

DEVELOPMENT OF MULTI-PURPOSE TROLLEY

A Project Study

Presented to the Faculty of the
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by

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DEDICATION

First of all, I would like to thank our sponsors in making our thesis project possible. I would also like to thank my family especially my father for the strength and provisions that he gave. To my friends for their comforts in times of failures. Above all, to God that gives me the strength, courage, skills, and will to keep moving forward to complete this research.

-Marco

First, I would like to thank my mother and my father for their support and their encouragement when our group faces a great trial, and to God that enables me to do greater things to finish this research.

-Ian

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All Glory to your holy name.

Reuel Mark Reyes Dellosa

Marvin Ian Palad Episcopo

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ABSTRACT

The study, **Development of Multi-Purpose Trolley**, aims to provide a trolley that can be used to go through steps and obstacles while carrying different loads. This can also be used as an emergency cart. However, every kind of trolley is dependent on the strength of the person that will use the trolley. The equipment is just an improvement of the existing stair-climbing trolley having a similar functionality on wheels. It has the following features: folding with a locking mechanism, left and right-side flip for the extension, safety straps for holding the loads, tri-wheel designed to make it capable to go through steps. The prototype is convenient to operate its function of transporting and carrying different loads. The simple mechanism that the equipment was made of are the different types of steel like, aluminum 6061, angle bar, square pipe, shafting, plastic fiber with the corresponding operation of lay outting, bending, cutting, grinding, drilling, welding and painting. The test result showed that the equipment can be more useful with consideration of load and force exerted. The prototype was evaluated by 25 respondents composed of ten students, six faculty, and nine technical experts, was rated with an overall mean of 4.35, with a descriptive rating of “Very Satisfactory”. This signifies that the prototype is useful to all the users of trolley especially for the delivery helpers, rescuers, and for medical purposes.

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Chapter 1

INTRODUCTION

Background of the Study

In the modern day, transportation becomes a necessity more than being a luxury. There are different forms of transportation that can be classified according to its size, capacity, function or purpose. The most common type is the transportation vehicles. However, in industries, there is also a means of transportation in the form of forklifts, hand trucks, and even trolleys.

The trolley is an equipment used for transportation of different kinds of materials and heavy loads from one place to another. Many people in the society are using different kinds of trolleys such as platform trolley, hand trolley, wheel trolley, and etc. that are commercially available in the market. In some industries or companies, the use of trolley is very helpful especially during the transporting of a small number of loads. The problem is it tends to slow down the production or the transferring of materials from one station to a higher station due to the unavailability of ramps and even obstacles like stairs, humps, and uneven flooring. In some instances, ordinary trolleys do not have straps to secure the material being delivered that might result in improper material handling. Improper material handling has an adverse effect not only on the person who carries the materials but also to the material itself. For this reason, accidents might happen anywhere at any given time. It can cause breaking of the backbone if it is too heavy, parts of the body can be crushed if the load slipped off the hands of the carrier and can hit other people. Misuse of trolley also have bad effects, it may lead to delayed delivery, broken materials, and many more. When

accidents happen, rescuers do not arrive immediately, that's why the stretcher needed in transporting the injured person is not readily available.

The researchers come up with an idea of developing a Multi-Purpose Trolley to address these problems. Multi-Purpose Trolley has better specifications that will lessen the effort exerted in transporting a material or load from one place to another. In addition, it can also be used for emergency purposes that provides a secure, safe and convenient way of carrying an injured person.

Objectives of the Study

The general objective of this study is to develop a Multi-Purpose Trolley that is useful in transporting heavy loads and converting to an emergency carrier.

Specifically, the study aimed to:

1. Design a Multi-Purpose Trolley with the following features:
 - a. Foldable frame;
 - b. Nylon Strap Webbing;
 - c. Scooped stretcher and;
 - d. Wheelset
2. Fabricate the prototype as designed.
3. Test the prototype in accordance with its reliability.
4. Evaluate the performance of the prototype in terms of Functionality, Workability, Durability, Safety, Aesthetic, and Economy.

Scope and Limitation of the Study

This study focuses on the development and fabrication of a Multi-Purpose Trolley that has straps for bulky loads, body frame that can be folded like an ordinary trolley and can be stretched like a bed cart that can be used for emergency purposes. The trolley uses 6 functional rotating wheels so that it can go through small obstacles and even stairs.

The prototype, however, has a limited capacity weight of carrying an approximate load of 200 kg. The number of persons involved in putting the load to the carrier is dependent on their strength capacity to carry or lift. Another limitation is the height or the length capacity of the trolley intended for a maximum height of 6 ft. The overall weight of the prototype is 25 kg.

Chapter 2

CONCEPTUAL FRAMEWORK

This part presents the study of the related literature work and focuses essential arrangement of the study. It joins the theoretical model of the research and the operational importance of terms.

Review of Related Literature and Studies

The resulting writing helped the researchers in the conceptualization and development of the project.

Transportation

Transportation has constantly assumed a basic part in the advancement of society, initially as to exchange courses and harbors, yet more as of late with respect to land-and air-based frameworks also. The transportation system caught the attention of the industry on developing the economy of a country, an efficient and convenient transportation the better flow of economy rate because it holds all the goods and products of the country so it means the transportation display a big role in the growth of a country's economy.

Today, Industrial trolleys is an equipment used to transport materials, goods, and tools inside the industry. Through the years of innovation of an industrial trolley, there is a lot of trolleys has been created such as Hand trucks, Platform trolleys and etc. the purpose of these innovations is to help in transportation of materials and in every innovation, there is always an advantage and disadvantages existed. Industrial trolleys are hard to use especially when it comes to a stair and some obstacles along its way that can delay the transportation of materials. Yet, which is better? is it best if there is an innovation that goes through any obstacles and to provide a fast and convenient transportation.

This research, Multi-Purpose Trolley, focuses on innovating the industrial trolleys or hand trucks to a trolley that has a capability to go upward and downward by adding a rotatable wheel.

Material Handling

Material handling is the movement, protection, storage and control of materials and products throughout manufacturing, warehousing, distribution, consumption, and disposal. A company's material handling framework and procedures are set up to enhance customer service, diminishing stock, shorten delivery time, and lower general taking care of expenses in assembling, dissemination and transportation.

In material handling, there must be an equipment for transporting from one location to another. The major equipment used in transporting in material handling are conveyors, cranes, and industrial truck.

In relation to the function of the prototype, the principle of material handling is observed. The Multi-Purpose Trolley can transport a cargo from one place to another in a shorter time.



MATERIAL HANDLING

Presented by Aditya shah

Figure 1. Material Handling

Source: https://cdn.slidesharecdn.com/ss_thumbnails/materialhandling-160126142515-thumbnail-4.jpg?cb=1453818728

Types of Trolley

There are different types of the trolley that exist in the market some of which are the following: Hand Trolley, Wheeled Trolley, Folding Trolley, Sack Trolley, Kitchen Trolley, Garden Trolley or Wheelbarrows.

These are the trolleys that exist with different types and picked based kind of material that will move is much utilized frequently. Hand trolley is made of hard materials with definite types along with steels, aluminum, and high-effect plastic. Accustomed load comes in the hand trolley with accepted sizes used in, yet there is still precise design for heavy and light, large and short products. The aim of this trolley is to have an easy transportation of heavy loads and the demand for this arises every day in the society.

Folding Trolley

According to Simoes (2014) that the main purpose of a folding trolley is to allow the equipment to be a stackable and collapsible trolley. Furthermore, it is regularly made of aluminum and commonly known to be light weighted material and also being folded that consume less space when not being used. This trolley still relates to the transporting of materials.

In relation to the function of the prototype, the concept of the folding trolley is observed. The Multi-Purpose Trolley can be folded, stretched and also is known to be light weighted material.



Figure 2. Folding Trolley

Source: https://images-na.ssl-images-amazon.com/images/I/413q%2BQQ0UvL._SX342_.jpg

Kitchen Trolley

According to Complete Care Shop, a kitchen trolley is used as an extra equipment to move or transport hot drinks and food in a more convenient and safer way. This type of trolley has been developed to make the transporting of meals ideal for people. This trolley has more division for different purposes such as stacking and storing kitchen utensils. Kitchen trolley provides an excellent comfortability and support to the user who uses the trolley.

In relation to the function of the prototype, the concept of the kitchen trolley is observed. The brace of Multi-Purpose Trolley is from the concept design of kitchen trolley that makes the prototype more durable.



Figure 3. Kitchen Trolley

Source: [http://media.4rgos.it/i/Argos/4246963_R_Z001A?\\$Web\\$&w=570&h=513&\\$WebPDPBadge570\\$&topright=empty&bottomleft=empty](http://media.4rgos.it/i/Argos/4246963_R_Z001A?Web&w=570&h=513&$WebPDPBadge570$&topright=empty&bottomleft=empty)

Among these different types of the trolley, the hand truck and kitchen trolley were used in conceptualizing the design of the prototype. The hand truck served as the source concept for the frame and lifting actions, while the kitchen trolley's brace was the concept design for the support of the prototype.

Kumar et al (2014) developed a stair climbing hand trolley that is designed purposely to lessen the liability rather than increasing it. Commonly used hand trolley work only on a flat ground. However, when it comes to an irregular surface the use of this hand trucks decreases in moving an object. According to his research lifting a hand truck upstairs, the user must provide extra force upward to lift the whole weight of the cart and its content, furthermore, this new concept of a hand trolley has the capability delivering objects that can climb upstairs.

In relation to the study of Kumar et al (2014) and the prototype, the concept of tri-wheel and the utilization of the trolley is observed. The prototype's distinctive feature as compared to the existing is its capability to be stretched and converted to an emergency stretcher



Figure 4. Stair Climbing Hand Trolley

Source: <http://www.handtrucksrus.com/crashdetail.aspx?id=929&cx=gp>

Nafis (2010) studied a new concept on how to transport a load when it faces some stairs, obstacles, terrains. In our society, not all buildings are built with an elevator so it became a dilemma on transporting heavy loads. To go through such stairs, the stair

climbing trolley provides the best solution to run through every terrain, and stairs and this concept of trolley became beneficial to some libraries, hospitals.

The concept of making this prototype is somewhat related to the work made by Kumar et al (2014), wherein in their study, they emphasized the purpose of a stair climbing trolley. However, in the works of Nafis (2010), his new concept of transporting a load in buildings without elevator became a dilemma.

In relation to the study of the Nafis (2010), to the prototype, it is in this premise that the researchers combined these ideas and came up with the innovation and development of a Multi-Purpose Trolley. The prototype has the advantage of lifting loads and injured persons for emergency purposes.

