ENG60703 Managing Projects for Success

Project Report (10%)

Submission Deadline: Sunday, 2nd December 2018 by 23:00

Project Title	BEEpsweep- Multi-functional Detachable Autonomous Cleaning Robots	
Group Members and ID	Yip Winn Sheng Alwyn	0326644
	Wong Yi San	0326426
	Eugene Gow Jun Yi	0326755
	Lim Min Yee	0330907
	Kuan Jun Wei	0331502
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NOTE:

Plagiarism will not be tolerated.

Late submission will be subjected to a mark deduction penalty following the policy of the school, which is a deduction of **10%** for the first day and **5%** for each subsequent day late. A weekend counts as 1 day.

Lecturer reserves the right to not accept work submitted more than 1 week late.

CONTENT

1.0 Introduction and Objectives

Generally, cleaning work such as sweeping, mopping and window cleaning require a lot of labour. This tedious and tiring cleaning work is usually carried out by adults. Therefore, ever since the 1860s, a variety of vacuum cleaners have been introduced. This automatic robotic vacuum cleaner is able to move by itself to perform its function. It did tackle the issue of tangled wires and energy-consuming cleaning work. However, it is still not productive enough for the current generation because other cleaning functions such as mopping and sweeping have to be done as well in order for the place to be fully clean.

Moreover, assigning household chores to children has always been a major concern for parents. Albeit their intentions of training and building up a sense of responsibility in their children as well as encouraging family unity, it is admittedly unsafe to entrust a child to do household chores by him or herself.

Therefore, in this module project, we aim to combine two features (vacuum cleaning and mopping) into one cleaning system where two devices operate individually. One device (runner as we call it) does the mopping while the other vacuum cleans. In our design, the device has two working modes which are autonomous and manual.

Our goal is to make household chores less tedious, safe and more fun so that even children can take part in cleaning duties. To achieve this, we created a user interface with touch buttons as shown in Figure 1 for the user to control the runners. This can enhance the interest in children to do the cleaning work, since they can control the runners as if they are playing with remote controlled toy cars.

Besides, we added an additional feature which is metal detector. The metal detector is installed to the vacuum cleaner. When the metal detector is turned on, it will notify the user when important items are sucked up. This can help us to track missing items such as jewellery.

2.0 Overall Project Assessment

The initial objective of this project was to build an autonomous cleaning device system which allows multiple runners to perform individual tasks simultaneously. Initially, the three main cleaning functions were vacuuming, mopping and window cleaning. During the early stages of the project, window cleaning was dropped out of the project due to the complexity and time constraint. This was replaced with an additional feature which is a metal detector which allows users to detect missing jewellery.

In order to indicate the level of success of the project, this project can be evaluated by four criteria which is schedule, quality, cost and client satisfaction. This project started during week 2 and progresses until week 14. Our project is considered successful as within the period of 12 weeks we are able to meet the objectives of our project. This feat was achieved by proper planning and also the hard work that the team has shown throughout the whole project. In addition, major milestones were set in the gantt chart as this would determine the direction of the project. Some milestones have to be achieved in order to proceed to the next task. Hence, every task must be done within the stipulated time schedule in order to avoid any slippage during the project.

As for the quality, we are able to achieve the three main qualities which is to build a vacuum cleaner system, program the system to be autonomous and also enable the metal detector. This feat was done by distributing tasks into a few groups. By doing so, we are able to save time and also focus solely on the quality that we are looking to achieve. Throughout the project, we were also looking at different features that can be added to the project in order to exceed the initial quality that was stipulated. By doing so, we are able to increase value to the project also display that we are committed in achieving the quality that has been set.

Cost management was one of our highest priorities in this project. This was because we were given a minimal budget of RM200 to build something innovative. Hence, financial planning was very crucial throughout the whole project. Throughout the whole project, we only spent less than RM100 which is below the stipulated budget. This was achieved as we elected a treasurer to keep track of our spendings throughout the whole project. At the same time, we were able to obtain electrical components and materials from our lab which helped us save cost. Besides, we surveyed several vendors before purchasing any items in order to obtain the lowest price. All this enables us to successfully build our project within the allocated budget.

