

PENGESAHAN LAPORAN PROJEK AKHIR TAHUN

Laporan projek bertajuk Multi-Functional Wheelbarrow Prototype. Laporan ini dikemukakan kepada Jabatan Kejuruteraan Mekanikal di Politeknik Sultan Salahuddin Abdul Aziz Shah sebagai syarat untuk penganugerahan Diploma Kejuruteraan Mekanikal.

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Tarikh Diesmak :

AKUAN PENULISAN LAPORAN AKHIR

“Kami akui bahawa laporan ini adalah hasil kerja kami sendiri kecuali nukilan yang setiap satunya telah kami jelaskan sumbernya”.

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PENGHARGAAN

Ucapan setinggi-tinggi penghargaan dan ribuan terima kasih yang tidak terhingga kepada penyelia kami, Puan Asnizah binti Sahekhaini kerana telah banyak membantu kami dari pelbagai segi seperti membaiki idea projek, memberi cadangan-cadangan yang sangat membantu dalam kemajuan projek dan juga memberi sokongan kepada anak murid beliau semasa melaksanakan projek dan pembentangan akhir projek di PITEK.

Selain itu, sekalung penghargaan untuk semua pensyarah Politeknik Sultan Salahuddin Abdul Aziz Shah yang telah mencurahkan segala ilmu kepada kami sehingga ke semester akhir bagi Diploma Kejuruteraan Mekanikal. Akhir Sekali, ucapan ini juga ditujukan kepada ibu bapa kami yang telah banyak memberi sokongan dari segi kewangan, dan juga moral bagi menjayakan projek ini.

Dengan ini, tamatlah projek akhir tahun kami berserta laporan akhir setelah banyak dugaan dan cabaran yang terpaksa kami harungi, tetapi semua itu kami jadikan sebagai satu pengajaran dan pengalaman manis yang cukup berharga selama menimba ilmu di Politeknik Sultan Salahuddin Abdul Aziz Shah.

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[Prepared by Eric Ezekiel a/l Thomas – 08DKM17F1264]

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CHAPTER 1

INTRODUCTION

1.0 BACKGROUND

A wheelbarrow is defined as a large, open container for moving things in with a wheel at the front and two handles at the back, used especially in the garden [1]. The term “wheelbarrow” is made of two words: “wheel” and “barrow”. “Barrow” is a derivation of the old English “bearwe” which was a device used for carrying loads.

With archaeological evidence it was proven that the earliest wheelbarrow came from the second century Han dynasty in the form of a one-wheel cart which was found in Emperor Hui’s tomb murals and brick tomb reliefs [2]. The painted tomb mural of a man pushing a wheelbarrow was found in a tomb at Chengdo, Sichuan province, which was dated around 118 AD.

Wheelbarrows that was first created in China came in two types. The first type which was commonly used has a large, centrally mounted wheel. The second type was universally front-wheeled wheelbarrows which are still being used till now [3]. The central-wheel type wheelbarrow could transport six human passengers at once, laborious amount of energy exacted upon the animal or human that was pulling the wheelbarrow. The weight of the burden was distributed equally between the wheel and the puller [4].

In the 17th century, European visitors to China appreciated the device and it was given a considerable amount of attention by a member of the Dutch East India Company, Andreas Everardus van Braam Houckgeest , which was stated in his writing on 1797 who described its design and ability to hold large amount of heavy package [5]. Since then, the wheelbarrow has spread to different regions in the early era such as Greece, Rome and Medieval Europe .

CHINA



Figure1.0: The one-wheeled Chinese wheelbarrow, from [Zhang Zeduan's](#) (1085–1145) painting [Along the River During Qingming Festival](#), [Song Dynasty](#).



Figure2.0: A metal wheel barrow in [Haikou](#)City, [Hainan](#) Province, [China](#)

Medieval Europe

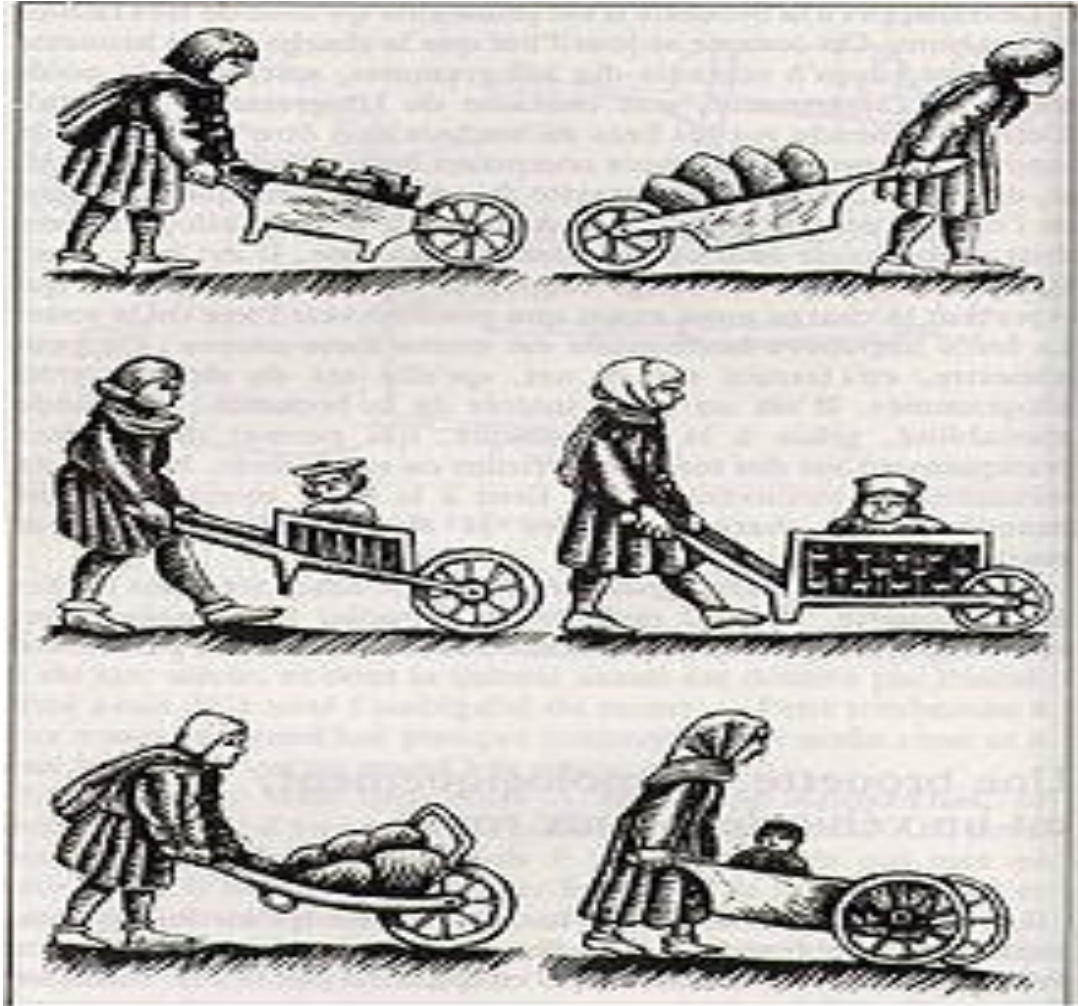


Figure 3.0: The Medieval era wheelbarrow

MODERN VARIATIONS OF WHEELBARROW

A British inventor James Dyson invented the ‘Ballbarrow’ in the 1970’s. An injection moulded plastic wheelbarrow with a spherical ball which replaced the wheel at the front end. Compared to a conventional design, this wheelbarrow is easier to be used on soft soil and more literally stable with heavy loads on uneven ground due to the large surface area of the ball which decreases the pressure exerted towards the ground.

An electric power-assisted wheelbarrow was introduced in the year 1998 called the Honda HPE60 [6][7].