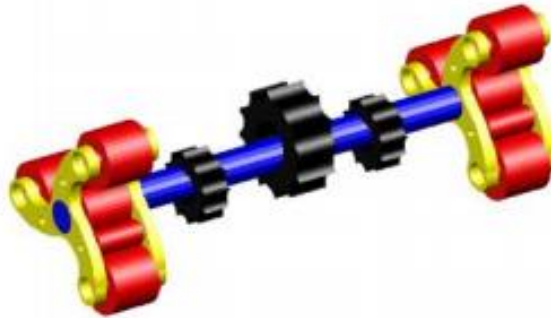


Figure 5. Stair Climbing Trolley

Source: <http://ieom.org/paper/Final%20Paper%20for%20PDF/261%20Nafis%20Ahmed.pdf>

Materials needed for Multi-Purpose Trolley

These are the materials needed in fabricating the Multi-Purpose Trolley such as pipes, wheels, hinges, straps, stretcher, bearings.

Pipe

There are different types of pipes that exist in the market some of which are the following: Stainless Pipes, Aluminum Tube Square, PEX Piping, Copper Piping use in Plumbing, PVC Piping, Galvanized Pipes, Brass Pipes used in Plumbing, Mild Steel Pipes.

A pipe is a cylindrical object that is commonly used to transfer substances which can stream fluids, powders, and masses of tiny solids. Pipes can also be used in structural applications because it is well known to have the ability to withstand force or high pressure.

Aluminum Tube- Square

Aluminum Square Tube is available in alloys 6061-T6 and 6063-T52. Aluminum 6061 is the most widely used alloy, offering better corrosion resistance and weldability than other Aluminum Square Tube, but less strength. Alloy 6063 offers high corrosion resistance and is commonly used for outdoor structural applications such as Aluminum Tube railings and trims.

In relation to the function of the prototype, the concept material of the Aluminum Tube Square is observed. It serves as the main frame of the Multi-Purpose Trolley because of its high corrosion resistance.

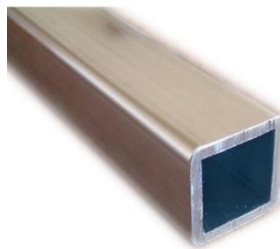


Figure 6: Aluminum Tube- Square

Source <https://4.imimg.com/data4/NH/DQ/MY-21518140/square-hollow-aluminum-tube-500x500.jpg>

Mild Steel Pipe

Mild steel is known to be a very strong material that has a low carbon content of less than 0.18. Mild steel can be formed into a variety of physical shapes. Mild steel pipes and tube are easier to manufacture and cost cheaper than most other metals. Usually, coppers and other types of the metal cover mild steel pipes to protect from corrosion. Structural, mechanical, and other engineering purposes commonly use mild steel pipes and tubing. To prevent mild steel pipes from rusting, regular maintenance should be done. The expected life of mild steel pipe is 50 to 100 years in well-protected environments.

In relation to the function of the prototype, the concept material of the Mild Steel Pipe is observed. It serves as the handle, shafting and the extension of the Tri-Wheel because of its strength capabilities.



Figure 7. Mild Steel Pipe

Source: <http://www.simplexmetal.net/mild-steel-products.html>

Among the other kinds of pipes, the researchers decided to use Aluminum Tube-Square because it provides durability and also has a cheaper price than other metals that can give a better performance. Aluminum Tube- Square is made up of cheap aluminum steel and is very light in weight for structural purposes. And the researcher decided to use Mild Steel Pipe for the extension of the Tri-Wheel.

Wheel

There are different types of wheels that exist in the market some of which are the following: Tri-Wheel, Polyurethane, Pneumatic, Rubber Balloon on Caster Wheel, Rubber on Cast Iron Wheels, Solid Elastomer Wheel.

A wheel is a circular object that is used to rotate on a hub. The wheel is considered to be as one of the important parts of a vehicle that allows easy transportation of a heavy object from one place to another. The discovery of the wheel comes from the late Neolithic, also, might be found in conjunction with other innovative advances that offered ascend to the early Bronze Age. The wheel has a low resistance to motion compared to dragging, and bearings are utilized to help decrease friction at the interface.



Figure 8. Wheel

Source: <http://globe-views.com/dcim/dreams/wheel/wheel-01.jpg>

Tri-Wheel

According to Forsyth et al (1967) stated that the Tri-wheel was designed in the Lockheed Aircraft Corporation. Tri-wheel is an innovated 3-rotatable wheel that is made for climbing stairs. The function of the Tri-wheel is to adapt automatically in terms of the terrain or topography that the wheel is making in contact. The present invention is directed

to a cart for transporting cargo that is capable of climbing stairs. Tri-wheel has a triangular set of wheels that can operate in any type of terrain, a wheel that allows the trolley to go through any obstacles like holes, rock, and steps. These obstacles prevent the front low wheel to execute its forward motion, but it does not affect the driving axle. The motion of Tri-wheel is shown in Figure 9.

In relation to the function of the prototype, the concept material of the Tri-Wheel is observed. The Multi-Purpose Trolley adopt the principle of Tri-Wheel that allows the prototype to go through the obstacles and some stairs

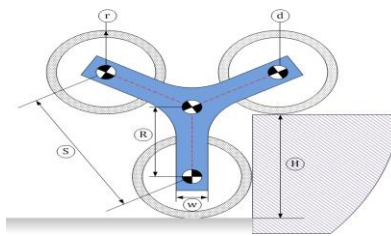


Figure 9. Tri-Wheel

Source: http://4.bp.blogspot.com/-08tlpLtukYM/Us_xBvWu3VI/AAAAAAAAAQ/ycpst-a7jDo/s1600/STAIR+CLIMBING+WHEEL+1.png

Polyurethane

Polyurethane wheel is designed to have shock absorption that lessens the noise. It also has high rollability, high speeds, and durability that makes it a long-lasting wheel. This polyurethane has a capacity ranging from 150 to 10,300 pounds to carry. Furthermore, according to Hamilton Caster & Mfg. Co. (1907), Polyurethane has the highest quality of urethane and has a distinctive characteristic of green threads that inert chemical from reacting. In addition, it is also non-friction, non-conductive, not affected by oil, grease, and solvents and it can protect the floor from markings.

In relation to the function of the prototype, the material Polyurethane is observed. The Multi-Purpose Trolley adopt the material of Polyurethane because of its designed to have shock absorption that lessens the noise. It also has high rollability, high speeds, and durability that makes it a long-lasting wheel



Figure 10. Polyurethane

Source: https://images-na.ssl-images-amazon.com/images/I/710p7461JSL._SY355_.jpg

Among the different types of wheels, the researchers decided to use the Tri-wheel and Polyurethane in making the project. The design of the Tri-wheel that will allow the prototype to go through stairs, obstacles, and terrain made it a possible option. The researchers also decided to use Polyurethane because it provides a strong grip on the floors, provide wall protection and can withstand any position or direction that the prototype will make.

Hinges

There are different types of hinges that exist in the market some of which are the following: Butt Hinges, Strap Hinges, Concealed Hinges, Ladder Hinges.

According to Thomas Publishing Company, there are different hinges that are used as base materials tooling, and machining techniques. Hinges can be used in materials that provide folding, flipping, expanding and securing the materials.

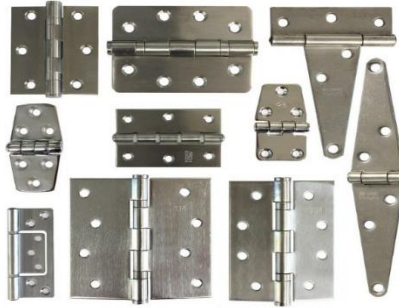


Figure 11. Hinges

Source: <http://www.otaiba4decor.com/ar/online.php?cat=10>

Butt Hinges

According to Padmanabhuni (2014), Butt Hinges has applications extending from doors, windows, cabinets and other furniture. Mortise Hinge is usually attached to doors and to its frame. Stainless steel hinges are more particular for interior design projects. In relation to the function of the prototype, the material Butt Hinges is observed. The Multi-Purpose Trolley get the concept of Butt Hinge for the application of extending from left and right-wing extension and the stand of the prototype.



Figure 12. Butt Hinges

Source: <http://www.finewoodworking.com/2010/12/16/how-to-install-butt-hinges-2>

Ladder Hinges

According to Boothe (1986), it is an improved hinge to have a folding ladder and it provides a pivot pin. This hinge has a shaft that rotates and slides through the hub and lock the hinges with pins for security. In addition, this hinge is suitable to recess the shaft when aligned angularly and can extend and locked for every position of the shaft. An axial alignment of the bore and recess that makes it achieved its full extension.

In relation to the function of the prototype, the material Ladder Hinges is observed. The Multi-Purpose Trolley get the concept of Ladder Hinge for the application of locking mechanism utilized in folding the prototype.



Figure 13. Ladder Hinges

Source: http://ladderhinge.com/e_products/show/?21-ladder-locking-hinge-21.html

Among these different types of hinges, the researchers decided to use the Ladder Hinges in folding the frame because it has the capability of locking, securing and holding. However, butt hinges will be used for the side folding because of its structure and characteristics.

Strap

There are different types of straps that exist in the market some of which are the following: Nylon Strap Webbing, Watch Strap, Snap Fastener, Hook and Loop Fastener.

The strap is a narrow normally level strip or thong of an adaptable material and particularly made up of leather that is utilized for securing, holding together, or wrapping. It can also be used as a holder that bind items such as objects, animals, even people. The strap is ordinarily utilized as part of the packaging industry to secure or attach things. It may be produced from a wide range of materials, such as plastic, steel, paper, or fabric. Strap became so important especially when it comes to the safety of every individual such as belt strap, medical strap, harness that holding and keeping us from any hazard in the area.



Figure 14. Strap

Source: http://www.keyring.com/images/products/detail/19492001_nylon_strap_buckle_open_600px.jpg

Nylon Strap Webbing

Nylon strap webbing is good for medical restraint application because this kind of strap can give a better and comfortable hold compared to a normal garter. It lessens the chances of accidents for it provides security while transporting the material. A ladder lock

for tightening and loosening the strap is an added feature that gives the carrier security for safe transportation. As indicated by plastic-buckle.com, restorative restrictions for the most parts are used to stop individuals with serious physical or mental issue from hurting themselves or others.

In relation to the function of the prototype, the material Nylon Strap Webbing is observed. The Multi-Purpose Trolley utilize the same concept of having the nylon strap webbing for it give a better and comfortable hold compared to a normal garter and to provide a security while transporting the material.



Figure 15. Nylon Strap Webbing

Source: <http://www.plastic-buckle.com/images/products/detail/NPPbs.jpg>

Stretcher

There are different types of stretchers that exist in the market some of which are the following: Medical Stretcher, Scoop Stretcher, Litter Stretcher.