Client satisfaction is essential in every project and is one of the important evaluations in determining the success of the project. In order to achieve a satisfactory client satisfaction, multiple testings were done with the product in several conditions and situations. By doing so, we are able to build a product that meets the requirement of most types of customers. During the early stages of the project, a survey was also done to determine the feature that most customers would prefer out of a cleaning device. This would help us ensure that our project meets the needs of our customers.

3.0 Schedule Review

Table 1 Gantt Chart

WBS Code	TASK	WEEK/DATE													
		01	02	03	04	05	06	07	08	09	10	11	12	13	14
						✔								✔	✔
1.0	**Understand and Observe**														
1.1	**Research**														
1.1.1	Identify challenge														
1.1.2	Gather information and statistics														
1.1.3	Conduct interviews/surveys														
1.2	**Plan**														
1.2.1	Analyse information obtained														
1.2.2	Identify root causes of challenge														
1.2.3	Identify solutions to challenge														
1.2.4	Calculate estimated BV of proposed solution														
2.0	**Ideate**														
2.1	**Detailed Drawing**														
2.1.1	Identify subsystems and components														
2.1.2	Sketch out design														
2.1.3	Provide specifications and label design														
3.0	**Prototype**														
3.1	**Budget Management**														
3.1.1	Compare prices and quality among vendors														
3.1.2	Purchase and obtain materials														
3.2	**Construction**														
3.2.1	**Motion System**														
3.2.1.1	Construct base and casing														
~~3.2.1.2~~	~~Construct whegs~~														
3.2.1.3	Assemble wheels~~/whegs~~ and motors to base														
3.2.1.4	Coiling of copper wire														

3.2.2	**Cleaning System**														
3.2.2.1	Construct vacuum mechanism														
3.2.2.2	Construct mop mechanism														
3.2.2.3	Construct water storage, tubing and pump														
~~3.2.2.4~~	~~Construct window cleaning mechanism~~														
3.2.3	**Control System**														
3.2.3.1	Construct circuit for motion system														
3.2.3.2	Construct circuit for cleaning system														
3.2.3.3	Construct circuit for Bluetooth connection														
3.2.3.4	Programming for motion system														
3.2.3.5	Programming for cleaning system														
3.2.3.6	Programming for Bluetooth connection														
3.2.3.7	Programming for metal detecting system														
3.3	**Integration**														
3.3.1	Review and finalize design														
3.3.2	Integrate all systems														
3.4	**Testing**														
3.4.1	Test functionality														
3.4.2	Test reliability														
3.4.3	Test safety														
4.0	**Enhance/Improve**														
4.1	Increase efficiency														
4.2	Improve aesthetic														

KEY	Planned		Accomplished Planned Task		Additional Task	

Table 1 above shows the Gantt Chart that was planned during the planning stage showcasing the project timeline from week 1 to week 14.

1.0 Understand and Observe

1.1 Research

Although expected to finish in Week 1, all subtasks were completed in Week 2. This 1 week delay was because we were unable to obtain approval for the idea of our project from the project supervisor. Therefore, the team had to repeat the same tasks to obtain a different innovative idea that has business value.

1.2 Plan

All tasks were completed in Week 3 as according to schedule. Most of the subtasks in 1.1 and 1.2 were done together. Information like business value was already researched on and briefly calculated earlier during the research stage. Hence, the subtasks in 1.2 were not delayed even though the subtasks in 1.1 were.

2.0 Ideate

2.1 Detailed Drawing

All tasks were completed in Week 4 which is a week later than planned due to a change in the design of our product after having a consultation session with the project supervisor. The reason was that it was unrealistic to build so many features in a short period of time. Hence, the wall climbing feature was eliminated. During that period, we went through another brainstorming session which required some time to properly plan the new design which was the metal detector that would be integrated with the vacuum cleaning system.