Power assisted wheelbarrows are now widely available from several manufacturers. Power wheelbarrows are commonly used in a range of applications. The technology has improved to enable wheelbarrows to take much heavier loads, beyond weights that a human could transport alone. Wheelbarrows with motors are generally diesel powered or electric battery power. This wheelbarrow is often used in a small-scale construction application where access for larger plant machinery are not needed [8].



Figure 4.0: The HONDA HPE60 wheelbarrow

1.1 PROBLEM STATEMENT

A standard wheelbarrow is not particularly stable, and it carries a heavy load high up and can tip over easily. This is because it uses a single tire which makes it wobbly and causes back stiffness [9], especially when filled with heavy slushy load such as concrete. This wheelbarrow design makes it easier to unload and can be steered easily. However, this type of wheelbarrow lacks stability which is a major problem.



Figure 5.0: Conventional wheelbarrow

The dual or triple tired wheelbarrows are available which has high stability and could carry heavy loads compared to the single tired wheelbarrow. But, these types of unit are usually seen on construction sites. These wheelbarrows are not commonly used in gardening and for household activities in our country which is a drawback. This makes wheelbarrow users not able to use a wheelbarrow of their preference.



Figure 6.0: Dual Tire and Triple Tire Wheelbarrow

Moreover, great amount of labour/worker in many tasks including construction and farming undergo low back musculoskeletal injury due the design of the wheelbarrow which ergonomically poor [9].

Finally, most of the wheelbarrows have one thing in common. They are only used to transport loads. Conventional and automatic wheelbarrows are not multi-functional. Moreover, these wheelbarrows could only be used on ground and could not move up a stairway. Due to this, loads like a wet concrete could only be transported using a load transfer system like a ramp for small steps.

The problems above can be simplified as:

- The conventional wheelbarrow is not multi-functional.
- The conventional wheelbarrow is not stable when in use.
- Users are not able to use a wheelbarrow of their preference.
- The conventional wheelbarrow causes low back musculoskeletal injury.

- Loads have to be transported manually or by using other load transfer system up small steps.

1.2 OBJECTIVE

The Objective of this project is as following:

- To design a multipurpose wheelbarrow by adding useful functions to a conventional wheelbarrow.
- To fabricate and assemble the multipurpose wheelbarrow with suitable materials.
- To carry out trials on the multipurpose wheelbarrow to identify flaws and limits of the multipurpose wheelbarrow.

1.3 PRODUCT SCOPE

The scopes of this project (MULTI-FUNCTIONAL WHEELBARROW) as follows bellow;

FEATURES	DESCRIPTION
Simple and multi-functional	Simple design that has no complex parts or electrical systems but able to conduct different tasks.
Ergonomic design	Designed to avoid strain in the spine when transporting loads.
Able to move up a stairway	Specially build tires allows the wheelbarrow to be moved up a stairway.
Reduces burden of users	Easy to be pushed or pulled.
High stability	More than a wheel is used to support the barrow which increases its stability.
Reduces spillage of medium	Additional fixture forms a barrier to avoid medium from spilling out of the wheelbarrow.
Flat free tires	Tires that are air filled are replaced with rubber and Polyurethane (PU) tires.

Table 1.0: Project scope

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

A wheelbarrow is defined as a large, open container for moving things in with a wheel at the front and two handles at the back, used especially in the garden [1]. The term “wheelbarrow” is made of two words: “wheel” and “barrow”. “Barrow” is a derivation of the old English “bearwe” which was a device used for carrying loads.

Wheelbarrows are compound machines which consist of three simple machines that are lever, wheel and axle, and inclined plane. Wheelbarrows use more than one simple machine to reduce the effort needed to do a work, making them compound machines. Adding extra simple machines spreads the effort and force required to do the job and enables the wheelbarrow to do more than one job.

Simple machines are defined as any basic devices that alter the magnitude and direction or both, of an applied force traditionally including the lever, wedge, inclined plane, wheel and axle, pulley and screw [10][11]. In a wheelbarrow, lever, inclined plane and, wheel and axle is used.

A lever consists of a load, a fulcrum and effort or known as force that is applied [12]. Based on the wheelbarrow, the medium carried in it will be the load, the pivot point will be the fulcrum and the force applied to the wheelbarrow to lift it is the effort. When a force is applied on one end of the lever, a force at the other end of the lever is created [10].



Figure 7.0: Concept of lever in a wheelbarrow

Wheel and axle are simple machines that reduces the friction that is acted on a moving object, making the object easier to transport [12] [13], which in this case we can refer to the wheelbarrow. The tire of the wheelbarrow is the wheel and the rod through the center of the tire is the axle[13] Like all other simple machines the wheel and the axle system changes the force by changing the distance over which the force is applied, If the input is reduced to $1/5$ the output force, the force that is applied to the wheel five times its distance. This term is called the mechanical advantage. Mechanical advantage allows humans to perform tasks that would require more force than a person could produce easily, but must obey the conservation of energy [14].



Figure 8.0: Wheel and Axle

An inclined plane consists of a sloping surface. It is used for raising heavy loads. The plane offers mechanical advantage [10] [14]. This is because force required to move an object up the incline is less than the weight being raised. Expressed mathematically $F=W \sin \Theta$ where W is the weight of the load and Θ is the angle of the inclined plane [10]. Only when a wheelbarrow is tipped ahead or on its side it is considered to consist of an incline plane (during unloading process).

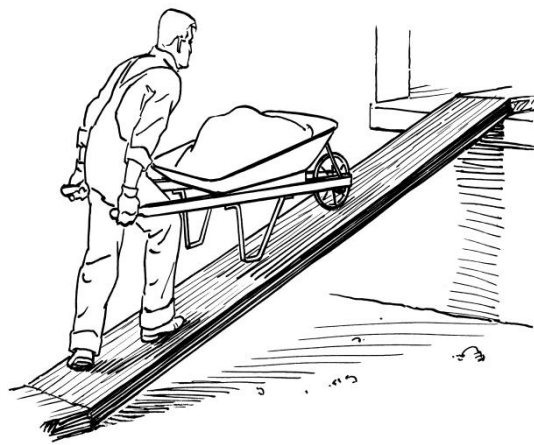


Figure 9.0: Inclined Plane

2.1 WHEELBARROW INVENTIONS

Due to design of the conventional wheelbarrow which did not fulfill/satisfy the needs of the people, many inventors have come up with ideas to innovate the wheelbarrow in order to solve certain problems such as stability, functions, and its design.

On 13th of August 1935 a wheelbarrow design was patented in the United States which was invented by George M. Carter, Jackson and Mich [15]. The wheelbarrow design is as the conventional wheelbarrow that is used now. The frame work of the wheelbarrow is made up of strong aluminum alloy to reduce from one half to two third of a similarly constructed steel wheelbarrow. It is also stated in the patent that pneumatic tires replaced with solid tires. The low- pressure pneumatic tire is applied to replace solid tire which undergoes material failure and rapid where due to crystallization of metal from severe shock resulting from irregular surface and load. This characteristic of the wheelbarrow allows it to absorb sharp stresses (σ) without fracture of materials and shocks. The modulus of elasticity (E) when using a strong aluminum alloy is one third of the steel which means the sharp stress is distributed over a great distance of flexure and the maximum strain (ϵ) is reduced [15] [18]. The overall design of this wheelbarrow has brought a positive impact to its users and is still being applied till now.