A stretcher is a mechanical assembly utilized for moving patients who require medical care. Stretchers are commonly used in hospitals, search and rescue operations and other military services. Stretchers are used to transport the sick and wounded troops in 1868 war. Through the years, there are many innovated stretchers produce around the

globe. Basic stretchers are the simple type that is portable and lightweight. It is usually made of synthetic material supported by two poles or tubular aluminum frame.



Figure 16. Stretcher

Source: <https://www.tentco.co.za/images/basic-large-stretcher.png>

Medical Stretcher

The medical stretcher is commonly used for emergency purposes that help the injured person is being transported to the ambulance. There are some accidents that may cause severe injury, and inappropriate action can make the situation worse. Basically, medical stretchers are made to assure the safety of the patients. It is one example of a device that can move the patients from one place to other. Medical stretcher secures the ergonomic state of both carrier and patients during the transporting process for it allows the carrier to lift the patient with a distributed force. A handheld innovated mechanical stretcher can be held between two ends of the stretcher. Transferring or moving a patient from one place to another place in a form of a stretcher designed as a bed. Perry et al (2014) state that “types of hospital transfers include bed to stretcher, a bed to a wheelchair, wheelchair to chair, and wheelchair to toilet and vice versa.

According to Guha et al (1989), “it is difficult to transport patients using conventional stretchers particularly in rough terrains with obstacles, narrow staircases, and inadequate spaces.”.

In relation to the function of a Multi-Purpose Trolley in this kind of equipment “Medical Stretcher” comes the idea of a convertible trolley into an emergency stretcher. The conventional stretchers are difficult to use particularly in rough terrains with obstacles, narrow staircases, and inadequate spaces as contrary to the application and functionality of the researchers’ prototype.



Figure 17. Medical Stretcher

Source: <https://medical-stretchers.com/117/mobi-pro-x-frame-ems-ambulance-stretcher.jpg>

Scoop Stretcher

The Scoop stretcher provides secure transportation of the patient to go to the hospital with its innovative restraint straps. This stretcher has its ergonomic structure that helps patients with hip injuries and spine problems. This stretcher has an adjustable length and an opening for X-ray purposes. It is easy to fold and store due to the materials used. Aluminum is an example of a light material that can support up to 350 lbs.

Scoop stretcher mainly provides patient’s immobilization for transport and safe clearance along the way. And somewhat decreases the complication in the cervical spine

and has telescoping tubes that allow adjustment in length to make the patient fitted in various situations.

In relation to the function of a Multi-Purpose Trolley in this kind of equipment “Scoop Stretcher” comes the idea of a secured transportation of the patient to go to the hospital with its innovative restraint straps. It is easy to fold and store due to the materials used. Aluminum is an example of a light material that can support up to 200 lbs.



Figure 18. Scoop Stretcher

https://upload.wikimedia.org/wikipedia/commons/thumb/8/89/Civiere_a_aubes.jpg/200px-Civiere_a_aubes.jpg

Ball Bearing

Based on the project report of Kumar et al (2014), ball bearing needed to reduce the friction in rotating and to add support in radial and axial load in order to achieve its main purpose. In addition to this, it needs at least two races to hold the balls and transmit the loads in the balls. Furthermore, the ball bearing’s general application is to provide a fixed and rotating assembly. The balls will rotate if the bearing races rotate as well.

Based on Muthanna et al (2017) that the “wheel is self-bearing with roller bearings and the life of the bearing has to be calculated as follows:

The life of bearing is given by,

$$L_{10} = (C/P)^P [5]$$

Where, L_{10} = rated bearing life (in million revolutions)

C = Dynamic load capacity (N)

P = Bearing load (N)

$P = 3$ for ball bearings

$= 10/3$ for roller bearings

In relation to the function of the prototype, the Ball Bearing serves as one of the main mechanism in the operation of the Tri-Wheel. The prototype utilized the concept of the ball bearing for it is the tool needed bearing needed to reduce the friction in rotating and to add support in radial and axial load in order to achieve its main purpose.



Figure 19. Ball Bearing

Source: <http://kginternational.com/wp-content/uploads/2015/01/Deep-Groove-Ball-Bearings.jpg>

Cutting Process

According to Barathkumar et al (2016) “In many industries, the process of cutting sheet metal is done by using punching machine. However, in other small industries, the use of the separate machine for sheet metal cutting is not possible. In any type of industries, sheet metal plays a vital role in various applications. Affordability is the main factor in the

case of small and medium scale industries. In order to increase the production rate and profitability, there is a need to reduce the cost.

Cutting is a process in which one object is being separated in two or more options. Knife and saw are commonly used for this process. The cutting process is being done by causing fracture of the material that is being processed. In every stroke, every friction there is a small piece that will fracture away, called chips. The common cutting process includes sawing, shaping, drilling, grinding, milling, and broaching.

In relation to the function of the prototype, the process of cutting is observed in this prototype. The Multi-Purpose Trolley utilized the cutting process in which the materials of the prototype are being separated into two or more options.



Figure 20. Cutting Process

Source: <http://image.made-in-china.com/43f34j00SyatUcqBEkbF/Cutting-Saw-Blade-Cutting-Non-Ferrous-Metal-Tct-Circular-Saw-Blade.jpg>

Tube Bending

Chandramouli states that “Bending of the tube is more difficult than sheets because tubes tend to undergo folding or may collapse if subjected to bending stress. When the tube is subjected to bending, the tube wall of the outer side of the bend is subjected to tensile

stress, while that inside the bend is subjected to compression.” Interior fills or fitting may not require in the thick tubes.

In relation to the function of the prototype, the process of tube bending is observed in this prototype. The Multi-Purpose Trolley utilized tube bending process in which the handle of the prototype is being bent.



Figure 21. Tube Bending

Source: <http://image.thefabricator.com/a/understanding-benders-and-bender-applications-tube-bending-machine.jpg>

Grinding Process

Grinding is one of the most common processes of cutting. It is the material cutting process that contracts a sharp tool whose cutting elements are grains of abrasive material known as grit. This process can produce a very fine finish and precise dimensions. Grinding Wheel is a tool commonly used for grinding, it is composed of an abrasive material that is often used for shaping a workpiece in means of rubbing that leads to a friction that leads the workpiece being worn away. Grinding can also be used to gain a reflective and smooth surface.

Klocke (2009), mentioned that “processes like continuous profile grinding and discontinuous generating grinding with double cone disc become less important in the last couple years, the processes such as continuous generating gear grinding, discontinuous

profile grinding and honing of tooth flanks still gain a rising importance. The result of the is analyzing through functionality, the development status, respectively, maturity as well as identifiable trends.”

In relation to the function of the prototype, the process of grinding process is observed in this prototype. The Multi-Purpose Trolley utilized the process of grinding in cutting, cleaning, finishing the prototype. Grinding process also applies especially for cleaning the slags left during the welding process.



Figure 22. Grinding Process

Source: [http://4.bp.blogspot.com/-](http://4.bp.blogspot.com/-UTJ0IZA47VY/VngBuEEaYDI/AAAAAAAAA1Q/dbNbGPVeStk/s1600/surface+grinding.jpg)

UTJ0IZA47VY/VngBuEEaYDI/AAAAAAAAA1Q/dbNbGPVeStk/s1600/surface+grinding.jpg

Assembly

Assembly is a line in production wherein the prototype is being assembled and all accessories are being in tacked. It is also an act of installing together a set of equipment, set of pieces, and fragments. It consists of manpower and machine in an industry by which the progression of interchangeable materials is dynamically gathered.

According to Wallis (2014) “the challenges of developing and producing products within a shorter period of time are needed for the manufacturing industries to be considered as competitive.”

In relation to the function of the prototype, the process of assembly is observed in this prototype. The Multi-Purpose Trolley utilized assembly wherein the prototype is being assembled and all accessories are being in tacked.

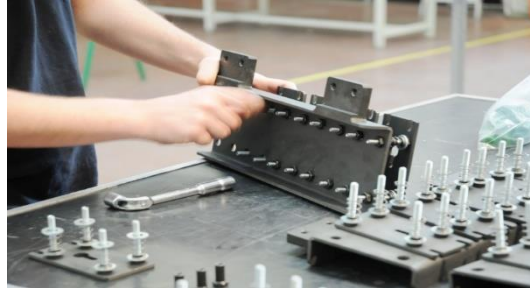


Figure 23. Assembly

Source: http://www.gfautomazioni.it/wp-content/uploads/2016/06/WUP_8127.jpg

Welding

There are different types of welding process that exist in the industry some of which are the following: Gas Cutting, Shielded Metal Arc Welding, TIG Welding. Submerged Arc Welding.

Two metals that are being joined together is called welding. It is a process that requires using an electrode to bond two pieces of metal using heat, and pressure. It is a good option for joining metals permanently.

Shielded Metal Arc welding

Shielded Metal Arc welding is a type of welding process that used a welding power supply to create an electric arc that produces heat and melt filler metal. The cooled melted metal will serve as binders. Direct current (DC) or either alternating current (AC) can be used for this welding process.

In relation to the function of the prototype, the process of Shielded Metal Arc Welding is observed in this prototype. The Multi-Purpose Trolley utilized SMAW welding wherein the prototype is being assembled by using a welding power supply to create an electric arc procedures heat and melt filler metal.



Figure 24. Shielded Metal Arc Welding

Source: http://www.lonestar.edu/departments/webservices/program_welding.jpg

Among these welding processes discussed, the researchers decided to use the Shielded Metal Arc Welding because it is easier to use, more precise, neat, and gives better results.

Evaluation System

These are criteria that are considered in the TUP Evaluation Instrument for Developed Prototype that was used in evaluating the achievement of the prototype, such as:

Functionality is the trait of being sufficient to its right purpose and the capability of its design through its practicality;

Workability is the ability to be fitted to put into effective operation; capable of being worked, handled or dealt with;

Durability is where the value or quality of equipment used, is being discussed, the reliability and the endurance of the material;

Safety is the status of being secured from or to lessen the risk of accident;

Aesthetics focuses on the arrangement, color, assembly and the design which depends on the appearance;

Economy indicates that the project design can be used economically;

Conceptual Model of the Study

The paradigm showed below is the conceptual model of the preceding findings, related literature, theories, concepts, studies presented and observations taken as demonstrated as follows.