3.0 Prototype

3.1 Budget Management

Although there was a week delay during the ideate stage, the project progress was brought back on track during this stage since most of the components could be obtained from the laboratory. So, there was no need for us to source the materials from vendors and compare prices. According to the project timeline, this stage was completed on week 3 as planned.

3.2 Construction

For the motion system, there was an additional task since there was a change in idea during the ideate stage. The coiling of copper wire task was added to replace the wheg assembly as the wall climbing feature was eliminated.

As for the cleaning system, there was a week delay in the construction of the vacuum cleaning system. There was a difficulty for the vacuum to suck up the dust/dirt and some modifications were made. The modifications made include lowering the vacuum opening to the ground and also changing the thickness of the fan blade.

For the control system, there was also a week delay from Week 11 to Week 12 on the programming of the Bluetooth connection. This was due to the inability of the Bluetooth module to connect to the phone. On the other hand, there was an additional task regarding the metal detecting system.

3.3 Integration

Subtasks were completed on time as planned during week 12. There were no modifications made since all the parts fitted perfectly onto the base. All the individual parts also worked as planned during integration.

3.4 Testing

Subtasks were completed a week behind schedule. The testing was expected to be completed during Week 12 but was delayed to Week 13. The delay was a result of the difficulty faced in the control system part of 3.2 which was the programming of the Bluetooth connection. Hence, we could not conduct testing during this time since both runners needed to be connected to the Bluetooth and controlled using the phone. However, the issue was solved in Week 12 and we began testing right after that.

4.0 Enhance and Improve

All subtasks were completed in Week 13 as according to schedule. The product works as an integrated system. The aesthetic of the product was enhanced.

4.0 Scope Review

Project Team/Stakeholders:
Team leader: Alwyn Yip
Core team: Wong Yi-San, Eugene Gow Jun Yi, Lim Min Yee, Teoh Zhi Heng, Kuan Jun Wei
Stakeholders: Taylor's University, Sponsors

Project Goal:
To produce a multi-functional, detachable, autonomous cleaning robot system.

Project Scope:

1. Build a prototype within a budget of RM200
2. Compact, with high functionality

Milestones/Deliverables:

1. Identify business value
2. Design prototype (simple and efficient)
3. Construct prototype
4. Integrate all parts
5. Improve the system

Success Metrics:

1. High business value
2. Project cost within the budget
3. Project completed within schedule
4. Quality of product meets the minimum quality standard

5.0 Budget Review

Table 2 Bill of materials

Bill of Material							
No.	Material	Description	Vendor	Unit Price (RM)	Quantity	Total (RM)	Project Total (RM)
1	Arduino UNO	-	Cytron	96.00	3	288.00	0
2	DC Motor	3V-6V	Cytron	1.50	5	7.50	0
3	Bluetooth Module	HC-05	Cytron	15.90	3	47.70	47.70
4	Neodymium Magnet	8mm x 3mm	Lazada	2.40	11	26.40	26.40
5	Perspex	0.5m x 0.5m	Lazada	50.00	1	50.00	0
6	Turbine Fan	Laptop cooling fan	Lazada	8.40	1	8.40	0
7	Micro Servo	SG90	Cytron	7.00	3	21.00	0
8	Lipo Battery	-	Cytron	12.50	2	15.00	0
9	Ultrasonic Sensor	HC-SR04	Cytron	3.20	4	12.80	12.80
10	Jumper Wires	Pack of 40 pc	Lazada	2.50	1	2.50	0
11	Motor Shield	-	Lazada	19.90	2	39.80	0
12	RC Wheel	65 x 26.5mm	Cytron	10.00	2	20.00	0
13	Filter Cloth	Mesh fabric	Lazada	3.50	1	3.50	0
14	Dust Container	5cm x 5cm x 2cm	Lazada	2.00	1	2.00	0
15	Circular Plate	Diameter 6cm	Lazada	0.60	3	1.80	0
16	Breadboard	-	Lazada	2.70	2	5.40	0
17	Microfibre Cloth	Diameter 7cm	Lazada	3.70	1	3.70	0
18	9V Battery	-	Lazada	2.00	1	2.00	0
Grand Total (RM)						557.50	86.90

The table above illustrates the bill of material during the planning stage. There were a few changes made in the purchase of materials throughout the project. Some materials were borrowed from the laboratory and some were purchased from different vendors which caused a change in cost. Initially, the total cost was RM 557.50 and our project total (after subtracting the materials that could be self-sponsored or borrowed) was RM 86.90. However, we managed to obtain a few more of the materials (to be purchased) from the laboratory instead.

