TITLE: Project Proposal For A Reagent Pendulum Mixer

TRC3000 Project Proposal

Team name: 1-7

Team members: Sri Shanka (32818939), Joshua Baker (33879885), Sithum Peramuni Gedara(32343213), Sam Hillcoat (31576214)

1 Introduction

Commercial laboratories can supply standard or bespoke chemical reagents to its users. There are clear advantages in maximising the use of automation in many of the processes in these laboratories. For instance, automation allows for more efficient handling and control of chemical reactions to achieve the desired product qualities. It also allows the laboratory to improve on its safety and environmental sustainability profile.

In view of this, there is an impetus to embark on pilot projects that seek to address the following:

1) To establish the physical workability of a testing station built on a low-cost automated handling platform that is able to test a reagent that is routinely used.

2) The receive guidance on how to manage the development of an automated system that involves the preparation of the reagent as well as its testing before being packaged into bottles.

2 Objectives

The objectives of this project are:

- **Objective 1: Mix Reagent using a pendulum**: Design and implement a system that effectively mixes the reagent using a pendulum mechanism, ensuring thorough and uniform mixing. Also, Enhance the design of the pendulum to achieve optimal movement and mixing efficiency, ensuring that the pendulum's motion is both smooth and effective in mixing the reagent.
- **Objective 2: Prevent Spillage:** Design a secure and stable mixing setup that prevents any spillage of the reagent during the mixing process, maintaining the integrity of the experiment and minimising waste. Test different types of pendulum shapes and gripper moving paths to get the best mixing motion.

- **Objective 3: Minimise Operational Risk:** Implement design features and safety measures that reduce the likelihood of structural failure or operational hazards, ensuring that the system is robust and reliable during testing.

3 State of the Field

3.1 Chemical Reagents

3.1.1 Definition and Types of Chemical Reagents

In general terms, a chemical reagent is a chemical, mixture, substance or compound that is introduced as part of a chemical reaction. Almost all chemical reactions and synthesises require reagents, making them an essential part of both laboratory and industrial scale chemistry.

Reagents can be either elemental materials, specific chemical substances or a mixture of chemical substances. They are often in liquid form however may also be used as a solid or gas.

The term reagent is often used interchangeably with other more specific terms for substances used in chemical reactions. A *reactant*, for example, is a type of reagent, however it refers to chemicals used in a reaction that are consumed or transformed into a product over the course of the reaction. A reagent is not necessarily consumed in a reaction and can be used as a *solvent*, or a *catalyst*.

A *solvent* is a specific type of reagent (typically a liquid) used to produce a chemical solution by dissolving other substances (the *solute) s*olvents are often used to dissolve chemicals as to provide a medium in which chemical reactions can occur. A solvent is not consumed during the reaction and remains chemically unaltered throughout the reaction. Examples of solvents used in common chemical processes include Water, Ethanol, Benzene, and Dichloromethane (DCM). The choice of solvent to use varies dramatically depending on the other reagents in the chemical process.

A *catalyst* is another type of chemical reagent that is not consumed or altered in a reaction. A catalyst is used to increase the rate of a reaction, by interacting with the other reagents to lower the required activation energy to begin a reaction. Catalysts are often used in industrial scale chemical processes to increase efficiency, a key example is the Haber-Bosch process of producing ammonia, which uses an Iron catalyst. Catalysts are often metals such as Iron or Platinum, however there are many more chemically complex catalysts that are widely used.

In industrial processes, there are many basic chemical reagents that are useful for many types of reactions and manufacturing processes, an example of some of these reagents is as follows:

Sulfuric Acid (H_2SO_4)

Used in many chemical and manufacturing processes, such as the production of fertilisers, oil and petroleum refining as well as production of steel.

Hydrochloric Acid (HCl)

Used heavily in the production of plastics and plastic materials. HCl is also commonly used throughout the chemical industry as a generic acid and common reagent for pH adjustment in many products.

Ammonia (NH_3)

Used in fertiliser production as a source of nitrogen, ammonia is one of the most important chemical reagents used in modern farming and food production. Ammonia is also used as a source reagent for explosive materials.