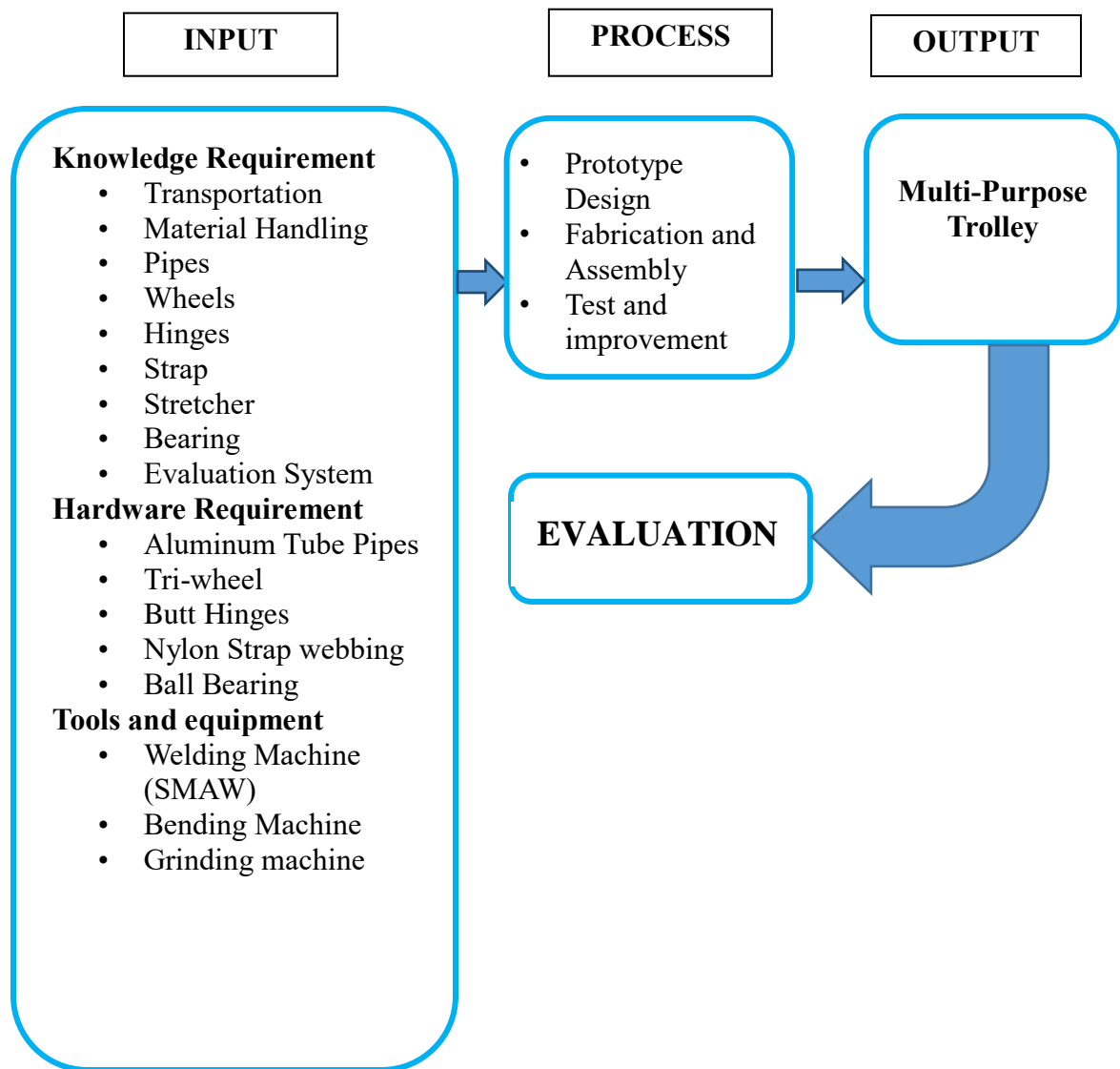


Figure 25. The Conceptual Model of the Study

The conceptual model, as illustrated in Figure 26 shows the different stages of the process involved in order to achieve the objectives of the study.

The input stage consists of knowledge requirements like the step by step procedures in constructing the Multi-Purpose Trolley. The hardware requirements include aluminum tube pipes, tri-wheel, butt hinges, nylon strap webbing, ball. Tools and equipment which include welding machine (SMAW), bending machine, grinding machine.

In the process stage, project design, fabrication, assembly, and testing and improvement are delicately taken care of.

As a result of the processed input, the final output is being the Multi-Purpose Trolley.

Operational Definition of Terms

To have a thorough understanding on the study the following terms are defined as to how they are used in the study.

Multi-Purpose Trolley refers to a hand trolley that is made up of aluminum tube-square, poly nylon plastic, tri-wheel, and nylon strap webbing that can be stretched and convertible into a stretcher. This can be used in times of emergency. The Multi-Purpose Trolley has the capability to go through obstacles and some stairs along its way.

Foldable Frame refers to the main part of the prototype that holds the other parts and attachments. It is made of Aluminum 6061 square tube.

Scooped Stretcher refers to the part of the prototype that is made from poly nylon plastic and used to carry or transport an injured person.

Tri-wheel refers to the rolling component of the prototype that is attached to the frame by the triangular attachment made from mild steel, whereas, the wheel is made up of polyurethane material.

Nylon Strap Webbing refers to the nylon strap webbing that is for securing the load or patient whenever it is transported.

Handle refers to the ergonomically designed part where the operator holds the prototype.

Hinge refers to the guide in folding or flipping of the frame, the side-folding frame, and the dock board.

Chapter 3

METHODOLOGY

This chapter presents the project design, project development, its operation and testing procedure.

Project Design

This Multi-Purpose Trolley is designed to transport and carry materials or injured person easier. The main frame of the prototype is made of an Aluminum 6061 square pipes and other components. Stainless steels were used for the platform, Tri-Star wheel and polyurethane were used for the wheelset. Poly-nylon plastic material was used for the bed or carrier. To secure the load or person being carried, nylon webbing strap was used. These different parts were illustrated in Figures 26 to 28.

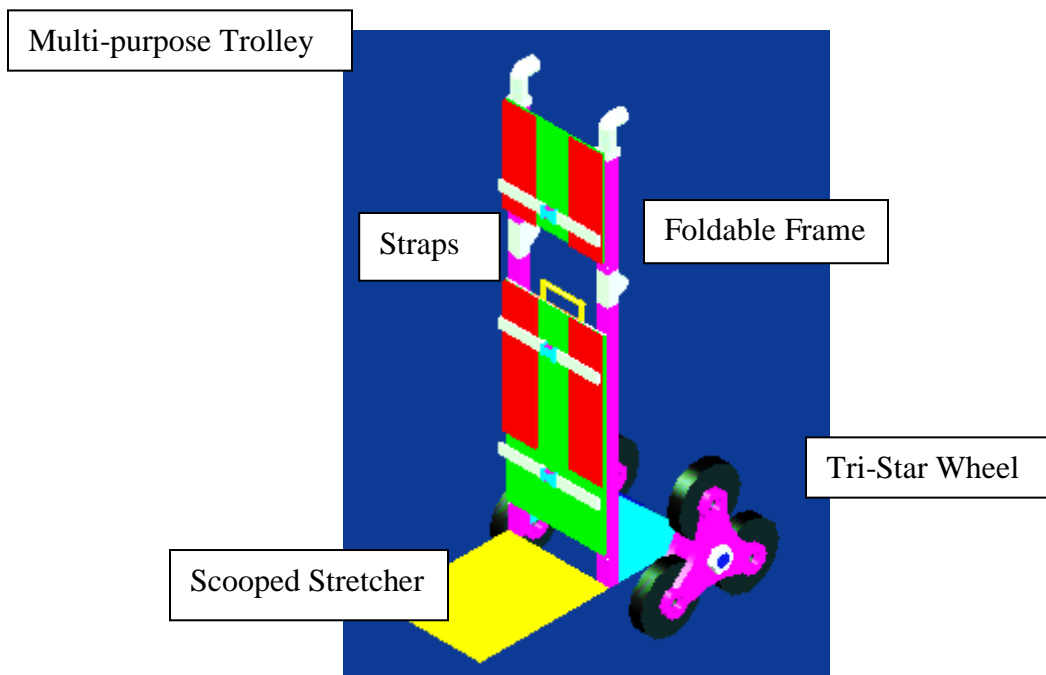


Figure 26. Prototype Assembly

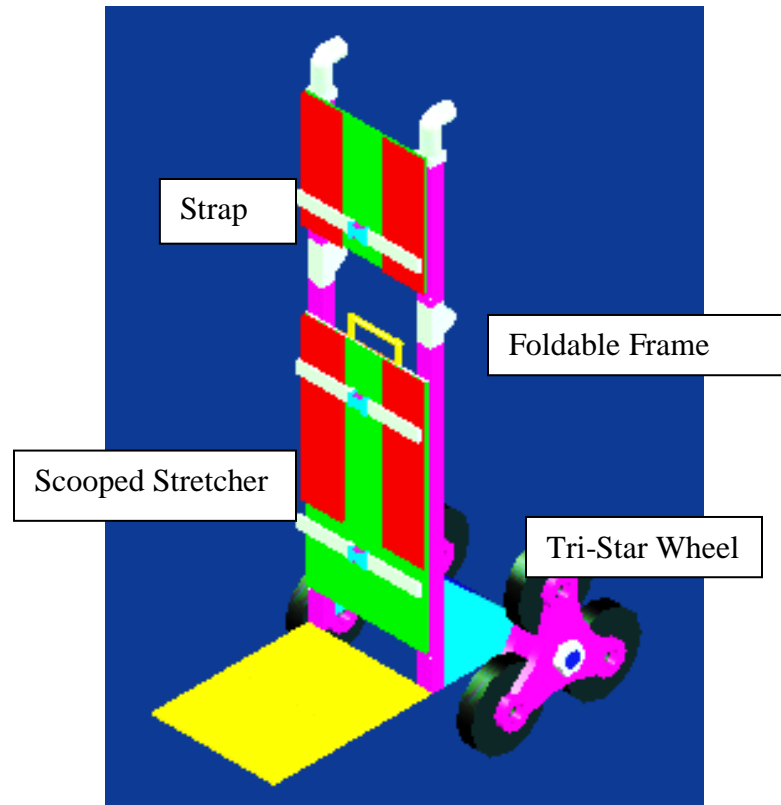


Figure 27. Isometric View of Multi-Purpose Trolley

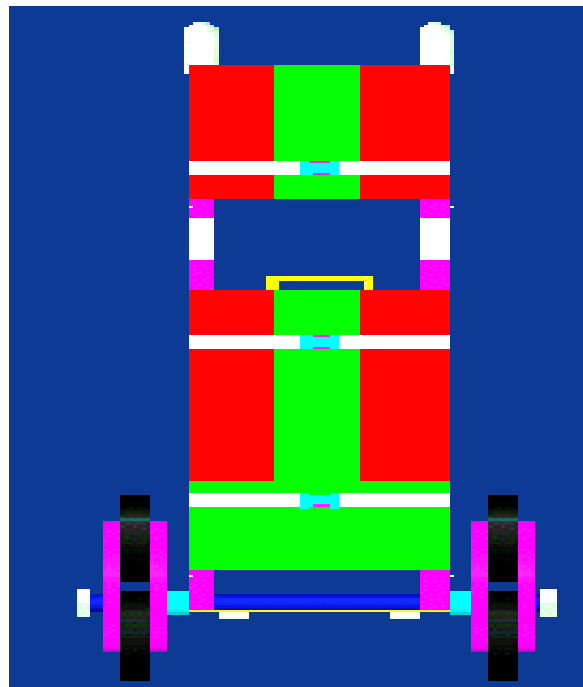


Figure 28. Front View of Multi-Purpose Trolley

The materials needed in fabricating the Multi-Purpose Trolley were readily available on the market as well as the tools and equipment used.