Table 3 Change in project cost

No	Materials	Original Price/Unit (RM)	Original Vendor	Current Price/Unit (RM)	Current Vendor	Current Quantity	Current Total (RM)	Change in Price (RM)
1	Bluetooth Module	15.90	Cytron	20.00	QQ Online Trading	2	40.00	8.20
2	Neodymium Magnet	2.40	Lazada	2.20	Lazada	5	11.00	15.40
3	Ultrasonic Sensor	3.20	Cytron	-	-	-	0	0

Table 3 shows the change in material quantity and cost as compared to what was initially planned. For the Bluetooth module, the original price and online vendor was RM 15.90 from Cytron Technology. However, the shipping time was long so we went to the nearest physical vendor which was QQ Trading and purchased 2 Bluetooth modules with a cost of RM 40.00 in total. This vendor offered the lowest price compared to other physical vendors we surveyed, hence we purchased the Bluetooth modules from them. We were also able to obtain 5 neodymium magnets with a cost of RM 2.20 each which is cheaper by 20 cents compared to the vendor we were planning to purchase from on Lazada. Besides, ultrasonic sensors were planned to be purchased at total RM 12.80, but we were able to borrow them from the laboratory instead.

Up until Week 13, we spent a total of RM 51.00 which was within the budget. The extra money left was kept in the case of an emergency. In Week 14, an issue with the borrowed Arduino and motor shield arised. An additional RM 70.00 was spent to purchase a new set of Arduino and motor shield. Therefore, the total project cost summed up to RM 121 which was still within the budget.

After updating our budget, we reflected on a few things. Firstly, we should conduct a thorough research beforehand and consider multiple vendors so that we have time to change vendors later on if necessary. Moreover, we have to be specific in our design and all the required materials. A time limit should also be set to obtain the materials after we have the product design. Lastly, we should remind ourselves on the importance of budget planning in any project. All in all, we have a stronger awareness on the significance of budget planning and prepare for the worst-case scenario.

6.0 Quality Review

1. Autonomous cleaning devices

This was achieved by constructing runners that each has three ultrasonic sensors to detect obstacles. The data is transmitted to the Arduino where it is analysed. The Arduino proceeds to send output instructions to the two DC motors of the wheels that moves the runner around without bumping into any objects.

2. Toy car + Cleaning devices

This was achieved by combining the typical remote controlled toy user interface vehicle with the mobile cleaning runners. We utilised a mobile application to control the motion of the runners and HC-05 Bluetooth modules which acts as a medium to exchange data and commands between the Arduino and the phone.

3. Multifunctional + Metal detection

This was achieved by setting 3 main functions; vacuum cleaning, metal detection and mopping. One runner mops while the other runner vacuum cleans and detect metal. A coil of copper wire was placed at the vacuum opening that detects metallic items like jewelry and alerts users through a change in sound frequency emitted by a buzzer.

7.0 Areas of Improvement

1. Technical skills

At the start of the project, we only had basic programming knowledge and lacked thorough understanding in more complex coding like linking multiple Arduinos (each with their own functions/code) to one Bluetooth module that can all be controlled simultaneously on the phone. Even after conducting a lot of research, we could not compose a functioning code due to its complexity. In addition, we had other components to work on. Hence, comprehensive research on the topic should be done before deciding on the idea. Only then we can have a clearer picture and set realistic goals/quality standards of our desired product. We should not be too ambitious, and work with something we are more familiar with/capable of.

2. Time estimation and management

For a successful project, we have to ensure the time is sufficient for completion. This project was complex and required a lot of effort especially during the testing stage. We underestimated the complexity and time needed to perfect a system like this. Hence, we should be more particular about our time estimation and allocate an adequate delay time for all tasks.