Chlorine

Used in the production of PVC (polyvinyl chloride) based plastic products and materials. Chlorine is also used as a bleach in the textile industry.

Market Trends

Historically, many chemical products and processes had little regard for the impact on the environment or the risk of chemical pollution. Many chemicals, especially some organic compounds, are extremely pollutant and harmful to the environment and human health. There is a growing trend to try to move away from these chemicals and find more environmentally friendly or safer alternatives [2].

3.1.2 Quality of Chemical Reagents

Using a chemical reagent of a known quality is crucial to ensuring the desired outcome of a chemical reaction or process. Although the quality may not necessarily need to be high for all processes, a known and graded reagent quality is needed to ensure that a chemical reaction is safe and will occur as expected. It also allows chemical processes to be repeatable across different times and facilities, as a required grade of reagent can be specified for the process.

The quality of a chemical reagent refers to the purity of the desired chemical within the reagent solution or mixture. Depending on the type of chemical, a 100% pure chemical substance is impossible or prohibitively difficult or expensive to obtain. Reagents can be purchased or manufactured to differing levels for purity, and these can be graded based on the desired use case for the reagent.

Chemical grades are often established by government regulatory bodies, or by chemical manufacturers. The grade of a reagent gives an indication of the purity of the chemical, and what types of processes it is suitable for. Examples of chemical reagent grades include:

Analytical / Reagent Grade:

Extremely high purity reagent, often 99% and above, suitable for use in analytical chemistry and quantitative analysis.

Pharmaceutical Grade:

Extremely high purity reagents, meeting the specific requirements of government pharmaceutical regulatory bodies. Reagents are suitable for use in manufacture of pharmaceuticals for human use.

Laboratory Grade:

Reasonable purity but not suitable for analytical or pharmaceutical or food usage. Used commonly in laboratory environments.

Technical / Industrial Grade:

Potentially slight impurities, suitable for use in most industrial and manufacturing processes, however not suitable for use in a laboratory setting.

3.2 Automation in Chemical Laboratories

Automation plays a key role in the preparation, handling and processing of chemical reagents in laboratory and industrial settings. Integrating robotic actuators and digital control systems into chemical processes provides many benefits and improvements over traditional manual methods.

Automated systems can be applied to many tasks in a chemical laboratory, by either both task specific machinery optimised for one particular process, or more general automation solutions, appropriate for general chemical handling and tasks in a lab or smaller scale production environment [3].

An example of automation in a chemical laboratory include an automated dispensing system, where a precise amount of a chemical reagent is measured out and delivered to a vessel. This task can be prone to human error and is often time consuming to complete. An automated solution increases the precision as well as the speed of dispensing chemicals [3].

Automated mixing systems are another common piece of equipment used in a laboratory. These can be of many different designs and are designed to mix, stir or otherwise agitate a chemical mixture or solution. Mixing of chemical reagents often takes a significant period of time, so it is ideal to delegate this process to an automated system. Many mixing systems are integrated with a heating element or hotplate, to increase the rate of reaction, or complete the reaction at a desired temperature.

In industrial or chemical production environments, automation becomes an even more significant area. Industrial chemical production systems are often almost fully automated, with controlled flow rates, temperatures, pressures and mixing. This allows manufacturers to increase the efficiency of a production system and maximise output product relative to both time and the amount of input resources.

Automation is used heavily in processes involving harmful, toxic or dangerous chemicals, where contact with humans is unsafe and not practical. Using automated systems in these areas allows chemical manufacturers and laboratories to increase safety, as well as make use of chemicals that are otherwise considered too dangerous to handle, such as radioactive materials, or biologically hazardous samples.

4 Project Team

4.1 Team Dynamics

The team will all work to their best efforts on the project and will dedicate at least three hours of work towards the project. The team will use their experience with past subjects and extra curricular activities to help with the project. Due to the team having a vast array of different backgrounds will be of an advantage, as from these different experiences, there will be a different set of eyes and knowledge looking upon the project.

Sam

- As Sam has vast experience in CAD modelling and 3D modelling. He will be of great assistance to the team going forward. Due to having good experience with CAD, he will be able to make well designed and printed pieces for the project when needed. Sam is also well experienced with various types of software from embedded software to Arduino. Due to a main part of the project being coding, this will be extremely helpful for the team’s progression with the project.