The main frame of the trolley was made of 1-inch square pipes of Aluminum 6061. The prototype has the following dimension: 6ft and 14 inches x 1ft and 1-inch.

The type of stretcher that the researchers used is scoop stretcher that is made out of poly nylon plastic. The stretcher must be supported by its frame to make it last longer.

The Multi-purpose trolley includes a Tri-Star wheelset having three rotatable wheels designed to adapt to any kind of obstacles such as stairs, terrains to keep the transportation process more convenient.

Project Development

The Multi-Purpose Trolley consists of four major assemblies such as foldable frame; nylon strap webbing; scooped stretcher; and wheelset.

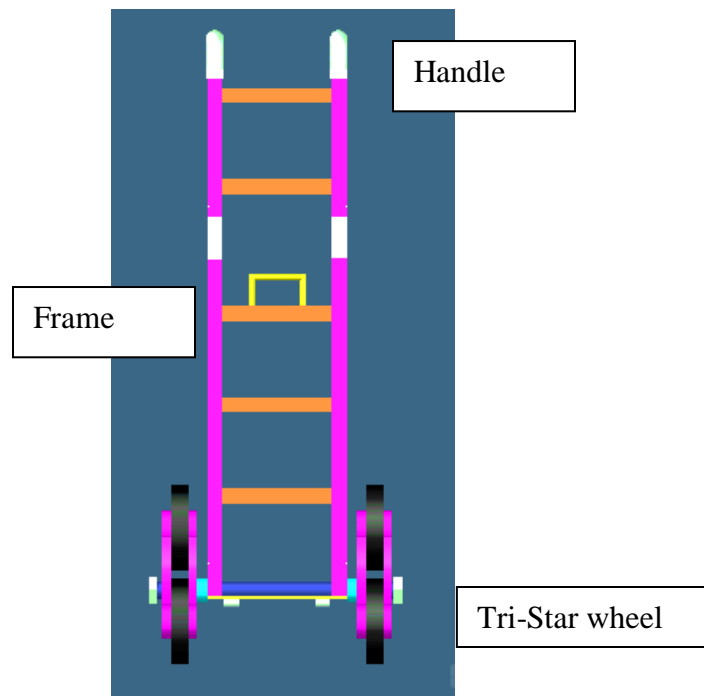


Figure 29. Frame Base Assembly

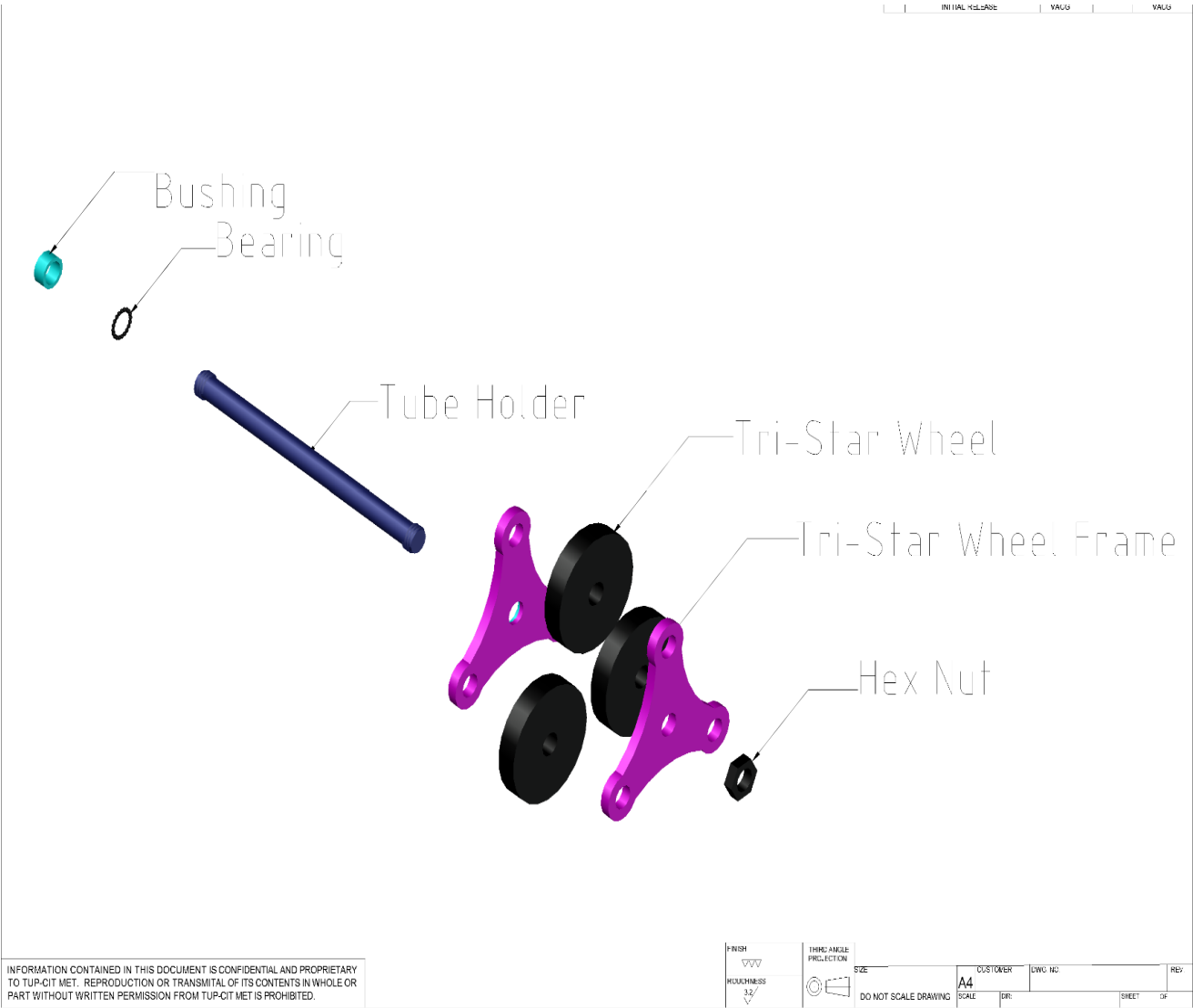


Figure 30. Wheelset Assembly

Fabrication Procedure

The construction of the project follows specific processes. These are the preparation of the materials, laying-out, fabrication, assembling and finishing.

The construction of the “Multi-Purpose Trolley” is composed of four major parts namely:

- a. Foldable frame;
- b. Nylon Strap Webbing;
- c. Scooped stretcher; and
- d. Wheelset

The following steps are followed during the fabrication of the prototype.

Folding Frame

1. Design the folding frame.
2. Prepare and cut the materials for the machining process.
3. Fabricate the detailed design of the cutting process.

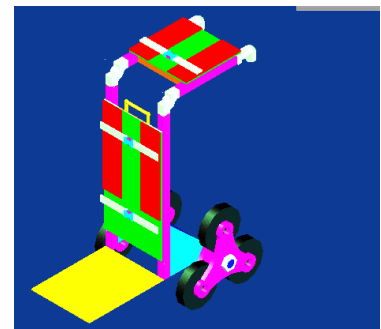


Figure 31. Folding Frame

4. Assemble all the parts using its fasteners as shown in Figure 32.
5. Check the fit allowance during the assembly.

Scooped Stretcher

1. Design the stretcher according to its dimensions.
2. Design the material needed for the side folding
3. Prepare the materials to assemble and harness the parts needed to hold the load.

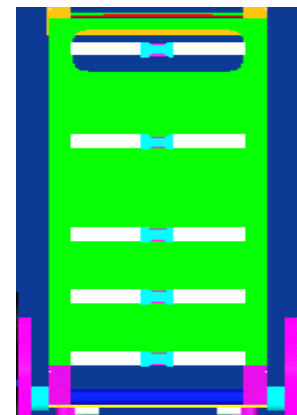


Figure 32. Scooped Stretcher

4. Assemble the hinges needed for folding and flipping.
5. Check the fit allowance to ensure proper assembly.

Trolley Frame Fixture

1. Design the Trolley Frame Fixture according to the size of the hollow bar
2. Prepare and cut the materials with machining allowance.
3. Fabricate the detailed design in the milling process.
4. Assemble all parts with the specified fasteners.
5. Check the fit allowance during the assembly.

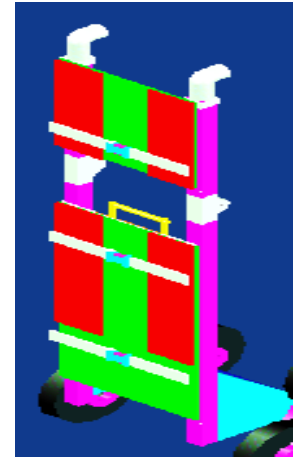


Figure 33. Trolley Frame

Wheel Set

1. Design the wheelset.
2. Prepare and cut the materials for the machining process.
3. Fabricate the detailed design through the milling process.
4. Assemble all the parts using its fasteners.
5. Check the fit allowance during the assembly.



Figure 34. Wheel Set

Operation and Testing Procedure

To ensure that the Multi-Purpose Trolley is operating properly, the researchers conducted series of tests and operations.

Operation Procedure

The procedures in the operation of the prototype are the following:

1. Select the precise materials to be used.

2. Position the trolley.
3. Set the dock board to hold the position of the frame.
4. Proceed to the assembling of the wheelset.
5. Observe the right angle of the frame of the trolley.
6. Load the weighted material.
7. Fasten and check the Nylon straps while holding materials.
8. Check the flatness of the Trolley.
9. Run the Tri-Star wheel on a flat surface and on the stairs.
10. Evaluate the trolley.

Testing Procedure

To ensure that the prototype functions properly the following testing procedure were conducted:

1. Prepare different weights ranging from 30 kg- 130kg.
2. Stretch the trolley;
3. Check the perpendicularity of the trolley's stand;
4. Check the position of the hinge in the frame; make sure it is in the right position in folding.
5. Check the retraction or extension of the handlebar to the frame.
6. Place the weights into the trolley;
7. Strap the loads for safety measure;
8. Measure the distance and record the time.
9. Add weights to the trolley;
10. Check again the condition of the said parts to prevent it from malfunctioning;

Note: the weight of load is dependent on the person that will carry the trolley

11. Repeat the procedure.

Evaluation Procedure

The evaluation procedure was done by presenting a survey pertaining to the reliability and durability of the prototype. The evaluation material was given to 10 students, 9 technical experts, and 5 faculty members from Mechanical Engineering Technology Department and 1 faculty member from Basic Industrial Technology Department.