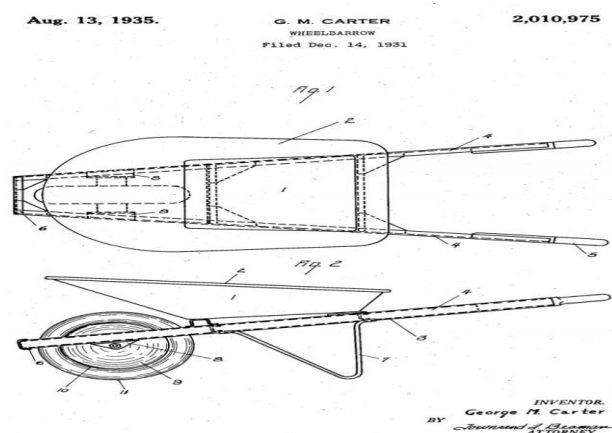
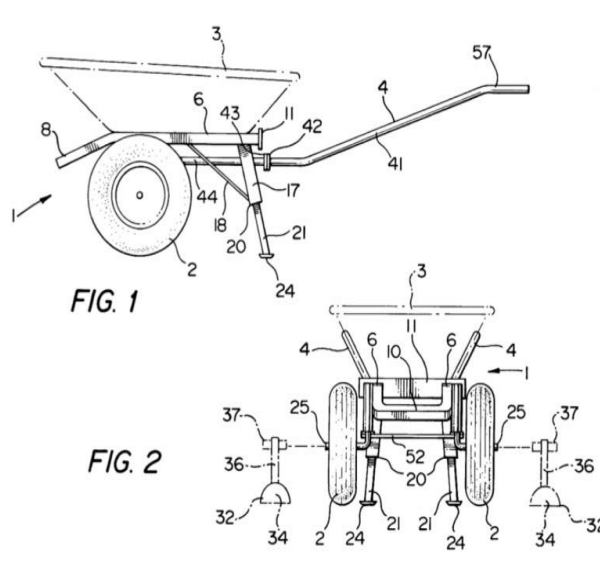


Figure 10.0: Wheelbarrow design by George M. Carter, Jackson and Mich

A two-tire wheelbarrow that can be easily steered was invented in the year 1999 by Gerard J. Bisailon (Magog) and Rolland Bisailon (Racine), both of Canada. The invention was patented on 20th of July 1999 [16]. In the patent, it is stated that the conventional wheelbarrows are difficult to steer, particularly when fully loaded. The wheelbarrow includes a pair of L-shaped axles carrying wheels [10] rotatably mounted in vertical sleeves on the frame of the wheelbarrows [16]. A crossbar on the front end of the pair of handles carries a shaft rotatable in cylindrical bushings on the frame. A linkage is used to connect the front end of the shaft to levers [10] [12] on the vertical arms of the axle where the rotation of handles results in rotation of the shaft thus rotating the axles and wheels [10] around the vertical axes of the vertical arms of the sleeves to steer the wheelbarrow. In this invention of wheelbarrow, the stability of the wheelbarrow is increased by using two tires and the ability of the wheelbarrow to be steered is made easy by its steering system.



U.S. Patent
 Jul. 20, 1999
 Sheet 1 of 5
 5,924,708

Figure 11.0: Two wheeled barrow invented by Gerard J. Bisailon and Rolland Bisailon

Another invention of a wheelbarrow was the rear wheel system wheelbarrow. The invention was filed on 25th of March 1999 and patented on the 24th of April 2001. This wheelbarrow was invented by Guadalupe Garcia from California [17]. Rear wheels are used to replace the leg supports of a conventional wheelbarrow. This was a simple innovation towards the conventional wheelbarrow to improve the ease of its usage.

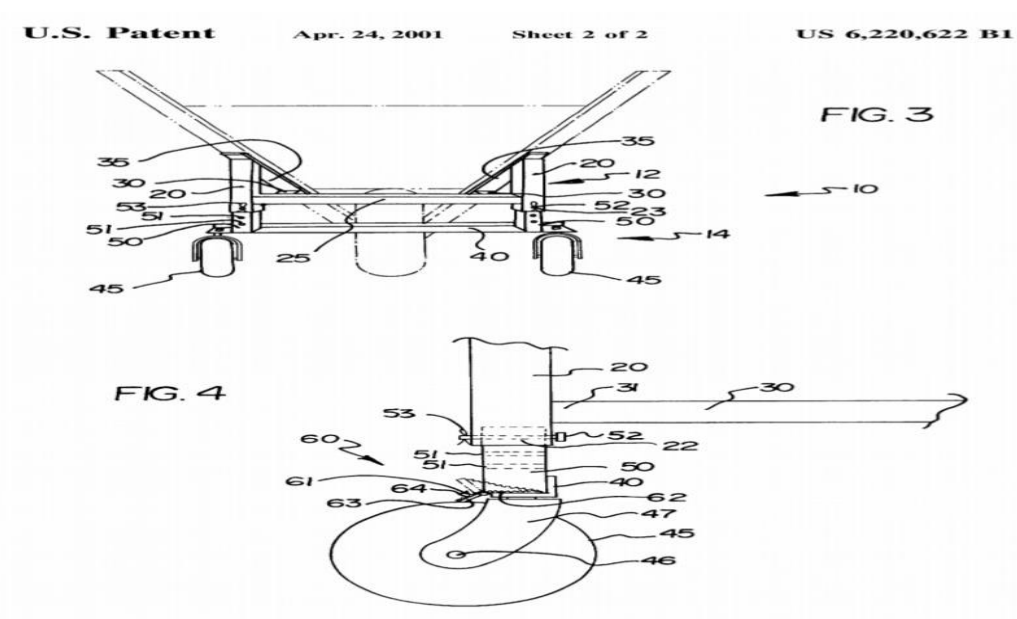


Figure 12.0: Rear wheel system wheelbarrow invented by Guadalupe Garcia

2.2 MODERN VARIATIONS OF WHEELBARROW

A British inventor James Dyson invented the ‘Ballbarrow’ in the 1970’s. An injection molded plastic wheelbarrow with a spherical ball which replaced the wheel at the front end [20]. Compared to a conventional design, this wheelbarrow is easier to be used on soft soil [20] and more literally stable with heavy loads on uneven ground due to the large surface area of the ball which decreases the pressure exerted towards the ground.



Figure 13: The James Dyson ballbarrow (DURRABALL)

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Figure 14.0: HONDA HPE60 wheelbarrow

2.3 History of Wheelbarrow

With archaeological evidence it was proven that the earliest wheelbarrow came from the second century Han dynasty in the form of a one-wheel cart which was found in Emperor Hui's tomb murals and brick tomb reliefs [2]. The painted tomb mural of a man pushing a wheelbarrow was found in a tomb at Chengdo, Sichuan province, which was dated around 118 AD.

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In the 17th century, European visitors to China appreciated the device and it was given a considerable amount of attention by a member of the Dutch East India Company, Andreas Everardus van Braam Houckgeest, which was stated in his writing on 1797 who described its design and ability to hold large amount of heavy package [5]. Since then, the wheelbarrow has spread to different regions in the early era such as Greece, Rome and Medieval Europe.