Joshua

- Joshua has had much experience with working with teams. This will help the team going forward as from past experiences, Joshua has learnt how to deal with conflict, planning and allocation of roles amongst a team. Joshua also has experience and is highly knowledgeable with CAD, especially Solidworks due to dealing with CAD from previous subjects. Joshua lives on Campus which will benefit the team due to being easily available to help with certain tasks such as supervising the printing of 3D parts for the team. Also by living on campus, it offers easy access to store items needed for the project in a close and secure location.

Shanka

- Shanka has had experience and vast knowledge with coding of automation before, as this project is purely automated, this will drastically improve and benefit the team. Due to Shanka living on campus as well, this will aid the team in respect for time and storage. Shanka also has experience with machining, this will be helpful experience for components that are required to be more sturdy and strong. Another experience that will be brought into the team is that Shanka has had previous encounters with working with teams and learning too, how to deal with planning and allocation of tasks.

Sithum

- Sithum has had experience like the rest of the team. Sithum is experienced with CAD and other programs like Arduino. Sithum however is greatly experienced with Matlab and Simulink due to having past experiences with these platforms in other subjects such as ENG1014.

With all these experiences that the team has to offer, the team is highly capable in each aspect of the project and will utilise everyone's knowledge in an efficient manner to maximise the output of the team for this project.

4.2 Team Communication

The team will communicate effectively with the use of multiple platforms each with a unique purpose and each assigned a time to be used. The team decided on using four forms of communication to allow for easy transfer of documents and quickly available access to documents, convenient messaging and an easy talking platform . The four platforms that will be used are: GDrive, FaceBook Messenger, Zoom and in person.

GDrive

- The G Drive will be the platform where the team will upload all documents related to this project. It allows for real time collaboration and supports all file types. Google Drive allows for documents to work on at the same time which the team thought would be beneficial to help with writing reports and taking notes. Another benefit for G drive is that each of the team members have access to the platform and it is easy to organise the folders and documents in a clean method. This platform will be utilised throughout the project.

Facebook Messenger

- The team decided that Facebook Messenger would be the best platform for communication between the team members. As it was one of the only platforms that all parties had access to and as it provides a platform for quick communication and rapid feedback. As Facebook Messenger is designed for quick queries and brief discussions, it will work perfectly for the team. This platform will be used any time the team has any important news or questions that need to be made aware of to the team in a quick manner.

Zoom

- The team will also use zoom if needed for team meetings that will not be in person if needed. For example if a party is off campus or falls ill. The reason for this choice of platform was due to multiple reasons. As Zoom has the capability of sharing the view of a party's computer screen, this will benefit the team due being able to clearly highlight and explain any issues that are foreseen within the code or reports. Another reason was that zoom is easy to access and use for all the parties involved.

In Person

- The team will also use the platform of In Person. This will be the most predominantly used platform for the team. This platform is the most efficient platform for communication out of all the platforms being used. Due to being able to explain and show any issues that arise instantly and having immediate feedback from the parties. This platform will be used during team meetings that are held out of class time and also will be used during class time.

5 Plan & Timeline

5.1 Plan

Our project "for A Reagent Pendulum Mixer" was split into four main sections, to align it with concepts and techniques learnt during workshops. This strategy ensures a smooth transition from our initial investigation to the final report of our project. The project extends for 12 weeks, beginning on July 19th, 2024, and ending on October 10th, 2024, which is when the final report is due.

Phase 1: Research, Proposal Development, and Feasibility Study (Weeks 1-4)

- **Task 1: Literature Review (Weeks 1-2)**

  We conducted a study, and a critical analysis of the prevailing automation technologies used into chemical laboratories. The following work was conducted with the aid of content learnt in "Planning & Scheduling" lecture of week 2, focusing on the principles of concurrent engineering. These concepts highlighted the significance of simultaneous task execution to save cost and time to market.

- **Task 2: Feasibility Study of Automated Testing Station (Weeks 2-3)**

  This project will study the feasibility of installing an affordable automated testing station. Theoretical concepts of lecture 1; Mechanisms and Kinematic Mounts were applied to analyse the kinematic limits and mobility of planar mechanisms, thus ensuring the mechanical validity of our design. In addition, meeting the intended automation objectives.

