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Electric Scooter (EZ Vroom)

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Abstract : The objective of this project is to design and fabricate a prototype of an electric scooter named EZ Vroom. EZ Vroom was designed for the purpose of facilitating commuting to and from campus to residential college. The design and fabrication of EZ Vroom aim to simplify student life on campus by making rentals accessible to UTHM students. Students recommended using electric scooters as it is very simple to handle, do not require a driving license, and also fuel (just only need to charge the battery). The maximum speed of this electric scooter is 45 km/h, and there is only one person to ride on it. Furthermore, this electric scooter is lightweight and also convenient to carry along with the battery can be fully charged in one hour. The EZ Vroom fabrication process also involves mechanical and fundamental electrical knowledge. The early phases involved sketching and designing the Ez Vroom using the Computer-Aided Design (CAD) application, later on to the fabrication of the EZ Vroom frame, and completing the wiring of the electrical components. The overall price for the development of this electric scooter is RM 600.00. The prototype undergone vigorous testing including toughness, velocity and endurance tests in which have been passed by EZ VRoom. The analysis shows that Ez Vroom is suitable for students to commute from and to residential college to campus safely.

Keywords: Electric Scooter, Transportation

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1. Introduction

The technology for electric scooters has advanced considerably faster during the last few decades. Peugeot created the Scoot'Elec, the first mass-produced electric scooter, in 1996. It had a top speed of 31 mph and a range of 29 miles. Despite being bulky and not very environmentally friendly due to its nickel-cadmium batteries, the Scoot'Elec was a huge hit. The lithium-ion battery, which today powers the majority of computers, smartphones, and tablets, was also created in the early 1990s. Compared to nickel-cadmium batteries, lithium-ion batteries were both significantly more effective and environmentally friendly. Electric scooters are now produced by a large number of companies across a number of nations, and it are more ubiquitous in urban areas. People can rent electric scooters from a number of ridesharing businesses, including Uber, Lime and Ola [1]. Electric scooters are more popular than more conventional forms of transportation because it is portable, simple to use, environmentally friendly, require less maintenance, and are subject to fewer regulations. Gas-powered scooters actually release more greenhouse gases per unit of their size than cars, and their fuel costs are nearly four times as much as those of electric scooters. The NANROBOT LS7, which has a top speed of 52 mph, is the fastest electric scooter on the market right now [2].

A compact, transportable vehicle that runs on electricity is called an electric scooter. The scooter's battery, which is hidden deep inside, serves as the motor's energy reserve. Batteries are the electric lines that connect the motor and battery. The major component of an electronic scooter is the controller, which transforms input from the throttle and electronic brake controls into the current for the motor. The power of the motor is determined by the voltage and current of the controllers, and the higher the voltage, the more powerful the motor [3].

In this final project, the electric scooter that can run for at least 45 minutes on a single charge and can move at least 30 km/j was developed. This scooter called EZ Vroom was chosen as the main title. EZ Vroom is capable of transporting students to their respective hostel. The selection of this title is also made to make it easier for UTHM students to come to class on time. In the design and fabrication of EZ Vroom, our group has researched various types of electric scooters sold in the market to develop ideas in making the design and selection of suitable components for EZ Vroom.

Table 1: Comparison between standard commercial electric scooters with EZ Vroom

Task	Standard commercial electric scooter [4][5]	EZ Vroom
		
Top speed	55 km/h	45 km/h
Safety	Break and front and rear light	Side mirrors, signal, brake, front and rear light,
Power usage	1600 Watt	500 Watt
Acceleration	36 km/m^2	36 km/m^2
Voltage	48 V	24 V
Driving mode	All-terrain	Easy Urban environment
Range	10 km	6 km
Battery lifetime	2 hour	45 minutes
Features	Heavy, versatile, expensive, and moderately safe	Versatile, affordable, safer, convenient, ergonomic

Weight	120 kg	100 kg
Product Weight	53 kg	47 kg
Charging	3 hour	1 hour
Efficiency	75%	67%

Table 1 shows the difference between standard commercial electric scooters with scooter electric (EZ Vroom). It can be seen that, standard commercial electric scooter have more voltage power, higher top speed and higher range as compared with EZ Vroom. This is expected since the EZ Vroom was design with low cost in nature.

2. Materials and Methods

When it comes to selection of material for EZ Vroom, the priority is to choose low cost and easy to get material within vicinity of Muar, Johor area. On top of that, the material must have suitable strength and acceptable toughness in order to avoid EZ Vroom from fail during operation.

In addition, method and equipment used to fabricate this electric scooter's prototype is what is available in rudimentary workshop which used basic engineering equipment such as welding, drilling and metal bending

2.1 Material Selection

The main material that was used to fabricate EZ Vroom is mild steel plate and mild steel tube. As mentioned earlier, the material that was used in this material must be low cost as well as easy to get and mild steel fit this objective. Apart from mild steel, 24 V electric motor and brush motor controller was used in this prototype.