CHINA

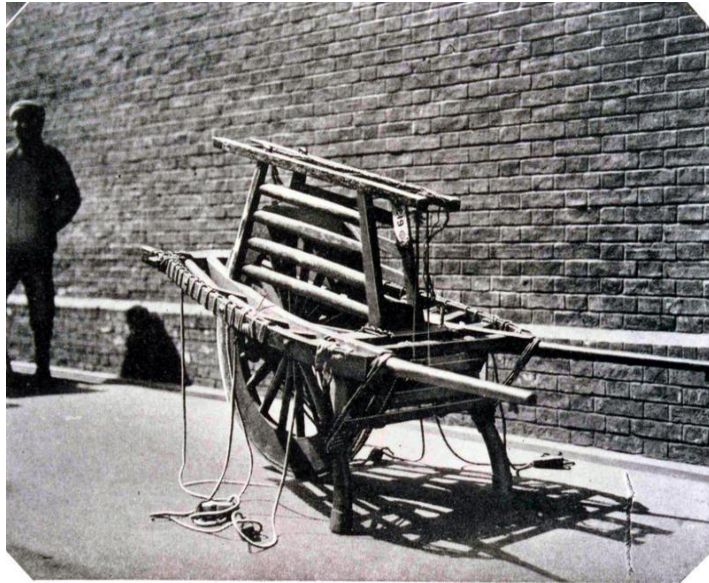


Figure 15.0: An old photograph of a Chinese wheelbarrow



Figure 16.0: The Chinese wheelbarrow in a museum

MEDIEVAL EUROPE



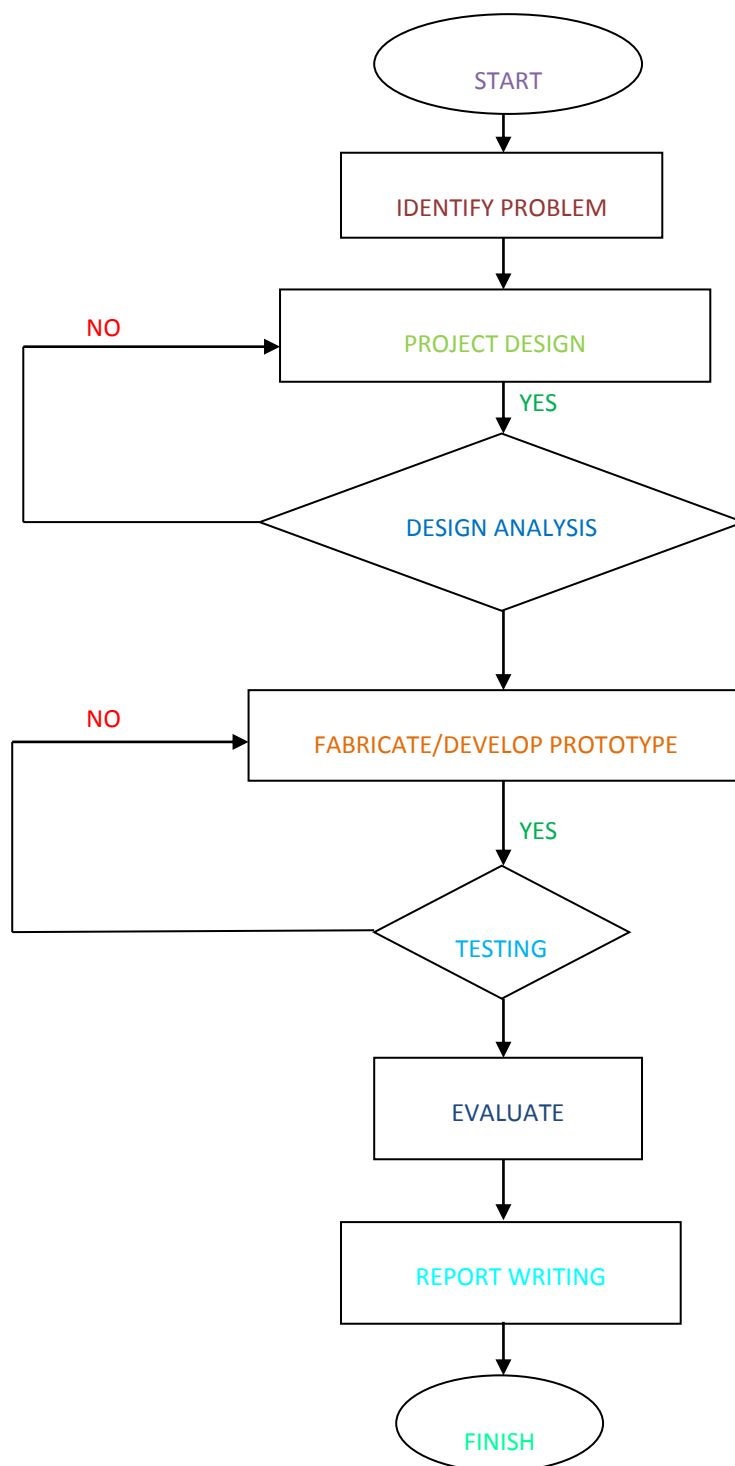
Figure 17.0: Medieval Europe wheelbarrow

CHAPTER 3

METHODOLOGY

Methodology is defined as the systematic, theoretical analysis of the methods applied to a field of study/research/project. Methodology offers understanding which method, set of methods, or best practices that can be applied to the project that is being done.

3.0 Method Flow Chart



3.1 WORKING PHASE

3.1.1 1st PHASE: PRODUCT NEEDS ANALYSIS

An online survey is conducted using an app called Survey Monkey to determine the needs of users that are required for a multipurpose wheelbarrow.

SURVEY QUESTIONS AND OPTIONS FOR RESPONDENTS

Question 1: Do You Use A Wheelbarrow in Your Daily Lives?

Options 1: [YES/NO]

Question 2: Why Do You Use A Wheelbarrow?

Options 2 : [TO TRANSPORT MEDIUM/AS DECORATIVE ITEM]

Question 3: Where Do You Use A Wheelbarrow?

Options 3: [CONSTRUCTION AREAS/HOUSE/FACTORIES/OTHERS]

Question 4: Do You Think the Wheelbarrow Used Today Is Useful?

Options 4: [YES/NO]

Question 5: Do You Think the Conventional Wheelbarrow Needs Innovation?

Options 5: [YES/NO]

Question 6: Would A Stairs Climbing Wheelbarrow Be Useful to You?

Options 6: [YES/NO]

Question 7: Do You Face Body Pain When Using The Wheelbarrow?

Options 7: [YES/NO]

Question 8: Do You Prefer Wheelbarrow with One Tire or Three Tires?

Options 8: [1 or 3]

Question 9: Is Pulling the Wheelbarrow Easier Compared to Pushing?

Options 9: [YES/NO]

Question 10: Would You like a wheelbarrow with detachable parts to enable you to add and remove additional fixtures to have a wheelbarrow of your liking?

Options 10: [YES/NO]

3.1.2 2nd PHASE: PRODUCT DESIGN

SKETCH 1

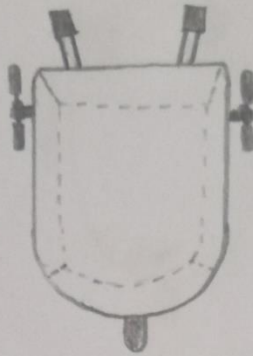
ADVANTAGES

- Has rear stairs climbing wheels to enable the wheelbarrow to move up a stairway.
- Suspension springs added to the stairs climbing wheels to absorb shock.
- Extendable body.
- Have clip locks to hold the body together when not elongated.
- Three –tire which offers more stability.

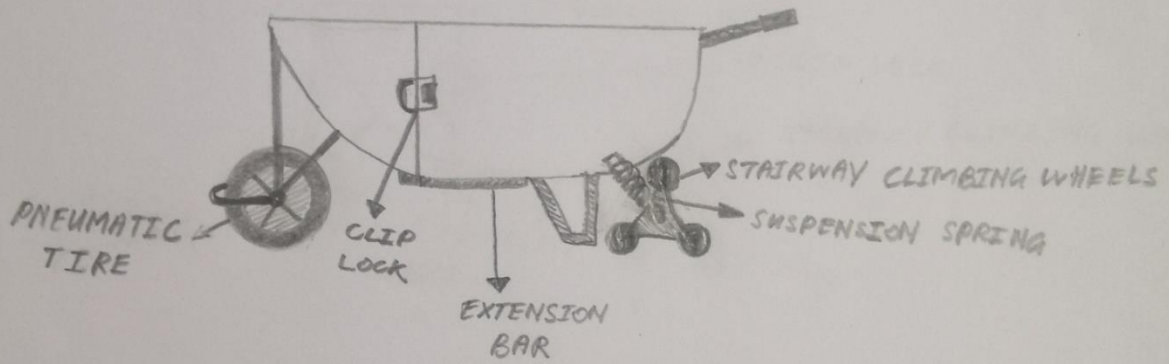
DISADVANTAGES

- Non-ergonomic design.
- Pneumatic tires are used which may puncture or loose air when being used.
- Cannot be used on muddy surfaces where the stairs climbing wheel might make the wheelbarrow get stuck.
- Not easy to unload.
- Undetachable rear tires.