- **Task 3: Proposal Writing and Review (Weeks 3-4)**

  Week 3: We initiate compiling the content for the project proposal, considering the results of the feasibility study and literature review. Carefully ensure the project background, goals and preliminary design criterions are met and considered.

  Week 4: Complete the proposal, including a thorough plan and schedule, and have a team review to make sure anything matches up and completes. Milestone: Submission of Project Proposal by the end of Week 4 (16/08/2024).

Phase 2: Design and Development (Weeks 5-7)

- **Task 4: Detailed Design of Testing Station (Weeks 5-6)**

  We shall provide a comprehensive design for the testing station, focusing on combining sensors and actuators to aid the chemical testing process. This phase utilises the information on sensors, actuators, and electronics, delivered in the Week 3 lecture. This phase also involves suitable component selection, exact control, and process monitoring.

- **Task 5: Development of Automation System (Weeks 6-7)**

  The automation system is intended to be constructed using the ideas from our circuit design and electronics courses of study. Contents of Week 2 highlights the importance of having proper circuit elements such as operational amplifiers to efficiently regulate and control the automated processes. This fact is taken into consideration during construction.

Phase 3: Implementation and Testing (Weeks 8-10)

- **Task 6: System Setup and Integration (Weeks 8-9)**

  The automation system and testing station will be set up and integrated. The Critical Path method (CPM) will be used to determine and monitor the important tasks required to complete the project successfully. This will ensure the functionality and correct installation of every component.

- **Task 7: Testing and Validation (Weeks 9-10)**

  The system will be tested intensively and validated to ensure that it meets all project goals. The Programme Evaluation and Review Technique (PERT) will be used to provide a stable and efficient testing method that deals with any uncertainty and predicts the duration of time required to conduct testing.

Phase 4: Reporting and Finalization (Weeks 11-12)

- **Task 8: Documentation and Reporting (Weeks 11-12)**

  Analysed data, theoretical and experimental results are compiled and presented in a detailed report in this final step. This report elaborates on each phase of the project, from planning to execution. It will showcase how the project adhered to the concurrent engineering principles and met its goals.

- **Milestone: Submission of Final Project Report by the end of Week 12 (18/10/2024).**

5.2 Timeline

The project is scheduled to be completed over 12 weeks, with the following breakdown:

Weeks 1-4: Research, Proposal Development, and Feasibility Study

- **Task 1:** Literature Review (Weeks 1-2)
- **Task 2:** Feasibility Study of Automated Testing Station (Weeks 2-3)
- **Task 3:** Proposal Writing and Review (Weeks 3-4)
  - Drafting the proposal (Week 3)
  - Finalising and reviewing the proposal (Week 4)
- **Milestone:** Project Proposal Submission (16/08/2024, Week 4)

Weeks 5-7: Design and Development

- **Task 4:** Detailed Design of Testing Station (Weeks 5-6)
- **Task 5:** Development of Automation System (Weeks 6-7)

Weeks 8-10: Implementation and Testing

- **Task 6:** System Setup and Integration (Weeks 8-9)
- **Task 7:** Testing and Validation (Weeks 9-10)

Weeks 11-12: Reporting and Finalization

- **Task 8:** Documentation and Reporting (Weeks 11-12)
- **Milestone:** Final Project Report Submission (18/10/2024, Week 12)

With distinct responsibilities and milestones before the project proposal and final report submission, this plan and timeframe assure successful project management.