There are several important things that need to be studied to ensure the model will work well and safely. Among the elements that need to be studied are the type of materials and components used, the proper application process, objective analysis products, and the cost of each material and component used. Next, maximum weight of the rider is 100 kg. Excessive weight or more than 100 kg cannot be accommodated by EZ Vroom which will cause structural damage to EZ Vroom resulting damaging tires and bearings.

The 12 inch bicycle tires were chosen for this EZ Vroom. However, the EZ Vroom site or so-called deck made of mild steel has a high strength that can accommodate the weight of the user. Apart from that, mild steel also has high weldability to facilitate the fabrication process and even the price of mild steel is affordable according to the final year project budget. In order to avoid mild steel to rust, anti-rust spray was used on the surface of the mild steel.

Next, a 500 W DC 24 V DC Electric brushed motor with a bracket was chosen for this project. The following are the specifications of the selected motor [6]:

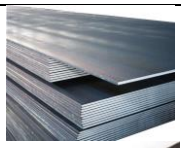
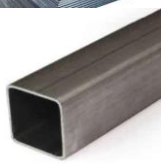
Table 2: DC Motor Specification

No.	Description	Parameter
1	Rated Voltage	DC 24 V
2	Rated Power	500 W
3	Rated Speed	2500 RPM
4	Main Color	Black
5	Weight	4.4 kg

Table 2 showed the of the DC motor. The rated voltage is 24 V while the rated speed is 2500 RPM. EZ Vroom did not need a high-speed motor thus a voltage controller was employed to control the speed of the motor.

Next, the motor and battery are placed on the deck in this project. To maintain this component, the cover of the electrical component is fabricated with a steel shield so that the component is not exposed to water which can damage the component. In addition, safety accessories such as signals, front and rear lights, and side mirrors are also available on the EZ Vroom to ensure the safety of users during the day and night.

Table 3: List of materials, and description

No.	Pictures	Materials	Description
1.		Mild Steel Plate	The function of the mild steel plate is as a footwear platform.
2.		Mild Steel Square Tube 2 x 2	This steel is the main material of the scooter's frame and source of strength
3.		24 V 500 W DC Motor	A DC motor is an electronic circuit that uses a one-way source of electrical current to transform electrical energy into kinetic motion. Function of DC Motor (Direct Current) DC motor is an important circuit to be able to convert electrical current into kinetic energy. The DC motors used in this project are 24 V and 500 W.
4.		Brush Motor controller 24 V	Brushless DC motors (also known as BLDC motors or BL motors) are brushless DC motors that do not have brushes. The controller sends current pulses to the motor windings, which govern the synchronous motor's speed and torque.
5.		Sealed lead acid battery 12 V 7.2 Ah	Energy storage for electric scooters.
6.		Handle bar	The handle is used to control and balance the electric scooter.
7.		Straight Forks	The component of a bicycle that supports the front wheel is called a fork. The two blades of a fork are often linked at the top by the fork crown.
8.		Bicycle tires (12 inch)	Contact between scooter and road surface
9.		Front light	Helps the rider see further in front of them or clearer in dark places

10.		Side mirror	Observing objects both from sides and behind

Table 3 showed the full list of material that was used to fabricate this prototype. In total, ten raw material and device was used to develop the EZ Vroom not including small but important such as screw and electrical wire.

2.2 Cost Estimation

Table 4: Total cost EZ Vroom

Component	Quantity/unit	Price (RM)
Mild Steel Square Tube	4 / (1.5 x 2.0 x 78) inch	40.00
Mild Steel Plate	2 / (0.5 x 24 x 78) inch	20.00
24V 500W DC Motor	1	233.00
Sealed Lead Acid Battery	1	50.00
Straight Forks	1	15.00
Bicycle Tyre Tyre	2	40.00
Handle Bar (Zero Drag)	1	15.00
Front light	1	5.00
Backlight (For safety)	1	3.00
Signal light	2	5.00
Side mirror	2	8.00
Motor switch	1	5.00
Chain	1	11.00
	Total	450.00

The cost estimation to buy material and equipment is listed on **Table 4**. Bear in mind that the total cost is not reflecting the selling price of the EZ Vroom since it is not included the fabrication cost, overhead cost and profit margin.

From **Table 4**, it can be seen that the highest cost of the EZ Vroom is electric motor followed by battery. The electric motor play major role in this scooter hence the best in the class electric motor was chosen and not the lowest cost.

2.3 Fabrication Process

The fabrication of EZ Vroom, there are various types of tools or equipment used throughout the fabrication process.

Table 5: Tools and equipment used throughout the fabrication process

No.	Pictures	Tools	Description
1.		Welding machine	A welding machine is a device used to join materials together.
2.		Rivet Gun	Riveter are used to make high-strength joints in a range of materials, including metals, plastics, wood and leather.