The researchers' explained to the students and faculty members the prototype on how it works before it proceeds to the actual evaluation. The prototype was evaluated after conducting the demonstration. The evaluation form for this prototype development was filled out by all the evaluators.

The researchers' adopted the six-point criteria coming from the College of Industrial Technology instrument for evaluation. This includes the functionality, workability, durability, safety, aesthetics and economy. Each point of the criteria has three items to be evaluated. Each point of the criteria was graded using the Likert Scale as demonstrated in Table 1.

Table 1

Likert Scale

Numerical Rating	Descriptive Rating
5	Outstanding
4	Very Satisfactory
3	Satisfactory
2	Fair
1	Poor

After conducting an evaluation, the survey forms were collected, tabulated, analyzed and computed to determine the mean ratings. The level of quality and performance of the prototype was determined by the result of the evaluation using the scale to show the range of mean values demonstrated in Table 2.

Table 2

Range of Mean Values

Range of Mean Values	Descriptive Meaning
4.51 – 5.00	Outstanding
3.51 – 4.50	Very Satisfactory
2.51 – 3.00	Satisfactory
1.51 – 2.50	Fair
1.00 – 1.50	Poor

Chapter 4

RESULTS AND DISCUSSION

This chapter presents the project description, project structure, project capabilities and limitations, as well as the project evaluation, which includes the test results.

Project Description

The development of a Multi-Purpose Trolley was designed to lessen the effort exerted in transporting a material or load from one place to another. In addition, it can also be used for emergency purposes that provide a secure, safe and convenient way of carrying an injured person.



Figure 35. Multi-Purpose Trolley

The Multi-Purpose Trolley has a tri-wheel that holds the weight of the main body of the prototype. The tri-wheel has a dimension of 4 inches diameter that can roll over a stair with standard dimension of 8 inches rise and 9 inches run. It is welded and attached to the lower shafting of the trolley.

The mainframe was made of 6ft and 14-inches x 1ft and 1-inch aluminum 6061 that holds the prototype together, and because it is an aluminum material it keeps the prototype from corrosion. It is a ladder-type frame that makes a greater foundation and can keep the plastic fiber from breaking.

Safety strap was also provided on the sides of the prototype to increase the safety that it can give to the cargo and patient. This will keep the loads from falling or discomforts. This safety strap is made of 84.5 inches Nylon webbing. It is used to hold the load, and patient from the prototype.

Project Structure

The Multi-Purpose Trolley consists of several parts such as a foldable frame, nylon strap webbing, scooped stretcher and wheelset.

The mainframe was made of 6ft and 14-inches x 1ft and 1-inch Aluminum 6061 that holds the prototype together.



Figure 36. Main Frame

The safety strap that is made of nylon webbing was placed on the sides of the prototype. Each strap measures 84.5-inches length and 2-inches width

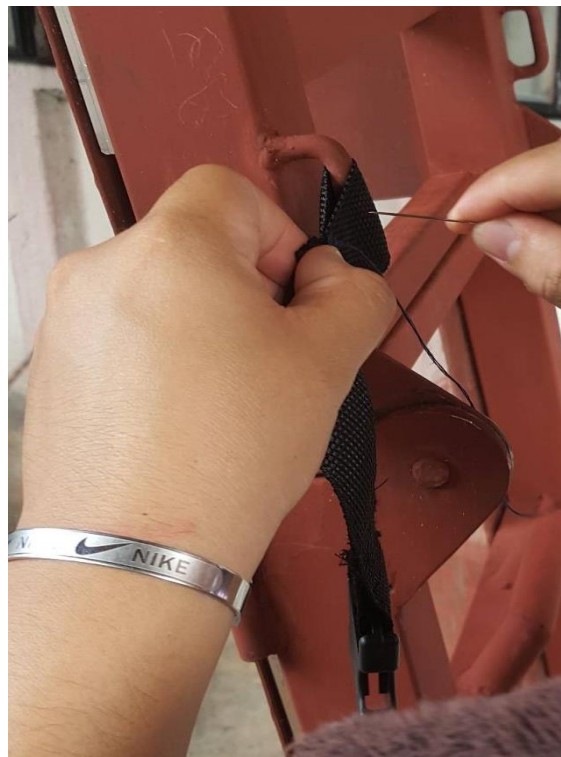


Figure 37. Safety Straps

The Scooped Stretcher is made of plastic fiber and was attached to the mainframe. The dimension of the lower plastic fiber is 37 inches by 13 ½ inches, while the upper plastic fiber measures 27 ¾ inches by 13 ½ inches.



Figure 38. Scooped Stretcher

The Multi-Purpose Trolley has a tri-wheel that holds the weight of the main body of the prototype. The tri-wheel has a dimension of 4 inches diameter that can roll over a stair with standard dimension of 8 inches rise and 9 inches run. It is welded and attached to the lower shafting of the trolley. The prototype uses 6 functional rotating wheels so that it can go through small obstacles and even stairs.



Figure 39. Wheelset

Project Test Results

Test Results

The prototype was tested by lifting a cargo weighing 30 kg to 130 kg as shown in Figures 40 to 44. It is still durable but dependent on the person carrying the loads.



Figure 40. Carrying 80 kg



Figure 41. Carrying 80 kg



Figure 42. Carrying 130 kg



Figure 43. Weighing the 55 kg



Figure 44. Carrying the 110 kg

In carrying the cargo load of 80 kg and 130 kg of 50 meters, it took the carrier 40 and 50 seconds though it became so hard because carrying is always dependent to the person who carries the load. The weight of the load is shown in Figure 44.

Table 3

Summary of Weight Test Results

Samples / Trials	Medium Multi-Purpose Trolley	Weight		
		Weight	Distance	Time
1	Person	54 kg	2 steps	2 sec(s)
2	Person	63 kg	2 steps	5 sec(s)
3	Person	110 kg	2 steps	3 sec(s)
4	Cargo	30 kg	30 m(s)	37 sec(s)
5	Cargo	70 kg	80 m(s)	1:21 sec(s)
6	Cargo	80 kg	50 m(s)	40 sec(s)
7	Cargo	130 kg	50 m(s)	50 sec(s)

The processing time of carrying the load was also identified before proceeding to the fabrication of the samples. Carrier's quality time was categorized as the best processing time. As shown in Table 3, samples 1 to 3 show the different weights that the prototype can withstand, from 54 kg to 110 kg, in just a matter of seconds. Samples 4 to 7 shows that it can also carry cargo loads weighing 30 kg to 130 kg for a distance of 30 meters to 80 meters. However, the efficiency of the prototype is dependent on the person who will carry the loads.

Project Capabilities and Limitations

The Multi-Purpose Trolley is an equipment intended to lessen the effort exerted in transporting a material or load from one place to another. In addition, it can also be used for emergency purposes that provides a secure, safe and convenient way of carrying an injured person.

The prototype, however, has a limited capacity weight of carrying an approximate load of 200 kg. The number of persons involved in putting the load to the carrier is dependent on their strength capacity to carry or lift. Another limitation is the height or the length capacity of the trolley intended for a maximum height of 6 ft. The overall weight of the prototype is 25 kg.

Project Evaluation

The evaluation on the performance of the developed prototype is based on the six (6) criteria included in the TUP's formulated evaluation instrument, namely: functionality, workability, durability, safety, aesthetics, and economy.

Table 4

Mean Result for Functionality

Criteria	Mean	Descriptive Rating
Functionality		
Ease of operation	4.44	Very Satisfactory
Provision of comfort and convenience	4.16	Very Satisfactory
User-friendliness (portability and adjustability)	4.4	Very Satisfactory
Grand Mean	4.33	Very Satisfactory

In terms of Functionality, the evaluators gave a descriptive rating of “Very Satisfactory”, with a grand mean rating of **4.33**. The indicator under Functionality that got

the highest mean was “ease of operation” with a computed mean of 4.44 and a descriptive rating of Very Satisfactory. This result revealed that the prototype is easy to operate without having a technical expertise and in terms of carrying loads and patient upstairs.

Table 5

Mean Result for Workability

Criteria	Mean	Descriptive Rating
Workability		
Availability of materials	4.44	Very Satisfactory
Availability of technical expertise	4.32	Very Satisfactory
Availability of tools and parts	4.44	Very Satisfactory
Grand Mean	4.40	Very Satisfactory

In terms of Workability, the evaluators gave a descriptive rating of “Very Satisfactory,” with a grand mean rating of **4.40**. The indicator under Workability that got the highest mean was the “Availability of materials” and the “Availability of tools and parts,” with a computed mean of 4.44 and a descriptive rating of Very Satisfactory. This result revealed that the material, tools, and parts of the prototype were readily available in the market.

Table 6

Mean Result for Durability

Criteria	Mean	Descriptive Rating
Durability		
Strength of the prototype	4.28	Very Satisfactory
Capability to hold provisional equipment	4.36	Very Satisfactory
Rigidity and accuracy of joints and other parts	4.28	Very Satisfactory
Grand Mean	4.31	Very Satisfactory

In terms of Durability, the evaluators gave a descriptive rating of “Very Satisfactory” with a mean rating of **4.31**. The indicators under Durability “Capability to hold provisional equipment” with a computed mean of 4.36 and a highest descriptive rating of Very Satisfactory. This result revealed that the prototype is capable of holding the provisional equipment.

Table 7

Mean Result for Safety

Criteria	Mean	Descriptive Rating
Safety		
Absence of sharp edges	4.24	Very Satisfactory
Provision of protective devices	4.36	Very Satisfactory
Provision of additional safety features	4.4	Very Satisfactory
Grand Mean	4.33	Very Satisfactory

In terms of Safety, the evaluators gave a descriptive rating of “Very Satisfactory” with a mean rating of **4.33**. The indicator under Safety that got the highest mean was the

“Provision of protective devices” with a computed mean of 4.36 and a descriptive rating of Very Satisfactory. This result revealed that the prototype provides a protective device for the safety of the object that will be loaded on the prototype.

Table 8

Mean Result for Aesthetics

Criteria	Mean	Descriptive Rating
Aesthetics		
Appropriateness of size	4.4	Very Satisfactory
Color appeal	4	Very Satisfactory
Simplicity of design	4.6	Very Satisfactory
Grand Mean	4.33	Very Satisfactory

In terms of Aesthetics, the evaluators gave a descriptive rating of “Very Satisfactory” with a mean rating of **4.33**. The indicator under Aesthetic that got the highest mean was the “Simplicity of design,” with a computed mean of 4.6 and a descriptive rating of Very Satisfactory. This result revealed that the prototype has a design that is simple.