3. Monitoring and controlling

Some tasks were delayed because we had spent extra time finishing the tasks prior to that. Hence, based on our Gantt Chart, we should consistently keep track and update the whole team on every current task progress during weekly meetings. We should also conduct an earned value analysis to be aware of our project performance and deviations (if any) from planned cost and schedule. This lowers the risk of the project running late so we would not need to resort to fast tracking or project crashing which may end up with cost increment.

4. Communication/Task Distribution

Members were assigned their roles based on their strengths, but some members were not comfortable with certain tasks and required help from more members due to the amount of effort/expertise needed. Due to this, the project progress was affected and tasks got delayed. As a team, we should hold a discussion and ensure that each member fully understands and is comfortable with their roles, tasks, and their assigned partners. The roles and tasks should also be distributed fairly and as according the individual's strengths and capabilities.

5. Planning

In the planning phase, we prepared a rough sketch of the product design but it was not detailed to the full extent. The dimensions were estimated and we did not take into account certain things like wire arrangement and power consumption. Hence, we should be more particular about the design and include all components, wiring/connection, mechanism, arrangement, interior and exterior look, down to the last detail.

8.0 Conclusions and Recommendations

In short, our project was a success because we achieved our goals within the given timeframe and budget while meeting the expected standard of quality. After completing this project, we reflected on areas that we can work on and improve in terms of product design and project management. Based on our experience, design recommendations include making the runners smaller and more compact so that it takes up less space, and placing smaller wheels closer to the runner's frame to reduce the gap between the runner and the wall.

For project management, we learnt that thorough research and planning is the most important aspect of a project. Detailed planning includes preparing the schedule, budget, quality standards, design, tasks and scope with utmost precision. Proper planning minimizes the risk of failures and ensures that even if we experience a failure, we always have a backup solution ready in our hands.

References/Appendix

Meeting Minutes (Week 2-13)

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Meeting Records

Name(s):

Yip Winn Sheng Alwyn	0326644
Kuan Jun Wei	0331502
Wong Yi-San	0326426
Lim Min Yee	0330907
Eugene Gow Jun Yi	0326755

Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 2 3/9/18 2PM Block D Level 2	N/A (No previous meeting)	1. Read through the project requirements in the handbook 2. Gathered and discussed input/ideas from each member 3. Filtered and listed out challenge statements and solutions proposed	

Team stage: Forming Justification: High motivation, low knowledge

Plan: 1. Research and calculate BV for the solutions/ideas that have been listed out
2. Consult project supervisor and seek approval

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Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 3 10/9/18 2PM Block D Level 2	1. BV for first-choice solution was roughly calculated 2. Approval was not obtained	1. Discussed and formed a new challenge statement 2. Brainstormed for new solutions 3. Assessed and listed out the best solution proposed	

Team stage: Forming Justification: High motivation, low knowledge

Plan: 1. Research and calculate BV for the new solution
2. Consult project supervisor and seek approval

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Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 4 17/9/18 2PM Block D Level 2	1. BV for the new solution was calculated 2. Approval was obtained	1. Discussed on product's main functions and its design 2. Listed out product's subsystems 3. Drew a rough design sketch of product 4. Assigned tasks for project proposal	

Team stage: Forming Justification: High motivation, low knowledge

Plan: 1. Research on internal mechanisms/processes and suitable materials
2. Prepare detailed drawing of product
3. Research on sources and costs of materials, prepare budget chart
4. Complete and submit project proposal on time

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Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 5 24/9/18 2PM Block D Level 2	1. Detailed drawing of product was completed 2. Budget chart was completed 3. Proposal nearing completion, to be submitted	1. Reviewed proposal, minor edits to be made 2. Assigned the week's tasks to members: a. Purchasing - Eugene b. Solidworks 3D drawing, printing - Min Yee, Yi-San c. Wheels construction, assembly - Alwyn, Jun Wei	