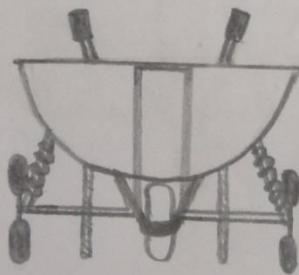
TOP VIEW



SIDE VIEW



FRONT VIEW



Sketch 1

SKETCH 2

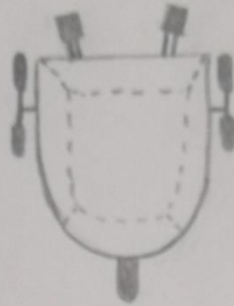
ADVANTAGES

- Has rear stairs climbing wheel to enable the wheelbarrow to move up a stairway.
- Extendable body.
- Have clip locks to hold the body together when not elongated.
- Has rubber front wheel which will not puncture and become flat.
- Three-tire to offer more stability.

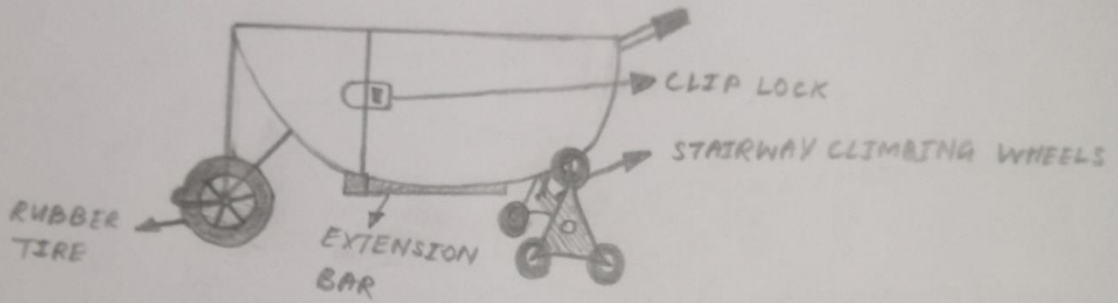
DISADVANTAGES

- Non-ergonomic design.
- Cannot be used on muddy surfaces where the stairs climbing wheel might make the wheelbarrow get stuck.
- Not easy to unload.
- The rubber tire might wear easily.
- Undetachable rear tires.

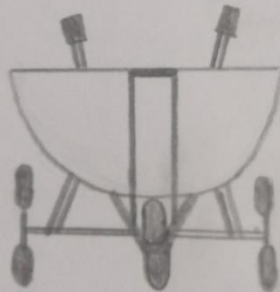
TOP VIEW



SIDE VIEW



FRONT VIEW



Sketch 2

SKETCH 3

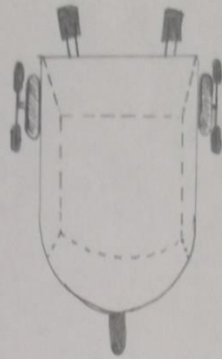
ADVANTAGES

- Has stairs climbing wheel to enable the wheelbarrow to move up a stairway.
- Extendable body.
- Have clip locks to hold the body together when not elongated.
- Uses Polyurethane (PU) tires which does not puncture and wear easily.
- Three –tire with stairway climbing tires which offer more stability.
- Can be used on muddy surfaces with attached PU tires to the rear stairs climbing wheels.

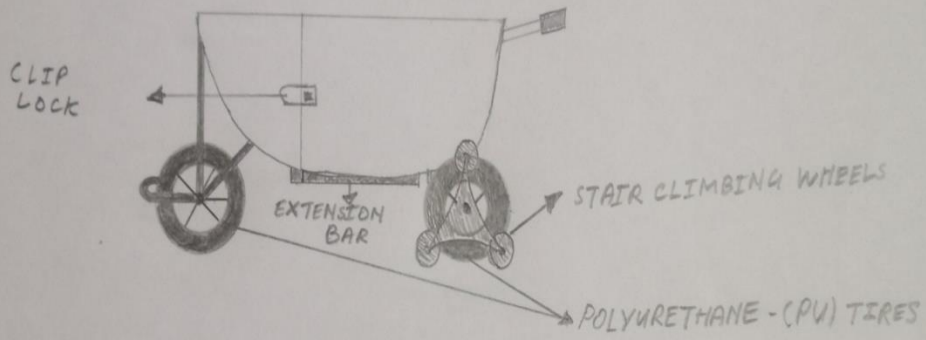
DISADVANTAGES

- Slightly heavier than a conventional wheelbarrow.
- Bulky look due to wide frames and numerous tires.
- Can't move in too narrow space.
- Non-ergonomic design.
- Undetachable rear tires.

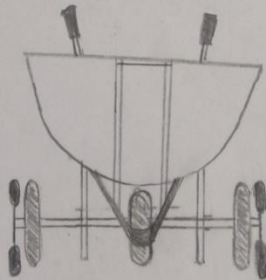
TOP VIEW



SIDE VIEW



FRONT VIEW



SKETCH 4

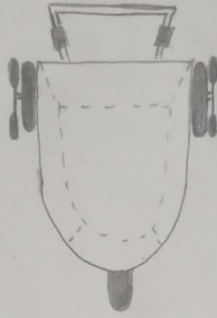
ADVANTAGES

- Has stairs climbing wheel to enable the wheelbarrow to move up a stairway.
- Uses Polyurethane (PU) tires which does not puncture and wear easily.
- Has cover to reduce spillage of medium.
- Ergonomic handle design.
- Three –tire which offer more stability.
- Can be used on muddy surfaces with attached PU tires to the rear stairs climbing wheels.
- All additional parts are detachable to allow users to replace parts and convert to the type of wheelbarrow they prefer.

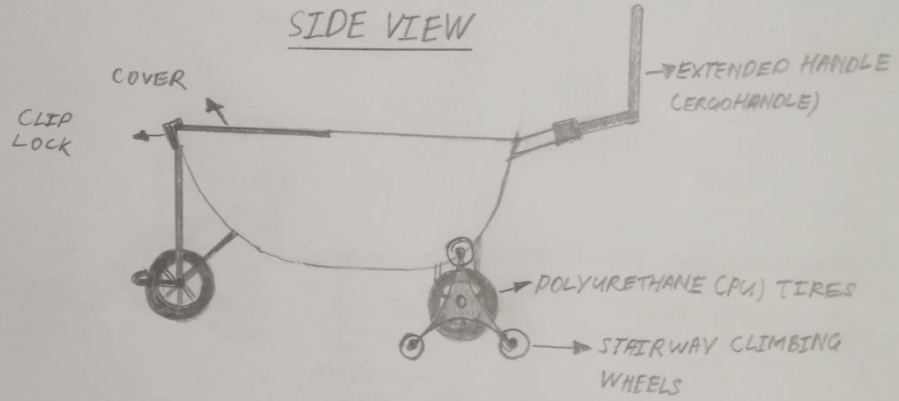
DISADVANTAGES

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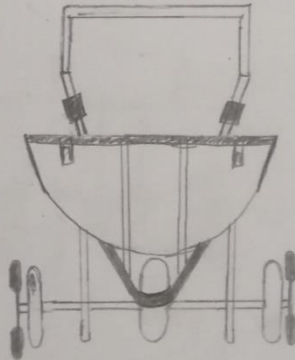
TOP VIEW



SIDE VIEW



FRONT VIEW



sketch 4

3.1.3 3rd PHASE: DESIGN VERIFICATION

USER REQUIREMENTS

According to the survey done, our design in the 4th sketch meets the requirement of wheelbarrow users. Based on the survey conducted we got to know the requirements that meet the needs of users. Requirements are as following:

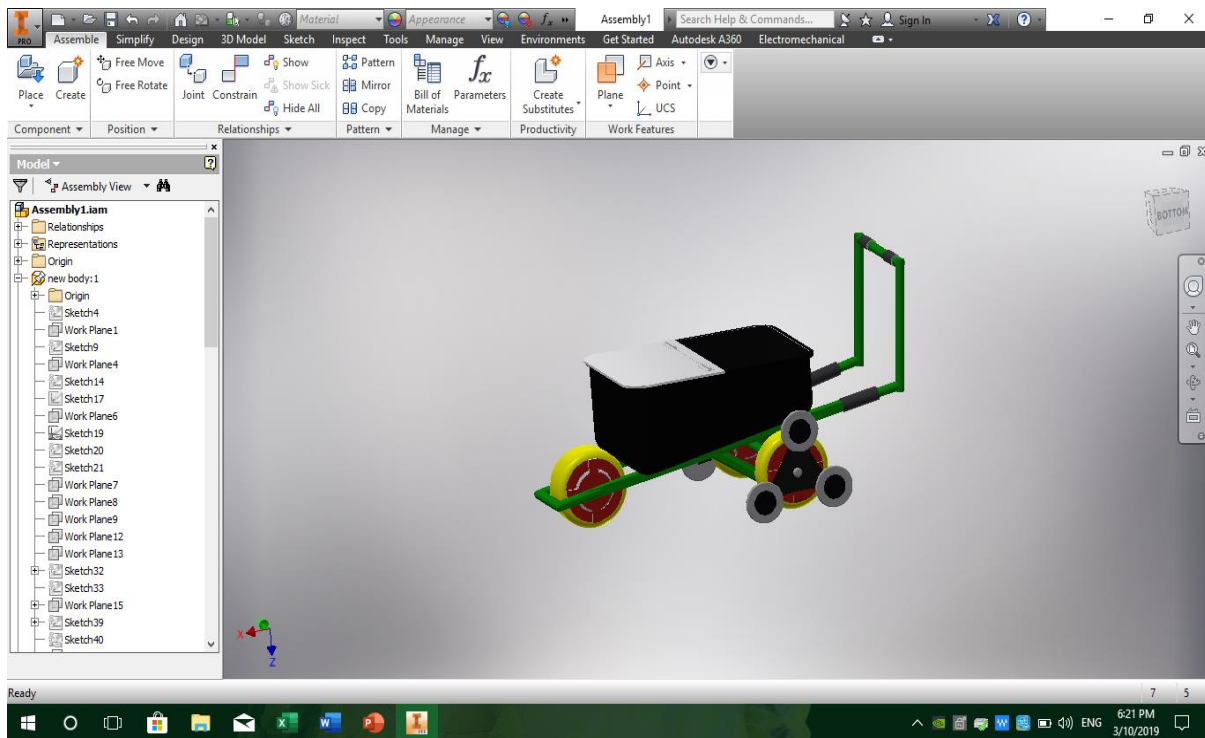
- i) 3-tired
- ii) Ergonomic design to solve body pain issues
- iii) Can move up a stairway
- iv) All additional parts are detachable

Data from the survey (refer Chapter 4: Results and Findings) has shown that:

- i) 79% of 34 respondents want a wheelbarrow with 3 tires
- ii) 59% of 34 respondents face body pains when using the wheelbarrow
- iii) 78% of 37 respondents want a wheelbarrow that can move up stairs
- iv) 56% of 34 respondents prefer wheelbarrow with detachable additional fixtures.

FINALISED DESIGN

The finalized idea of the multifunctional wheelbarrow prototype is drawn on the Inventor 2012 as shown in the figure below.



3.1.3 4th PHASE: PROTOTYPE FABRICATION/DEVELOPED

- **STEP 1- choose materials need for the prototype**

- i) Polyurethane wheels- height: 13inch Thickness: 3inch



- ii) Metal plates- 0.36cm and 0.5cm thickness



iii) Metal pipes- 2.7cm and 2.6cm diameter



iv) Front wheelchair tires- height: 6inch Thickness:2Inch



v) Clip lock



vi) Bolts and nuts



vii) Wheelbarrow- 3 cubic feet capacity, 0.8mm steel thickness



viii) Spray Paint



- **STEP 2- Find source of material**

- i) Online sources – Lazada and Shopee.
- ii) Hardware store.
- iii) Metal workshop.








- **STEP 3- Costing**

- i) Polyurethane tires(3units), front wheelchair tires(6units), bumper clip lock(2units): **RM150- ONLINE PURCHASING.**
- ii) Solid metal pipes and plates, bolts and nuts, gas welding; **RM200- MATERIALS AND SERVICE PROVIDED AT METAL WORKSHOP.**
- iii) Wheelbarrow: **FREE- RECYCLED.**
- iv) Spray Paint: **RM 25.**

TOTAL COST: RM 375

- **STEP 4- metal workings**

- i) Metal plates, metal pipes and wheels are measured according to the spec of the multifunctional wheelbarrow.
- ii) The plates, pipes and certain parts of the conventional wheelbarrow are cut, grinded and drilled according to the measurements.
- iii) The pieces are then welded together to form parts needed for the wheelbarrow.

PARTS	QUANTITY
Polyurethane (PU) Tires 	3
Tire bolt and nut set (long screw) 	2
Ergohandle (extended handle) 	1
Handle bolt and nut set (medium screw) 	4
Stairway climbing Wheelset 	2
Cover 	1
Cover bolt and nut set (short screw) 	2

- **STEP 5- add fixtures**

- i) Metal Parts such as the axle additional axle is welded to the wheelbarrow.
- ii) The additional PU wheels, stairs climbing wheels, Ergohandle (additional handle) and cover are added to the wheelbarrow using bolts and nuts.
- iii) Clip lock is then added to the cover.



- **STEP 6- Finishing**

- i) Sharp edges are grinded, and surface of the wheelbarrow is smoothed.
- ii) The wheelbarrow is painted to make it look elegant and as a corrosion prevention.



- **STEP 7- Safety measures**

- i) Handle grips are added to provide comfort to then hand and avoid injuries when holding the wheelbarrow handle.



3.2 PROTOTYPE TESTING

The multipurpose wheelbarrow prototype is put to a test to identify any flaws, its limits and full functionality.

Tests that are conducted are as following:

- i) Load test – The multipurpose wheelbarrow prototype will be used to carry different weights of load to determine the maximum load it could carry and to prevent overloading.
- ii) Stairway climbing test – The prototype will be moved up a stairway to make sure the stairs climbing wheels function properly.
- iii) Terrain test – The wheelbarrow will be brought on different types of surface to determine its ability to move on variety of surfaces.

The tests above are conducted in order to make sure the multipurpose wheelbarrow can function in a proper manner, safe to be use and will be able to satisfy the needs of its users by its ability to solve problems as stated in Chapter 1, subtopic 1.1. before it is further developed, and mass produced. The findings from these tests is explain in Chapter 4: Results and Findings.

CHAPTER 4

Results and Findings

4.0 INTRODUCTION

In this chapter, the data of survey done, the final product of the prototype and the results of testing that was conducted towards the multi-functional wheelbarrow prototype will be discussed in order to know its limitation in order to help in future development of this project. The test that are being done which are load test, stairway climbing test, and terrain test and the findings of the test are provided in this chapter for future reference.

SURVEY DATA



Figures shown below are the data collected from each survey question.

Analyze	
SHOWING: 37 of 37 Responses	
PAGE: 1 of 2	^ v
1. Name	
Responses	37 >
2. Gender	
Responses	37 >
3. Age	
Responses	37 >

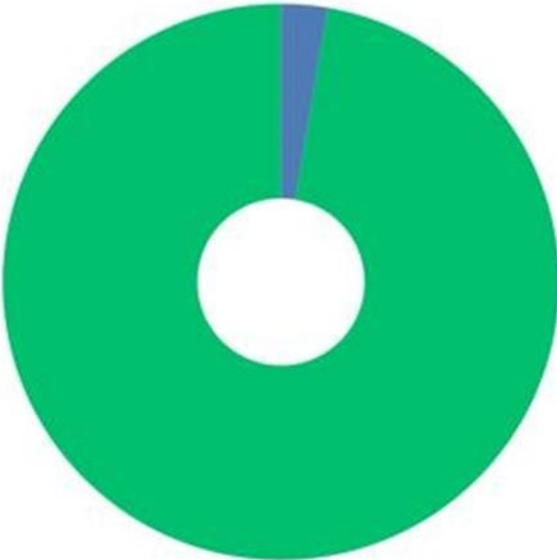
Question 1: Do You Use A Wheelbarrow in Your Daily Lives?