Table 9

Mean Result for Economy

Criteria	Mean	Descriptive Rating
Economy		
Economy in terms of materials used	4.32	Very Satisfactory
Economy in terms of time and labor spent	4.4	Very Satisfactory
Economy in terms of machines, tools, and parts used	4.4	Very Satisfactory
Grand Mean	4.37	Very Satisfactory

In terms of Economy, the evaluators gave a descriptive rating of “Very Satisfactory” with a mean rating of **4.37**. The indicator under Aesthetics that got the highest mean was the “Economy in terms of material used” with a computed mean of 4.32 and a descriptive rating of Very Satisfactory. This result shows the materials used in making the Multi-Purpose Trolley are readily available in the market. However, the brand-new frame of the trolley can only be purchased from the international market. In the Philippines, a second-hand frame of the trolley can be purchased from selected hardware shops. The plastic fiber of the prototype, once it is fully consumed can also be easily replaced.

Table 10

Summary of Evaluation of Results

Criteria	Mean	Descriptive Rating
Functionality	4.33	Very Satisfactory
Workability	4.40	Very Satisfactory
Durability	4.31	Very Satisfactory
Safety	4.33	Very Satisfactory
Aesthetics	4.33	Very Satisfactory
Economy	4.37	Very Satisfactory
Overall Mean	4.35	Very Satisfactory

Legend:

Numerical Scale	Descriptive Rating
4.51 - 5.00	Outstanding
3.51 - 4.50	Very Satisfactory
2.51 - 3.50	Satisfactory
1.51 - 2.50	Fair
1.00-1.50	Poor

The results of the evaluation conducted showed that the respondents and the experts were very satisfied with the outcome of the prototype, as evidenced in the overall mean of 4.35 with a descriptive rating of "Very Satisfactory." As shown in Table 10, workability criterion has the highest mean rating of 4.40 with a descriptive rating of "Very Satisfactory"

since the structural design of the Multi-Purpose Trolley works its functions and the capacity to carry and lift such weight.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions, and recommendations based on the results of the evaluations, remarks, and suggestions given by the panel of evaluators.

Summary of Findings

The prototype, Development of Multi-Purpose Trolley was designed and constructed based on the desired specifications and fabrications. It consists of several parts such as a foldable frame, nylon strap webbing, scooped stretcher and wheelset. The mainframe was made of 6ft and 14-inches x 1ft and 1-inch Aluminum 6061 that holds the prototype together.

The Safety strap that is made of Nylon webbing was placed on the sides of the prototype. Each strap measures 84.5-inches length and 2-inches width

The Scooped Stretcher is made of plastic fiber and was attached to the mainframe. The dimension of the lower plastic fiber is 37 inches by 13 ½ inches, while the upper plastic fiber measures 27 ¾ inches by 13 ½ inches.

The Multi-Purpose Trolley has a tri-wheel that holds the weight of the main body of the prototype. The tri-wheel has a dimension of 4” diameter that can roll over a stair with standard dimension of 8 inches rise and 9 inches run. It is welded and attached to the lower shafting of the trolley. The prototype uses 6 functional rotating wheels so that it can go through small obstacles and even stairs.

The Multi-Purpose Trolley is an equipment intended to lessen the effort exerted in transporting a material or load from one place to another. In addition, it can also be used

for emergency purposes that provides a secure, safe and convenient way of carrying an injured person.

The processing time of the carrying the load was also identified before proceeding to the fabrication of the samples. Carrier's quality time was categorized as the best processing time. As shown in Table 3, samples 1 to 3 show the different weight that the prototype can withstand, from 54 kg to 110 kg in just a matter of seconds. In samples of 4 to 7 shows that it can also carry cargo loads weighing 30 kg to 130 kg for a distance of 30 meters to 80 meters. However, the efficiency of the prototype is dependent on the person who will carry the load.

The results of the evaluation conducted showed that the respondents and the experts were very satisfied with the outcome of the project, as evidenced in the overall mean of 4.35 with a descriptive rating of "Very Satisfactory."

Conclusions

The following are the conclusions based on the findings and evaluations conducted in the study.

1. The Development of Multi-Purpose Trolley with the following major parts such as foldable frame, nylon strap webbing, scooped stretcher, and wheelset, were successfully designed.
2. The prototype was fabricated based on the design specifications and met the required dimensions.
3. The Multi-Purpose Trolley was tested and improved in accordance with its reliability.

4. The Multi-Purpose Trolley was evaluated by the chosen respondents in terms of functionality, workability, durability, safety, aesthetics and economy with an overall mean rating of 4.35, which is equivalent to a descriptive rating of Very Satisfactory.

Recommendations

Based on the findings and conclusions obtained from the evaluators, the following are recommended:

1. Provide an ergonomic design in placing the shafting, consider freedom of movement of the tri-wheel.
2. Modify the handle and following the ergonomic design.
3. Install a motorized wheel if possible.
4. Extend the length and width of the plate, if possible, to 4 inches more.
5. Provide more stand in the base plate and it can be folded when not in use.
6. Provide the wheel that can be pivoted.
7. Provide an operation's manual.

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APPENDIXES

Appendix A

GANTT CHART

Major Activities	Implementation Schedule															
	November				December				January				February			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Designing of the Project																
2. Sourcing of Parts and Materials																
3. Fabrication and Assembly																
4. Testing of the Prototype																
5. Project Evaluation																
6. Modification/Revision																
7. Documentation																

The preparation for the project designing took 4 weeks to be finished, and it was proceeded in acquiring all the tools, material, parts that are be using in fabrication and assembly. Fabrication and assembly lasted for almost seven weeks.

The first testing attempt that the researchers occurred in the third week of January. The second testing attempt happened after a week of revision, to check the workability of the prototype. It was evaluated for another week. After the evaluation two weeks was given for revision and modification of the papers. Documentation was done alternately in the development of the prototype

Appendix B
SAMPLE EVALUATION INSTRUMENT

Indicators	Numerical Rating				
A. Functionality	5	4	3	2	1
1. Ease of operation					
2. Provision of comfort and convenience					
3. User-friendliness (portability and adjustability)					
B. Workability					
1. Availability of materials					
2. Availability of technical expertise					
3. Availability of tools and parts					
C. Durability					
1. Strength of the prototype					
2. Capability to hold provisional equipment					
3. Rigidity and accuracy of joints and other parts					
D. Safety					
1. Absence of sharp edges					
2. Provision of protective devices					
3. Provision of additional safety features					
E. Aesthetics					
1. Appropriateness of size					
2. Color appeal					
3. Simplicity of design					
F. Economy					
1. Economy in terms of materials used					
2. Economy in terms of time and labor spent					
3. Economy in terms of machines, tools, and parts used					

Remarks/ comments and suggestions:

Appendix C
CORRESPONDENCE



Technological University of the Philippines
COLLEGE OF INDUSTRIAL TECHNOLOGY
Mechanical Engineering Technology
Ayala Blvd., Ermita, Manila



February 8, 2018

Dear Respondents:

Greetings!

The undersigned are the student of Bachelor of Technology major in Mechanical Engineering Technology (BT-MET) at the Technology University of the Philippines – Manila.

In this regard, I would look to seek your assistance in evaluating my prototype entitled, “Development of Multi-Purpose Trolley”.

Rest assured that the data that will be gathered will be treated with utmost confidentiality and shall be used strictly for professional purposed only.

Thank you very much.

Respectfully yours,

REUEL MARK REYES DELLOSA
MARVIN IAN PALAD EPISCOPE
ELIJAH RAMOS MARCO
Researchers

Noted by:

PROF. JOSEPHINE N. ALDEN

Thesis Adviser

Appendix D

PROFILE OF RESPONDENTS

Respondent No.	Name	Sex	Company/ Institution	Position/ Designation
1	Ramirez, Harvy C	M	TUP-M	Student
2	Malayan, John Jerick M.	M	TUP-M	Student
3	San Jose, Jan Louis	M	TUP-M	Student
4	John Nino L. Vega	M	Happy well management and collection services,	Technical Support Specialist
5	Helen R. Sanchez	F	N/A	End-user
6	Canzana, Rasauro Jose M.	M	TUP-M	Student
7	Kristoffer Torralba	M	TUP-M	Instructor
8	Robert Jawads	M	SRS glass & steel fabrication	Owner
9	Jerry Abanto	M	N/A	RME
10	Lodriguito, Anjo D.	M	N/A	Random
11	Amen, Albert Matthew G.	M	TUP-M	Student
12	Norman Golena	M	TUP-M	Student
13	Bernardo, Chris King C	M	TUP-M	Student
14	John ver S. Bristol	M	TUP-M	Student
15	Dianne Dela Cruz	F	TUP-M	SST-III
16	Winston	M	SRS glass & steel fabrication	Welder
17	Jolman	M	SRS glass & steel fabrication	Welder
18	Bucag, Marvin	M	TUP-M	Student
19	Paula Mamolo	F	TUP-M	Student
20	Erwin Yaon	M	SRS glass & steel fabrication	Welder
21	Edcel Ballon	M	SRS glass & steel fabrication	Welder
22	Buenaventura V. Sabater	M	TUP-M	Prof 2
23	Leonardo San Andres	M	TUP-M	Prof 2
24	Dorothy D. Manalansan	F	TUP-M	Instructor
25	Reynaldo S. Ladines Jr.	M	TUP-M	Prof 2

Appendix E
TOTAL BUDGETARY REQUIREMENTS

PARTICULARS	AMOUNT
1. Personal Services (PS)	
1.1 Contractual Labor	
a. Technician	PHP 1,970
Total Personal Expenses	PHP 1,970
2. Maintenance and Other Operating expenses	
2.1 Travel Expenses	PHP 1,400
2.2 Materials and Supplies	PHP 13,830
Total Maintenance and Other Operating Expenses	PHP15,230
TOTAL BUDGET	PHP 17,200

BILLS OF MATERIALS

Qty	U/M	Description / Specification	Unit Price	Extended Price
6	Pc(s)	Polyurethane caster wheel	150	900
5	Pc(s)	Nylon webbing strap	30	150
1	Pc	CRS 1x1	280	280
5	Pc(s)	Buckle	20	100
5	Pc(s)	Tailor	150	150
1	Set(s)	Plastic Fiber	200/sq.in	2,000
1	Set(s)	Galvanized steel Frame	3,000	3,000
2	Set(s)	Tri-star wheel	3,000	3,000
4	Pc(s)	Ball Bearing	25	100
1	Set(s)	Aluminum Tube Square- 6061	4,000	4,000
1	Set(s)	Handle	150	150
TOTAL				PHP 13,830