Team stage: Forming Justification: High motivation, low knowledge

Plan: 1. Purchase/obtain materials
2. Prepare Solidworks 3D drawing of base and casing, send for printing
3. Construct whegs, assemble wheels/whegs and motors to base

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Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 6 1/10/18 2PM Block D Level 2	1. Materials gathered 2. Solidworks 3D drawing has been edited, only the vacuum component will be 3D-printed, others to be self-constructed 3. Motors connected to the wheels were assembled to the base	1. There has been a modification in the product design to a simpler one with its core function intact. This decision was made due to time constraint and permission was granted from the project supervisor 2. Eliminated the wall climbing feature and simplified the main functions into: a) vacuum cleaning and metal detector (eg. jewellery), b) mop. Both runners will operate only on the ground	

Team stage: Storming Justification: Low motivation, low knowledge

Plan: 1. Design a metal detector system to be integrated into the vacuum system
2. Construct and test a simple prototype of the vacuum system
3. Complete programming of motion system and vacuum cleaning system

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Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 8 15/10/18 2PM Block D Level 2	1.The design of the metal detector system was finalised 2. A simple prototype of the vacuum system was constructed and tested, the actual vacuum component to be 3D printed 3. The programming for the motion system is half completed, to be combined with vacuum system	1. Prepared Solidworks 3D drawing of vacuum component and sent for printing 2. Constructed a simple prototype of the metal detector 3. Continued coding for motion system	

Team stage: Storming Justification: Low motivation, low knowledge

Plan:
1. Test metal detection system
2. Complete programming for the motion system and integrate with the vacuum and metal detection system
3. Construct and assemble base and casing for runners

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Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 9 23/10/18 2PM Block D Level 2	1. Metal detection system tested, actual system to be constructed and implemented to the vacuum system 2. Programming for the motion system is nearly completed, to be combined with the operating system (vacuum and mop) 3. Vacuum component printed, base and casing for first runner constructed, parts to be assembled	1. Updated each other on task progress and exchanged feedback	

Team stage: Storming Justification: Low motivation, low knowledge

Plan:
1. Construct and integrate metal detection system to vacuum system
2. Complete programming for operating and motion system of both runners
3. Complete construction of casing for second runner

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Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 10 30/10/18 2PM Block D Level 2	1. Metal detection system constructed, to be integrated with vacuum system 2. Programming for the both operating and motion system is completed 3. Casing for second runner constructed, to be assembled	1. Updated each other on task progress and exchanged feedback	

Team stage: Norming Justification: Low motivation, high knowledge

Plan:
1. Attach metal detection system to vacuum system
2. Test and improve code
3. Assemble both runners

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Week 11 8/11/18 2PM Block D Level 2	1. The metal detector was attached to the vacuum component, to be tested together with the vacuum motor 2. Both runners were fully assembled, tidiness to be worked on 3. Code fully tested, working as planned	1. Updated each other on task progress and exchanged feedback	

Team stage: Norming
Justification: Low motivation, high knowledge
Plan: 1. Test Bluetooth connection
2. Continuous testing on motion and control

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Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 12 13/11/18 2PM Block D Level 2	1. Bluetooth connection tested, one works while the other does not, to be troubleshooted and fixed 2. Only able to test the motion and control of one runner due to the issue stated above	1. Updated each other on task progress and exchanged feedback 2. Discussed on Bluetooth issue and shared suggestions	

Team stage: Norming
Justification: Low motivation, high knowledge
Plan: 1. Fix the Bluetooth issue
2. Continuous testing

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Eugene Gow Jun Yi	0326755

Week & date	Update/Progress since last meeting	Feedback/Items discussed at this meeting	Supervisor Signature & Date
Week 12 20/11/18 2PM Block D Level 2	1. Bluetooth issue solved 2. Both runners tested, working fine but need some minor improvements	1. Updated each other on task progress and exchanged feedback 2. Shared words of motivation to push the team to complete the project successfully before Engineering Fair	

Team stage: Norming

Justification: Low motivation, high knowledge

Plan: 1. Continuous testing
2. Further improvements in functionality and aesthetic

Team Analysis (Week 2-13)