Skipped: 0 Answered: 37

	Yes	65%	24
	No	35%	13

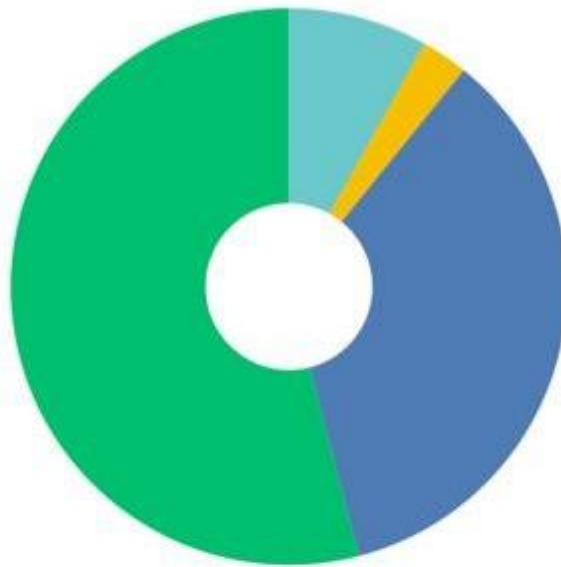
Question 2: Why Do You Use A Wheelbarrow?



Skipped: 0 Answered: 37

	To transports loads and mediums	97%	36
	To use as a decorative item	3%	1

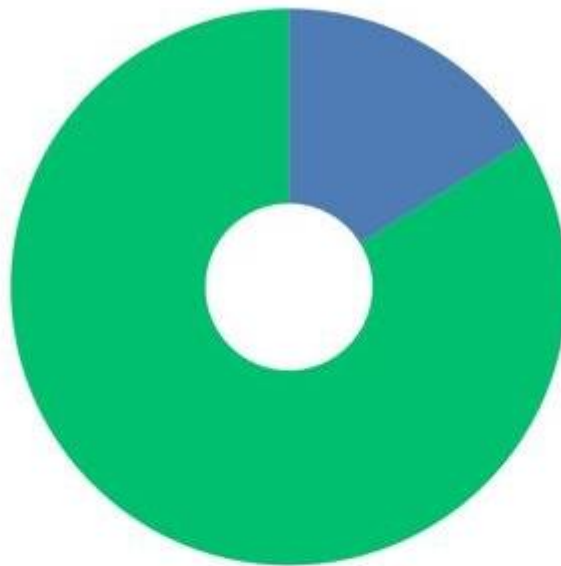
Question 3: Where Do You Use A Wheelbarrow?



Skipped: 0 Answered: 37

	Construction areas	54%	20
	House	35%	13
	Factories	3%	1
	Others	8%	3

Question 4: Do You Think the Wheelbarrow Used Today Is Useful?



Skipped: 0 Answered: 37

	Yes	84%	31
	No	16%	6

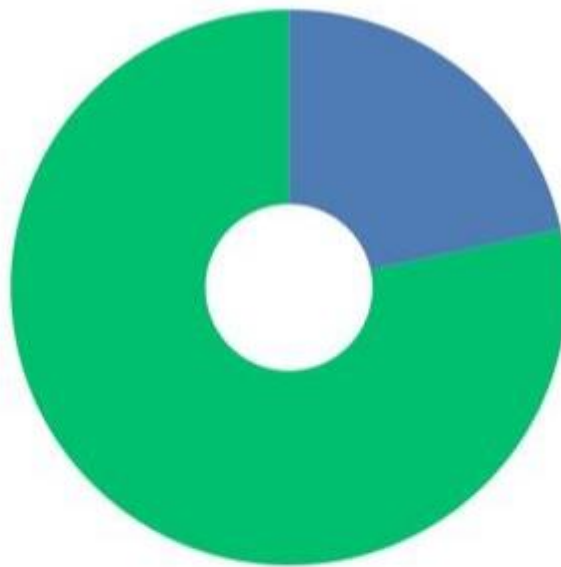
Question 5: Do You Think the Conventional Wheelbarrow Needs Innovation?



Skipped: 0 Answered: 37

Yes	89%	33
No	11%	4

Question 6: Would A Stairs Climbing Wheelbarrow Be Useful to You?



Skipped: 0 Answered: 37

	Yes	78%	29
	No	22%	8

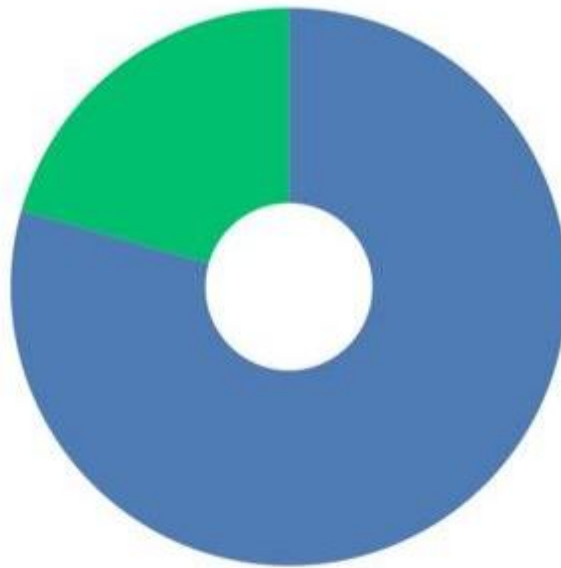
Question 7: Do You Face Body Pain When Using The Wheelbarrow?



Skipped: 0 Answered: 34

	Yes	59%	20
	No	41%	14

Question 8: Do You Prefer Wheelbarrow with One Tire or Three Tires?





Skipped: 0 Answered: 34

	1	21%	7
	3	79%	27

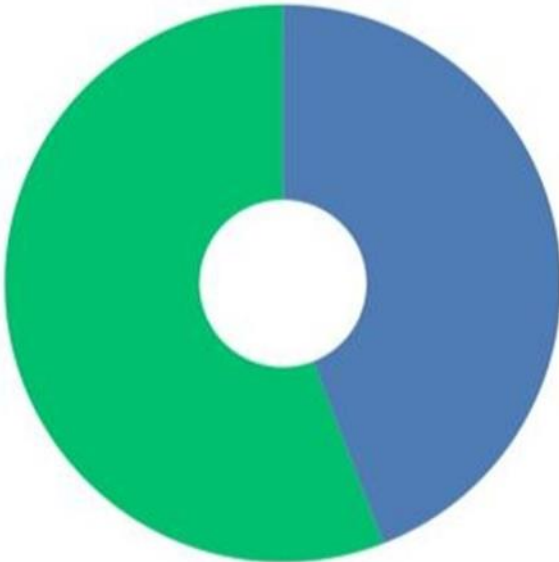
Question 9: Is Pulling the Wheelbarrow Easier Compared to Pushing?





Skipped: 0 Answered: 34

	Yes	47%	16
	No	53%	18

Question 10: Would You like a wheelbarrow with detachable parts to enable you to add and remove additional fixtures to have a wheelbarrow of your liking?