Appendix F
TOOLS AND EQUIPMENT USED

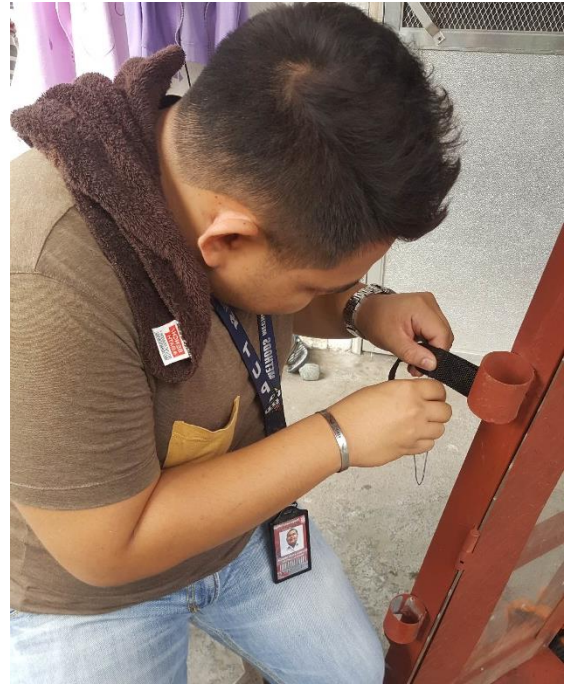
TOOLS	SPECIFICATIONS
1. Wrench	10
2. Rivets	1/8, 1/4
3. Pliers	Mechanical Pliers
4. Hacksaw	Stanley
5. Hammer	Ball Hammer
EQUIPMENT	
1. Portable Grinder	Cutting Disc
2. Welding Machine	SMAW Welding
3. Cut-off Machine	Cutting Disc
4. Hand Drill	1/8 to 1/4 drill bit

Appendix G

PICTURES TAKEN DURING FABRICATION, TESTING, AND EVALUATION



In these pictures shows the fabrication and attachment of the tri-wheel to the frame.



In these picture shows the testing and attaching the nylon strap webbing to the prototype.



In these picture shows the finished product of the prototype Multi-Purpose Trolley.



In these picture shows the test and evaluation of the prototype Multi- Purpose Trolley.



In these pictures shows the number of evaluators that evaluate the prototype Multi- Purpose Trolley.

Respondent No.	Functionality			x	Workability			x	Durability			x	Safety			x	Aesthetics			x	Economy			x	
	1	2	3		1	2	3		1	2	3		1	2	3		1	2	3		1	2	3		
1	5	5	5	5.00	5	5	4	4.67	4	5	4	4.33	5	5	5	5.00	4	4	5	4.33	4	5	4	4.33	
2	5	5	5	5.00	5	4	5	4.67	4	4	5	4.33	5	5	5	5.00	5	5	5	5.00	5	5	5	5.00	
3	4	4	4	4.00	5	4	5	4.67	5	4	5	4.67	4	4	4	4.00	5	4	5	4.67	4	4	4	4.00	
4	4	4	4	4.00	4	4	4	4.00	4	4	4	4.00	4	4	4	4.00	4	4	4	4.00	4	4	4	4.00	
5	5	5	5	5.00	5	5	5	5.00	5	5	5	5.00	4	5	5	4.67	5	5	5	5.00	5	5	5	5.00	
6	4	4	5	4.33	5	5	5	5.00	4	4	4	4.00	4	4	4	4.00	5	4	5	4.67	4	4	4	4.00	
7	5	4	5	4.67	5	5	5	5.00	5	5	5	5.00	5	5	5	5.00	5	4	5	4.67	5	5	5	5.00	
8	4	4	4	4.00	5	5	5	5.00	4	4	4	4.00	5	5	4	4.67	4	3	5	4.00	4	4	4	4.00	
9	5	4	5	4.67	5	5	5	5.00	5	3	5	4.33	2	3	4	3.00	3	3	3	3.00	2	3	4	3.00	
10	5	4	5	4.67	5	5	5	5.00	5	5	5	5.00	4	4	5	4.33	5	5	5	5.00	5	5	5	5.00	
11	5	4	5	4.67	5	5	5	5.00	4	5	5	4.67	4	5	4	4.33	5	4	5	4.67	5	5	4	4.67	
12	4	4	4	4.00	5	4	4	4.33	4	4	4	4.00	5	4	4	4.33	5	4	4	4.33	4	4	4	4.00	
13	4	4	4	4.00	5	5	5	5.00	5	5	5	5.00	5	4	5	4.67	5	4	5	4.67	5	5	5	5.00	
14	5	4	5	4.67	5	4	5	4.67	4	5	4	4.33	5	5	4	4.67	5	5	5	5.00	5	5	5	5.00	
15	4	5	5	4.67	4	5	5	4.67	5	5	5	5.00	5	5	5	5.00	5	5	5	5.00	4	5	5	4.67	
16	4	3	4	3.67	3	4	4	3.67	3	4	3	3.33	3	4	4	3.67	3	3	4	3.33	4	4	4	4.00	
17	4	3	4	3.67	3	3	3	3.00	2	4	3	3.00	3	4	4	3.67	2	3	4	3.00	3	3	3	3.00	
18	5	5	4	4.67	4	4	5	4.33	5	5	4	4.67	4	5	5	4.67	5	4	5	4.67	5	5	5	5.00	
19	5	5	5	5.00	4	4	4	4.00	4	5	5	4.67	5	4	4	4.33	4	4	4	4.00	5	5	5	5.00	
20	4	4	4	4.00	3	4	4	3.67	4	4	3	3.67	4	4	4	4.00	4	3	3	3.33	4	4	4	4.00	
21	4	4	3	3.67	4	3	3	3.33	4	3	3	3.33	3	4	4	3.67	3	4	4	3.67	4	4	4	4.00	
22	4	4	4	4.00	5	4	5	4.67	5	5	4	4.67	5	5	5	5.00	5	4	5	4.67	5	5	5	5.00	
23	4	4	4	4.00	3	4	4	3.67	3	3	4	3.33	4	4	4	4.00	4	4	5	4.33	5	4	5	4.67	
24	4	4	4	4.00	4	4	4	4.00	5	5	5	5.00	5	5	5	5.00	5	5	5	5.00	4	4	4	4.00	
25	5	4	4	4.33	5	4	3	4.00	5	4	4	4.33	4	3	4	3.67	5	3	5	4.33	4	4	4	4.00	
				4.33				4.40				4.31				4.33				4.33				4.37	4.35


Appendix I

User's Manual

1. Place the prototype in front of the object or injured the person to be transferred.
2. Open the foldable left and right wings extension for the bulky loads.
3. Transfer the loads on trolley, you can unfold the trolley with the use of lock place in the middle of the trolley if needed
4. Use the safety strap for the safety of loads and person loaded to avoid falling.
5. Check the joints and the strap if placed properly.
6. Incline the trolley by pushing the axis using your feet and pulling the handle.
7. Push/pull the trolley to your desired location.
8. Put down the trolley using the stand paced in back of it to unload.
9. Unload the loads in the trolley.

Appendix J

RESULT OF TURNITIN

	TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES Ayala Blvd., Ermita, Manila, 1000, Philippines Tel No. +632-301-3001 local 711 Email: urds@tup.edu.ph Website: www.tup.edu.ph	Index No.	F-URD-4.1-CSE
		Issue No.	01
		Revision No.	00
		Date	11242017
		Page	1 / 1
VRE-URD	CERTIFICATE OF SIMILARITY INDEX USING TURNITIN	QAC No.	CC-11242017

This is to certify that the thesis entitled


"DEVELOPMENT OF MULTI-PURPOSE TROLLEY"

authored by:


Elijah R. Marco
Reuel Mark R. Dellosa
Marvin Ian P. Episcopo,

has been subjected to similarity check on March 06, 2018
using Turnitin with generated similarity index of [6%].

Processed by:


FRANCISCO D. ESPONILLA II
Asst. Prof. 1, URDS

Certified correct by:


Prof. RENATO BUTCH R. BITUONAN
Director, University Research and Development Services

Transaction ID	
Signature	

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WORK EXPERIENCE

- On-the-Job Training – Alpha Techno Precision Tooling INC. “

November 7, 2016 – April 3, 2017

EDUCATIONAL ATTAINMENT

- Bachelor in Technology major in Mechanical Engineering Technology

Technological University of the Philippines

2014 – Present

- Theresian School of Cavite

Aguinaldo Highway, Bacoor City Cavite

2010 - 2014

- Rocepol Jane Academy

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2003 - 2010

SEMINARS ATTENDED

- 19th Job Fair with the theme of “Essentials of Landing a Job”

Technological University of the Philippines

March 07, 2018

- Metals Industry Research and Development Center, Department of Science and

Technology “Investment Casting (Presentation of Technology)”

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July 28, 2016

- Metals Industry Research and Development Center, Department of Science and Technology “Investment Casting (Presentation of Technology)”

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Imus City Cavite 2003 – 2009

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- Metals Industry Research and Development Center, Department of Science and Technology “Investment Casting (Presentation of Technology)”

Technological University of the Philippines July 28, 2016

- Metals Industry Research and Development Center, Department of Science and Technology “Investment Casting (Presentation of Technology”
Technological University of the Philippines July 28, 2016
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Technological University of the Philippines August 29, 2014
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- On-the-Job Training – Toyota Motors Philippines.

November 7, 2016 – April 3, 2017

EDUCATIONAL ATTAINMENT

- Bachelor in Technology major in Mechanical Engineering Technology

Technological University of the Philippines

2014 – Present

- Fruit of Knowledge Academe

Pasong camachille 2 generaltria cavite

2010 - 2014

- Fruit of Knowledge Academe

Pasong camachille 2 general trias cavite

2003 - 2010

SEMINARS ATTENDED

- 19th Job Fair with the theme of “Essentials of Landing a Job”

Technological University of the Philippines

March 07, 2018

- Metals Industry Research and Development Center, Department of Science and

Technology “Investment Casting (Presentation of Technology”)

Technological University of the Philippines

July 28, 2016

- Metals Industry Research and Development Center, Department of Science and Technology “Investment Casting (Presentation of Technology)”

Technological University of the Philippines

July 28, 2016

- Mechanical Technologist and Diemakers Society “Intellectual Property Rights Awareness”

Technological University of the Philippines

August 29, 2014

- Mechanical Technologist and Diemakers Society “Methods went to town” fun game.

Technological University of the Philippines

August 30, 2014

- Mechanical Technologist and Diemakers Society “Bridging the gap of Technology Application between the academe and the Industry”

Technological University of the Philippines

September 29, 2014

MEMBERSHIP IN PROFESSIONAL ORGANIAZTIONS

- Mechanical Technologist and Diemakers’ Society

Member