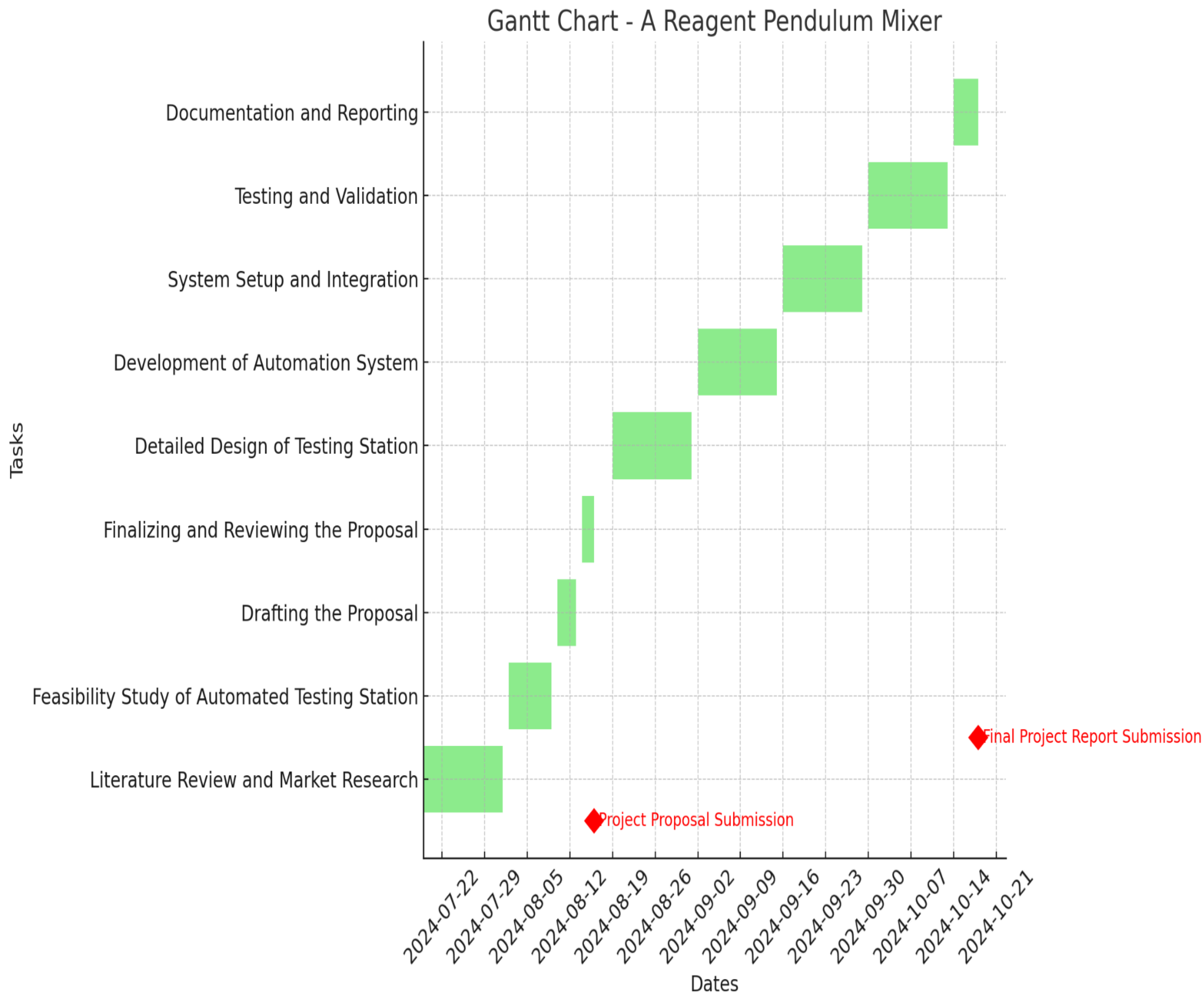

Figure 1: Project Timeline

6 Risk Management Plan

6.1 Occupational Health and Safety Risk

This section 6.1 addresses the impacts of the project on various aspects, including social, health, safety, legal, cultural, commercial, and political factors. The following subsections provide a detailed assessment of potential hazards and associated risks related to the project activities.

6.1.1 Definitions

The risk management plan considers the hazards and risks associated with all the project activities. The definition for hazards and risks are:

HAZARD: A source of potential harm or a situation with potential to cause harm or loss.

RISK: Probability of occurrence of an event that could cause a specific level of harm or loss to people, property, environment and financially over a time frame. To appropriately identify the risks of this project, the level of risk likelihood and risk consequence is defined in Section 6.1.1.1 and 6.1.1.2 respectively. Section 6.1.1.3 shows the risk level of a hazard on a scale in terms of risk likelihood and risk consequence.