3.		Drilling machine	A drilling machine and also hand drill is a powerful tool used to cut a round hole into or through metal, plastic, wood, or other solid materials through turning and advancing rotary drill bits into a workpiece.

Table 5: Tools and equipment used throughout the fabrication process (cont.)

No.	Pictures	Tools	Description
4.		Grinder	A grinder is generally used to precisely shape and finish the given materials with low surface roughness and high surface quality.
5.		Bending machine	A bending machine is a folding mechanism and its purpose is to assemble a bend on a workpiece.

Table 5 showed the tools and equipment that was used in to fabricate prototype of EZ Vroom. Among the tools are welding machine, bending machine and grinder. This equioment is a normal and standard tool inside a workshop. EZ Vroom does not involves sophisticated and complex manufacturing technique to fabricate it such as using CNC Machine, wire cut and et cetera.

2.4 EZ Vroom Component and Part Description

The component and parts of the EZ Vroom was carefully design with ergonomics in mind. The height of the handle is within reach of Asian men and woman. The switch on/off button is within reach using one hand operation. The full component and layout of the EZ Vroom showed in **Figure 1**.

Figure 1: Main component and layout of EZ Vroom

3. Results and Discussion

After the EZ Vroom was successfully fabricated, several tests run were conducted determine the capability of the EZ vroom in terms of speed, toughness, and endurance the EZ vroom can be used at a certain period of time.

3.1 Speed

To determine the velocity of the EZ vroom, tests were made on the EZ Vroom by finding the time required for a certain distance. There are 4 types of roads tested against the Ez vroom such as flat road, uneven road (pedestrian), hilly road, and grassy road as shown in the **Figure 2**.

(a): Flat road

(b): Univen road

(c): Hilly road

(d): Grassy road

Figure 2 (a-d): Testing of EZ Vroom at different road conditions

Table 6: Data to find the velocity for a distance of 20 m

Types of road	Average time required in 20 m (s)	Velocity for 20m (m/s)
Flat road	13	1.54
Uneven road	22.33	0.90
Hilly road	28.67	0.70
Grassy road	31	0.65

Tabel 6 showed the velocity of EZ Vroom in flat, uneven, hilly and grassy roads. It is shown that EZ Vroom velocity at flat road is is higher than in uneven road, hilly road and grassy road. The flat road is faster to EZ vroom moves because it has no obstacles and less friction while driving and the force pushing forward is slightly more than the other types of roads. Moreover, on every road traveled, we can see that on all these types of roads EZ Vroom can move best and even EZ Vroom is in stable condition and safe to use.

3.2 Toughness

The EZ Vroom toughness was also tested on grassy areas and on potholed roads. The condition of the electric scooter with regard to speed, physical condition, and rider conditions. In the observation, EZ Vroom is not suitable to move in the grass area because the grass will get stuck on the chain and stick to the smaller parts causing the scooter to move slowly and eventually stop.Next, the test run was conducted at a unevent surface where it will go through several potholed. In the test observations, there was a rubbing sound and bumps on the tires and chains.

3.3 Battery performance the EZ Vroom

The length of time EZ Vroom can be used is tested by charging the battery to full and then carrying EZ Vroom until EZ Vroom runs out of battery. EZ Vroom start time and maximum distance are calculated until EZ Vroom runs out of battery. So the result obtained is that the length of time EZ vroom can be used is 45 minutes which is 6 km. This suggests that students from residential colleges can ride EZ Vroom to get to campus. Furthermore, if the EZ Vroom runs out of battery, the battery needs to be recharged for 1 hour to recharge the battery so that the EZ Vroom can move automatically again. So, it can conclude that the efficiency of EZ Vroom is higher by 75% than the efficiency of electric scooters sold on the market which is 67%.

3.4 Environment and Sustainability

EZ Vroom is a product that provides sustainability to the environment. For example, EZ Vroom doesn't need fuel or gasoline to run it, instead, it uses an electric motor and a rechargeable battery. Furthermore, EZ Vroom does not emit smoke that can pollute the surrounding air and can even thin the ozone layer. Therefore, the use of EZ Vroom is strongly encouraged because it uses renewable materials.

In addition, the use of EZ Vroom can also reduce traffic congestion on the road. Therefore, EZ Vroom can speed up the students' journey to college and even make it to class on time. currently, when moving the EZ Vroom, the EZ vroom did not produce a loud noise during operation.

4. Conclusion

This project has successfully developed an electric scooter (EZ Vroom) which is targeted for the use of UTHM Pagoh students to go to campus from their residential college. Next, the EZ Vroom which can run for at least 45 minutes on a single charge and can move at least 45 km/h was developed. Furthermore, the EZ Vroom is very rugged and can go through various obstacles on the road but it cannot move on areas with high weeds alone.

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