SCHOOL OF ENGINEERING
ENGINEERING DESIGN AND INNOVATION (PRJ 60403)
Team Analysis Form

Name(s): Alwyn Yip Winn Sheng, Kuan Jun Wei, Eugene Gow Jun Yi, Lim Min Yee, Wong Yi-San

Week	Feedback	Team Stage	Team Activity	Lecture/ Learning	Project Status	Supervisor Signature & Date
2	a. Unable to conceive any idea b. Unable to decide between ideas	Forming	a. Studied the requirements in the handbook, researched and brainstormed ideas b. Filtered and listed out challenge statements and solutions proposed, calculated BV	a. Utilized brainstorming techniques b. Utilized business value technique	a. Ideas listed, final idea to be decided b. Idea to be asked for approval from module supervisor	
3	Approval denied	Forming	Formed a new challenge statement and brainstormed for new solutions, calculated BV	Utilized business value technique	Approval obtained	
4	a. No product design b. No budget chart	Forming	a. Determined main functions, researched on mechanism and materials, set dimensions b. Researched on sources and costs of materials	-	a. Detailed drawing prepared b. Budget chart prepared	
5	Materials not obtained	Forming	a. Purchase materials	-	a. Materials gathered	
6	a. Change in design b. Unsure of whether the vacuum system will work	Storming	a. Eliminated unnecessary features, simplified main functions, update design b. Constructed/Tested a simple prototype	-	a. Eliminated wall climbing feature and added a simple metal detector system b. Prototype works, components to be 3D printed	
7	N/A	N/A	N/A	-	N/A	-
8	a. Unsure of whether metal detection system will work b. Body of runners and vacuum components not constructed	Storming	a. Constructed/Tested a simple prototype b. Sent vacuum components for 3D-printing, constructed the base and casing for runners	-	a. Prototype works, actual system to be constructed and integrated with the vacuum system b. Components and body constructed/assembled	
9	a) Code does not work b) Slow progress in construction/ assembly	Storming	a) Conducted more research and continuous testing b) Quickened the casing construction of second runner, assembled first runner	-	a) Working code completed, to be tested with hardware and further improved b) Casing for both runners constructed, second runner to be assembled	
10	Slow progress	Norming	Increased efficiency and productivity of project sessions	-	Team progress is on tract with schedule	

11	Messy wiring, hard to tell them apart	Norming	Re-soldered and arranged all wires	–	Runners look neater	
12	Bluetooth connection issue	Norming	Got another member to work on the issue together with the person-in-charge, conducted troubleshooting	–	Issue solved	
13	The product works fine, but have some flaws	Norming	Made minor improvements	–	Finished product looks closer to what was expected	

Receipts:

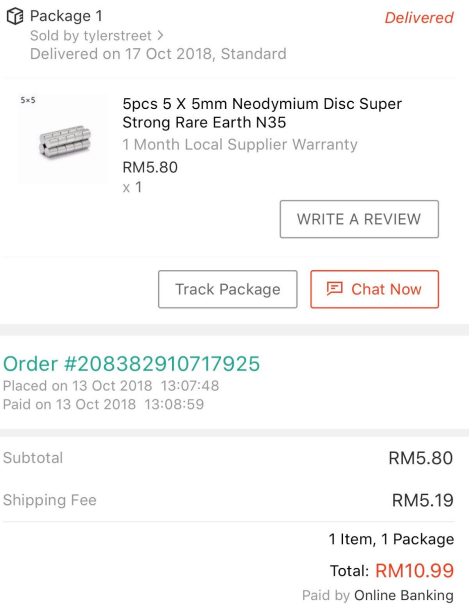
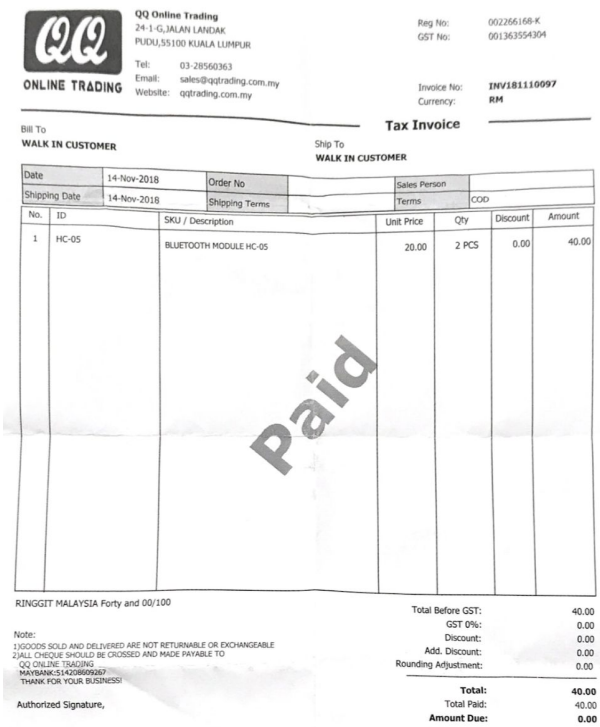