6.1.1.1 Risk Likelihood Scale

Table 6.1 shows the five consequence categories and its definition. The description has explained the impact level of each category.

Table 6.1: Risk Consequence Category Definition

Consequence Categories	Definitions
Severe	Completion of the project becomes impossible.
Major	Not able to proceed to another task / next phase. Completion of the project is delayed.
Moderate	Completion of tasks may be delayed by several weeks. May affect the completion of another task.
Minor	Completion of tasks may be delayed by several days. Will not affect the completion of another task.
Insignificant	Minor inconvenience. It will not affect the project timeline.

6.1.1.2 Risk Consequence Scale

Table 6.2 shows the five risk likelihood categories and its definition. The description of each category is based on Monash University OHS Risk Assessment guideline (Monash University, 2021)[4].

Table 6.2: Risk Likelihood Category Definition

Likelihood Categories	Definitions
Highly Likely	will occur in most circumstances when the activity is undertaken (greater than 90% chance of occurring)
Likely	will probably occur in most circumstances when the activity is undertaken (51 to 90% chance of occurring)
Possible	might occur when the activity is undertaken (21 to 50% chance of occurring)
Unlikely	could happen at some time when the activity is undertaken (1 to 20% chance of occurring)
Rare	may happen only in exceptional circumstances when the activity is undertaken (less than 1% chance of occurring)

6.1.1.3 Risk Assessment Matrix

Table 6.3 shows the risk level of a project hazard in terms of risk likelihood and risk consequence. Risk level classifications are based on Monash University OHS Risk Assessment Guideline (Monash University, 2021)[4].

Table 6.3: Risk Assessment Matrix

Consequence / Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Severe**
Rare	N	L	L	M	M
Unlikely	L	L	M	M	H
Possible	L	M	M	H	H
Likely	M	M	H	H	E
Highly Likely	M	H	H	E	E

Negligible (N), Low Risk (L), Medium Risk (M), High Risk (H), Extreme Risk (E)

6.1.2 Project Risks

Table 6.4 shows the identified potential project risks and its corresponding risk assessment.

Table 6.4: Non-OHS Risk Assessment Table

Project Hazard	Risk	Likelihood	Consequence	Risk level	Mitigation	Residual Risk
Wrong Material selection	Select wrong materials that will react with the mixing reagant.	possible	Major	High	Do research on the materials and the chemicals	High
Failure to do testing	Exceeding the allocated time for testing results.	possible	Severe	High	Do pre testing with another 3d printer. be fast.	High
Pendulum mounting failure	Pendulum doesn't twist/move as expected The pendulum may detach/break from the adapter during testing.	likely	Major	High	Keep testing different mechanisms. Using stronger fasteners to hold the pendulum. test the program Use lubricants if needed	High

low performance from team members	might not be able to finish the project due to low performance from team members	likely	Moderate	Medium	Have good communication with team members from the start of the project Help each other	Medium
Delayed ordered parts	Delivery of ordered parts for the design can be delayed by weeks	likey	moderate	High to medium	order parts sooner have a backup plan for the parts	medium

References

[1] M. J. Pearse, "An overview of the use of chemical reagents in mineral processing," *Minerals Engineering*, vol. 18, no. 1, pp. 1-16, Jan. 2005. [Online]. Available: https://doi.org/10.1016/j.mineng.2004.09.015. [Accessed: Aug. 15, 2024].

[2] D. A. Armbruster, D. R. Overcash, and J. Reyes, "Clinical Chemistry Laboratory Automation in the 21st Century - Amat Victoria curam (Victory loves careful preparation)," *Clin. Lab. Med.*, vol. 24, no. 4, pp. 713-734, Dec. 2004. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4204236/.

[3] P. Anastas and N. Eghbali, *Green Chemistry: Principles and Practice*. [Online]. Available: https://doi.org/10.1039/B918763B. [Accessed: Aug. 15, 2024].

[4] Monash University, "OHS Risk Assessment Guide," [Online]. Available: https://www.monash.edu/__data/assets/pdf_file/0010/1028467/OHS-Risk-Assessment-Guide.pdf. [Accessed: Aug. 16, 2024].