void loop() {
  readSerial();
  msteppers.run();
}
```

Three Stepper Control

```
/*
    Controlling multiple steppers with the AccelStepper and MultiStepper
library

*/

#include <AccelStepper.h>
#include <MultiStepper.h>

// Define the stepper motor and the pins that is connected to
AccelStepper stepper1(1, 2, 5); // (Typeof driver: with 2 pins, STEP,
DIR)
AccelStepper stepper2(1, 3, 6);
AccelStepper stepper3(1, 4, 7);

MultiStepper steppersControl;  // Create instance of MultiStepper

long gotoposition[3] = {0, 0, 0}; // An array to store the target
positions for each stepper motor

void setup() {

  stepper1.setMaxSpeed(1000); // Set maximum speed value for the stepper
  stepper2.setMaxSpeed(300);
  stepper3.setMaxSpeed(300);

  // Adding the 3 steppers to the steppersControl instance for multi
stepper control
  steppersControl.addStepper(stepper1);
  steppersControl.addStepper(stepper2);
  steppersControl.addStepper(stepper3);

 // gotoposition[0] = 0;
//  gotoposition[1] = 0;
//gotoposition[2] = 0;
//steppersControl.moveTo(gotoposition);

  delay (2000);
}


void loop() {
  // Store the target positions in the "gotopostion" array
  gotoposition[0] = 3200;  // 800 steps - full rotation with quater-step
resolution
  gotoposition[1] = 50;
```

```
  gotoposition[2] = 50;

  steppersControl.moveTo(gotoposition); // Calculates the required speed for all motors
  steppersControl.runSpeedToPosition(); // Blocks until all steppers are in position

  delay(1000);

  gotoposition[0] = 0;
  gotoposition[1] = 0;
  gotoposition[2] = 0;

  steppersControl.moveTo(gotoposition);
  steppersControl.runSpeedToPosition();

  delay(1000);
}
```

Test without library

```
/*
  Stepper Test Code w/o Stepper library V2
  Nema 17 stepper Motor with A4988 Driver
*/

// Define Constants

// Connections to A4988
const int dirPin = 5;  // Direction
const int stepPin = 2; // Step

// Motor steps per rotation
const int STEPS_PER_REV = 200;

void setup() {

  // Setup the pins as Outputs
  pinMode(stepPin,OUTPUT);
  pinMode(dirPin,OUTPUT);
}
void loop() {

  // Set motor direction clockwise
  digitalWrite(dirPin,HIGH);

  // Spin motor one rotation slowly
  for(int x = 0; x < STEPS_PER_REV; x++) {
    digitalWrite(stepPin,HIGH);
    delayMicroseconds(2000);
    digitalWrite(stepPin,LOW);
    delayMicroseconds(2000);
  }

  // Pause for one second
  delay(1000);

  // Set motor direction counterclockwise
  digitalWrite(dirPin,LOW);

  // Spin motor two rotations quickly
  for(int x = 0; x < (STEPS_PER_REV * 2); x++) {
    digitalWrite(stepPin,HIGH);
    delayMicroseconds(1000);
    digitalWrite(stepPin,LOW);
    delayMicroseconds(1000);
  }
```

```
  // Pause for one second
  delay(1000);
}
```

Hardcode Track Run

```
#include <AccelStepper.h>
#include <MultiStepper.h>

AccelStepper newStepper(int stepPin, int dirPin, int enablePin) {
  AccelStepper stepper = AccelStepper(stepper.DRIVER, stepPin,dirPin);
  stepper.setEnablePin(enablePin);
  stepper.setPinsInverted(false,false,true);
  stepper.setMaxSpeed(800);
  stepper.setAcceleration(2000);
  stepper.enableOutputs();
  return stepper;
}

unsigned long time;

AccelStepper steppers[5];

int incomingByte = 0; // for incoming serial data

MultiStepper msteppers;

long stepperPos[5] = {0, 0, 0, 0, 0};
long stepsPerFullTurn[5] = {4000, 3200, 3200, 3200, 3200};

int tokenPos=0;
char token[10];

char whichAxis = NULL;

int ctoi(int c) {
  return c - '0';
}

void moveDegrees(int stepper,double degrees) {
  double stepPos = stepsPerFullTurn[stepper] * degrees / 360.0 ;
  stepperPos[stepper] = (long)stepPos;
}

void slide() {
  delay (1000);
  // roate the teh steppers at either clockwise or counterclockwsie so
that the robot travels forwards and scoops teh ball
}

void deposit() {
  delay (1000);
  // deposit the balls Hardcode the angles and the location
```

```
  // trap door
}

void setup() {
  Serial.begin(9600);
  // init steppers based on RAMPS 1.4 pins
  steppers[0] = newStepper(40,41,31); // Don't know the pins
  steppers[1] = newStepper(2,5,32);
  steppers[2] = newStepper(3,6,33);
  steppers[3] = newStepper(4,7,34);
  steppers[4] = newStepper(12, 13, 35); // Don't know the pins

  msteppers.addStepper(steppers[0]);
  msteppers.addStepper(steppers[1]);
  msteppers.addStepper(steppers[2]);
  msteppers.addStepper(steppers[3]);
  msteppers.addStepper(steppers[4]);