Figure 1 Receipt for neodymium magnets



QQ Online Trading
24-1-G,JALAN LANDAK
PUDU,55100 KUALA LUMPUR
Tel: 03-28560363
Email: sales@qqtrading.com.my
Website: qqtrading.com.my

ONLINE TRADING

Reg No: 002266168-K
GST No: 001363554304

Invoice No: INV181110097
Currency: RM

Tax Invoice

Bill To
WALK IN CUSTOMER

Ship To
WALK IN CUSTOMER

Date	14-Nov-2018	Order No		Sales Person	
Shipping Date	14-Nov-2018	Shipping Terms		Terms	COD

No.	ID	SKU / Description	Unit Price	Qty	Discount	Amount
1	HC-05	BLUETOOTH MODULE HC-05	20.00	2 PCS	0.00	40.00

Paid

RINGGIT MALAYSIA Forty and 00/100

Total Before GST:	40.00
GST 0%:	0.00
Discount:	0.00
Add. Discount:	0.00
Rounding Adjustment:	0.00
Total:	**40.00**
Total Paid:	40.00
Amount Due:	**0.00**

Note:
1)GOODS SOLD AND DELIVERED ARE NOT RETURNABLE OR EXCHANGEABLE
2)ALL CHEQUE SHOULD BE CROSSED AND MADE PAYABLE TO
QQ ONLINE TRADING
MAYBANK:514208609267
THANK FOR YOUR BUSINESS!

Authorized Signature,

Figure 2 Receipt for Bluetooth modules

QQ Online Trading
24-1-G,JALAN LANDAK
PUDU,55100 KUALA LUMPUR
Tel: 03-28560363
Email: sales@qqtrading.com.my
Website: qqtrading.com.my

ONLINE TRADING

Reg No: 002266168-K
GST No: 001363554304

Invoice No: INV181110352
Currency: RM

Tax Invoice

Bill To
WALK IN CUSTOMER

Ship To
WALK IN CUSTOMER

Date	29-Nov-2018	Order No		Sales Person	
Shipping Date	29-Nov-2018	Shipping Terms		Terms	COD

No.	ID	SKU / Description	Unit Price	Qty	Discount	Amount
1	ARDUINO UNO R3	ARDUINO UNO R3(CHINA MADE)	35.00	1 PCS	0.00	35.00
2	ARDUINO MOTOR DRIVER SHIELD L298P	ARDUINO MOTOR DRIVER SHIELD L298P	35.00	1 PCS	0.00	35.00

Paid

RINGGIT MALAYSIA Seventy and 00/100

Total Before GST:	70.00
GST 0%:	0.00
Discount:	0.00
Add. Discount:	0.00
Rounding Adjustment:	0.00
Total:	**70.00**
Total Paid:	70.00
Amount Due:	**0.00**

Note:
1)GOODS SOLD AND DELIVERED ARE NOT RETURNABLE OR EXCHANGEABLE
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QQ ONLINE TRADING
MAYBANK:514208609267
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Figure 3 Receipt for Arduino and motor shield