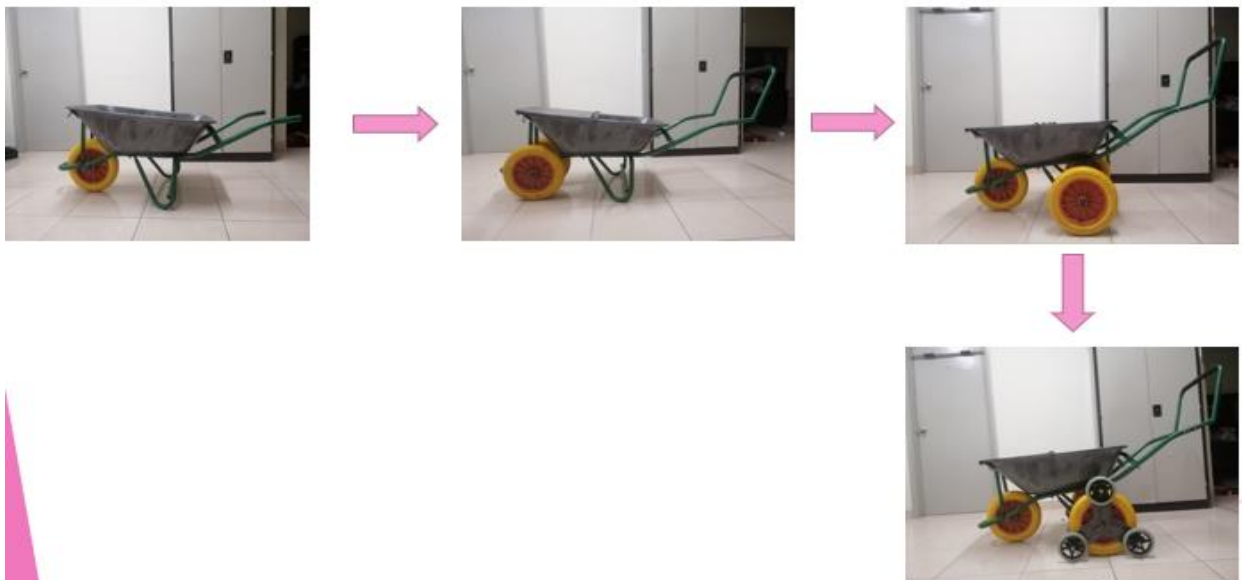
Skipped: 0 Answered: 34

	Yes	56%	19
	No	44%	15

4.2 FINAL PRODUCT OF PROTOTYPE



MULTI-FUNCTION OF THE PROTOTYPE



4.3 LOAD TEST

The load test is conducted by using load of 50Kg – 100 Kg on the prototype with different number of tires (single tire, double tire, and triple tire).

Load capacity of wheelbarrow (theoretical)

- The average wheelbarrow with 8 cubic feet can hold about 460Lbs(208.652Kg) of water or at most 1,200Lbs(544.311Kg) of concrete.
- So, the wheelbarrow of 3 cubic feet which is used for our project can support approximate 172.5Lbs(78.245Kg) of water and 450Lbs(204.117Kg) of concrete.
- Therefore, the multi-functional wheelbarrow can support approximate 345Lbs. (156.489Kg) of water and 900Lbs(408.233Kg) of concrete.

Load capacity of wheelbarrow tire (theoretical)



Pneumatic tire- approx. 300lbs(136.078kg)



Polyurethane tire- approx. 600lbs(272.155kg)

Results of load test

Number of Tires	results
Single Tire	<ul style="list-style-type: none"><li data-bbox="842 528 1315 618">• Ideal load for single tire usage is 50Kg<li data-bbox="842 640 1278 674">• Can carry up to 80kg of load.
Double tire	<ul style="list-style-type: none"><li data-bbox="842 701 1366 790">• Ideal load for double tire usage is 90 Kg<li data-bbox="842 813 1318 846">• Can support up to 100Kg of load
Triple tire	<ul style="list-style-type: none"><li data-bbox="842 873 1305 963">• Ideal load for triple tire usage is 100Kg<li data-bbox="842 985 1347 1019">• Can support load more than 100Kg

4.3 STAIRWAY CLIMBING TEST

In this test, the multi-functional wheelbarrow prototype is brought up an indoor stairs and outdoor steps to test the functionality of the step climbing wheelset.

We have found that this prototype is not suitable to be used on indoor stairs which are high, steep and size of steps are small. More effort was needed to pull this prototype up the indoor stairs. We have also learnt that bringing the multi-functional wheelbarrow up this type of stairs can be very hazardous due to its weight and the difficulty to pull it up which is caused by the steep and small sized steps of the stairs.

However, the prototype worked well on outdoor steps. It was pulled up easily and with lesser effort. The outdoor steps are less steep, short and the size of steps are larger, which the prototype was able to move up.

Therefore, the stairclimbing wheelset of the multi-functional wheelbarrow is only suitable to be used on outdoor steps.




Usage of stairway climbing wheelset on wheelbarrow

Type of stairs	Image	Suitability
Outdoor steps		
Indoor stairs		

4.5 Terrain Surface Test

The multi-functional wheelbarrow prototype is brought on terrains with different surface characteristics which are smooth, rough and uneven surface. This test is conducted to ensure the functionality of the wheelbarrow on different types of terrain.

RESULTS

Surface	Image	Results
Smooth (<i>TILES</i>)		<ul style="list-style-type: none">• Function well on smooth surface• PU tire used produces reasonable friction between tire and surface• Tire does not leave marks on the surface
Rough (<i>ROAD</i>)		<ul style="list-style-type: none">• Able to function quite good• A fair friction provided between tire and surface• the PU tires provided reasonable cushioning
Uneven (<i>GRASS</i>)		<ul style="list-style-type: none">• Able to function but not very well• The PU tires was not able to absorb much shock

CHAPTER 5

DISCUSSION AND CONCLUSION

5.0 Discussion

Through the process of developing our multi-functional wheelbarrow prototype, we believe that this prototype will be able to make a big change in the future in the wheelbarrow production industry. Our product is user friendly as we designed it to be used with ease as no complex parts are involved, and no electric or electronic parts which will make it harder to be used and fragile. The parts are designed to be all-detachable which meet the requirements of users where users can use a preferable type of wheelbarrow and also conduct maintenance easily. We have also found that the extended handle which is named as the Ergohandle has played a big role by ensuring users to have and maintain a good/ergonomic posture when handling the wheelbarrow to avoid musculoskeletal injury and also long term effect of using the wheelbarrow with an unhealthy posture. The stairway climbing wheelset has proved that during a construction, we do not need no build a permanent ramp or make a temporary ramp for a wheelbarrow as this wheelset helps the multi-functional wheelbarrow move up these steps with ease. From the tests conducted towards the prototype, we got to know its limitations and strengths which will be very helpful for further development of this prototype in the future.

5.1 Conclusion

From this project, our objectives that was set which are to design a multi-functional wheelbarrow by adding useful functions to a conventional wheelbarrow, to fabricate and assemble the multi-functional wheelbarrow with suitable materials, and to carry out trials on the multi-functional wheelbarrow to identify flaws and limits of the multi-functional wheelbarrow are achieved. The multi-functional wheelbarrow has a high potential to satisfy the needs of its user by solving many problems that are faced when using the conventional wheelbarrow. The design of the wheelbarrow which is ergonomic helps wheelbarrow users to reduce strains by maintaining a good posture when pushing or pulling the barrow. Moreover, the multi-functional wheelbarrow is more stable and does not tip over and could climb a stairway. This eliminates the use of load transfer system like a ramp to transport mediums up small steps. This wheelbarrow also reduces the amount of spillage of medium from the barrow which is a common problem faced by everyone when using the conventional wheelbarrow. Users are also able to convert their wheelbarrow to their preferred design like the single tire function, double tire function, triple tire function and also triple tire with stairway climbing wheelset. In conclusion, the multi-functional wheelbarrow is a great innovation towards the conventional wheelbarrow where certain problems are solved, and its use becomes more beneficial. In the future, the multipurpose wheelbarrow can be developed further to make it better and to increase its uses and improve functionality.

5.2 Recommendation

Below are the recommendations that can be applied towards the multi-functional wheelbarrow for further development of this prototype in the future to enhance its functionality.

- Add a hydraulic system to the wheelbarrow to dump load easier, which is hard to be done with this wheelbarrow due to its weight.
- Use more suitable material that are light but strong and rust resistant to reduce maintenance.
- Build an adjustable frame for the stairway climbing wheels so that the wheels can be used on stairways with various dimensions