  // Homing switch

  // Delay untill the begin switch
}

void loop() {

  // First Seed Pod
  gotoposition[0] = moveDegrees([0],degrees]);  // 800 steps - full
rotation with quater-step resolution
  gotoposition[1] = moveDegrees([1],degrees]);
  gotoposition[2] = moveDegrees([2],degrees]);
  gotoposition[3] = moveDegrees([3],degrees]);
  gotoposition[4] = moveDegrees([4],degrees]);

  msteppers.moveTo(stepperPos); // Calculates the required speed for all
motors
  msteppers.runSpeedToPosition(); // Blocks until all steppers are in
position

  // slide function

  // Second Seed Pod
  gotoposition[0] = moveDegrees([0],degrees]);  // 800 steps - full
rotation with quater-step resolution
  gotoposition[1] = moveDegrees([1],degrees]);
  gotoposition[2] = moveDegrees([2],degrees]);
  gotoposition[3] = moveDegrees([3],degrees]);
  gotoposition[4] = moveDegrees([4],degrees]);
```

```
  msteppers.moveTo(stepperPos); // Calculates the required speed for all
motors
  msteppers.runSpeedToPosition(); // Blocks until all steppers are in
position

  // slide function

  // Third Seed Pod
  gotoposition[0] = moveDegrees([0],degrees]);  // 800 steps - full
rotation with quater-step resolution
  gotoposition[1] = moveDegrees([1],degrees]);
  gotoposition[2] = moveDegrees([2],degrees]);
  gotoposition[3] = moveDegrees([3],degrees]);
  gotoposition[4] = moveDegrees([4],degrees]);

  msteppers.moveTo(stepperPos); // Calculates the required speed for all
motors
  msteppers.runSpeedToPosition(); // Blocks until all steppers are in
position

  // slide function

  // deposit function

  // Fourth Seed Pod
  gotoposition[0] = moveDegrees([0],degrees]);  // 800 steps - full
rotation with quater-step resolution
  gotoposition[1] = moveDegrees([1],degrees]);
  gotoposition[2] = moveDegrees([2],degrees]);
  gotoposition[3] = moveDegrees([3],degrees]);
  gotoposition[4] = moveDegrees([4],degrees]);

  msteppers.moveTo(stepperPos); // Calculates the required speed for all
motors
  msteppers.runSpeedToPosition(); // Blocks until all steppers are in
position

  // slide function

  // Fifth Seed Pod
  gotoposition[0] = moveDegrees([0],degrees]);  // 800 steps - full
rotation with quater-step resolution
  gotoposition[1] = moveDegrees([1],degrees]);
  gotoposition[2] = moveDegrees([2],degrees]);
  gotoposition[3] = moveDegrees([3],degrees]);
  gotoposition[4] = moveDegrees([4],degrees]);
```

```
  msteppers.moveTo(stepperPos); // Calculates the required speed for all 
motors
  msteppers.runSpeedToPosition(); // Blocks until all steppers are in 
position

  // slide function

  // Sixth Seed Pod
  gotoposition[0] = moveDegrees([0],degrees]);  // 800 steps - full 
rotation with quater-step resolution
  gotoposition[1] = moveDegrees([1],degrees]);
  gotoposition[2] = moveDegrees([2],degrees]);
  gotoposition[3] = moveDegrees([3],degrees]);
  gotoposition[4] = moveDegrees([4],degrees]);

  msteppers.moveTo(stepperPos); // Calculates the required speed for all 
motors
  msteppers.runSpeedToPosition(); // Blocks until all steppers are in 
position

  // slide function

  // deposit function

}
```

Homing test

```
#include <AccelStepper.h>
#include <MultiStepper.h>

// Define the stepper motor and the pins that is connected to
AccelStepper stepperBase( 1, 2, 5); // (type of driver, step pin, 
direction pin)
AccelStepper stepper1(1, 3, 6);
AccelStepper stepper2(1, 4, 7);
AccelStepper stepper3(1, 12, 13);

MultiStepper steppersControl;  // Create instance of MultiStepper

//Define Pins used
#define home_switch 22 //pin xx connected to Home Switch (MicroSwitch)
#define home_switch 23 //pin xx connected to Home Switch (MicroSwitch)
#define home_switch 24 //pin xx connected to Home Switch (MicroSwitch)
#define home_switch 25 //pin xx connected to Home Switch (MicroSwitch)
```

```
// Stepper Travel Varibles
long TravelX

void setup() {
  Serial.begin(9600);   // Start Serial monitor with speed of 9600 Buads

  pinMode(home_switch, INPUT_PULLUP);

  delay(5);  // Wait for EasyDriver wake up

  pos2Home();

}

void loop() {
  // put your main code here, to run repeatedly:

}

/*
@ Function where Stepper Motors will move to home
@ Stepper Motors will step until they reach the limit switch
@ Homes base stepper and each joint stepper (1,2,3)
*/
void pos2Home() {
  // Set max speed and acceleration of each stepper motor
  // We set the speed slower as slower is more accuate
  stepperBase.setMaxSpeed(100);
  stepperBase.setAcceleration(100);
  stepper1.setMaxSpeed(100);
  stepper1.setAcceleration(100);
  stepper2.setMaxSpeed(100);
  stepper2.setAcceleration(100);
  stepper3.setMaxSpeed(100);
  stepper3.setAcceleration(100);

  // Homing Base Stepper
  Serial.print("Base Stepper is Homing  . . . . . .")

  while (digitalRead(home_switch)) {      // Make the Stepper move CCW
unti the switch is activated
    stepperBase.moveTo(initial_homing);   // Set the position to move to
    initial_homing--;                     // Decrease by 1 for next move
if needed
    stepperBase.run();                    // Start moving the stepper
    delay(5);
  }
```

```
  stepperBase.setCurrentPosition(0);  // Set the current position as zero
for now
  stepperBase.setMaxSpeed(100);       // Set max speed (slower = more
accurate)
  stepperBase.setAcceleration(100);   // Set acceleration

  while (digitalRead(home_switch)) {      // Make the Stepper move CCW
unti the switch is activated
    stepperBase.moveTo(initial_homing);   // Set the position to move to
    stepperBase.run();                    // Start moving the stepper
    initial_homing++;
    delay(5);
  }

  stepperBase.setCurrentposition(0);
  Serial.println("Homming Complete: STPR Base");
  Serial.println("");


  // Homing 1st Joint Stepper
  Serial.print("1st joint Stepper is Homing  . . . . . .")

  while (digitalRead(home_switch)) {  // Make the Stepper move CCW unti
the switch is activated
    stepper1.moveTo(initial_homing);  // Set the position to move to
    initial_homing--;                 // Decrease by 1 for next move if
needed
    stepper1.run();                   // Start moving the stepper
    delay(5);
  }

  stepper1.setCurrentPosition(0);  // Set the current position as zero
for now
  stepper1.setMaxSpeed(100);       // Set max speed (slower = more
accurate)
  stepper1.setAcceleration(100);   // Set acceleration

  while (digitalRead(home_switch)) {    // Make the Stepper move CCW unti
the switch is activated
    stepper1.moveTo(initial_homing);    // Set the position to move to
    stepper1.run();                     // Start moving the stepper
    initial_homing++;
    delay(5);
  }

  stepper1.setCurrentposition(0);
  Serial.println("Homming Complete: STPR 1");
  Serial.println("");
```

```
  // Homing 2nd Joint Stepper
  Serial.print("2nd joint Stepper is Homing  . . . . . .")

  while (digitalRead(home_switch)) {  // Make the Stepper move CCW unti
the switch is activated
    stepper2.moveTo(initial_homing);  // Set the position to move to
    initial_homing--;                 // Decrease by 1 for next move if
needed
    stepper2.run();                   // Start moving the stepper
    delay(5);
  }

  stepper2.setCurrentPosition(0);  // Set the current position as zero
for now
  stepper2.setMaxSpeed(100);       // Set max speed (slower = more
accurate)
  stepper2.setAcceleration(100);   // Set acceleration

  while (digitalRead(home_switch)) {    // Make the Stepper move CCW unti
the switch is activated
    stepper2.moveTo(initial_homing);    // Set the position to move to
    stepper2.run();                     // Start moving the stepper
    initial_homing++;
    delay(5);
  }

  stepper2.setCurrentposition(0);
  Serial.println("Homming Complete: STPR 2");
  Serial.println("");


  // Homing 3rd Joint Stepper
  Serial.print("2nd joint Stepper is Homing  . . . . . .")

  while (digitalRead(home_switch)) {  // Make the Stepper move CCW unti
the switch is activated
    stepper3.moveTo(initial_homing);  // Set the position to move to
    initial_homing--;                 // Decrease by 1 for next move if
needed
    stepper3.run();                   // Start moving the stepper
    delay(5);
  }

  stepper3.setCurrentPosition(0);  // Set the current position as zero
for now
  stepper3.setMaxSpeed(100);       // Set max speed (slower = more
accurate)
```

```
  stepper3.setAcceleration(100);   // Set acceleration

  while (digitalRead(home_switch)) {    // Make the Stepper move CCW unti
the switch is activated
    stepper3.moveTo(initial_homing);    // Set the position to move to
    stepper3.run();                     // Start moving the stepper
    initial_homing++;
    delay(5);
  }

  stepper3.setCurrentposition(0);
  Serial.println("Homming Complete: STPR 2");
  Serial.println("");

}
```

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