CHAPTER -5

Project Designing

5.1 Design Considerations

Design considerations refer to some characteristics, which influence the design of the element or, perhaps the entire system. The strength of each element, its dimension and geometry are important design consideration from the mechanical point of view. As a transport for the physically disabled people the overall safety, stability, reliability, control, comforts etc are a very much important and taken in to consideration while de-signing it. However, the general points of consideration during the designing of the solar three-wheeler are: simplicity, strength, stability, safety, corrosion and wear, weight, size, flexibility, ease of control, modularity, efficient extraction of solar energy, effective use of solar energy and energy storage, all terrain tires for all terrain traffic ability/mobility, increased suspensions, biomechanics and comforts and cost.

Secondly factors that are considered for the fabrication of the wheel chair are weight or load, speed, width and height of the wheel chair. The body of the wheel chair is constructed to withstand a load of 80-100kg, including its self-weight and the speed is limited to 8-10 km/hrs for safety. The height and width of the chair are slightly modified from that of a conventional model. The solar frame is provided with an adjustable slot so that the height can be adjusted as required.

The transport idea concerned here is a solar power operated three-wheeler with light structure of moderate height-width and weight, which suits to Bangladeshi terrain. Also due emphasis is given to biomechanics, comforts, safety etc. while designing the seat for the solar three-wheeler. These features give greater stability, better maneuver ability, better mobility and comforts over the available manual three-wheelers. In a sense, a solar three-wheeler can be the complete solution for the transportation of physically disabled people of the country. Use of available resources (for components such as pipes for chassis/body, wheels, bearing etc. from the local market) and simplicity in designing result cost economy. This electric powered wheelchair is

essentially powered by electric motors located at the rear of the wheelchair. The motors run on batteries which can sometimes be a hassle for the user as it requires recharging through a wall outlet. Power ratings for electric wheelchair are around 2.5 to 6 amperes depending on the environment the wheelchair is used in. Batteries are available either in wet or gel cell, each having its pros and cons.

5.2 Design Phases

Designing of the solar three-wheeler has two major parts/aspects.

a. Designing the three-wheeler and it's components from mechanical and biomechanics point of view.
b. Incorporation of solar power system to the improved manual three-wheeler to achieve automation.
c. Effective use of limited solar energy (due to limited space/module), energy storage and power requirement (load) are also seriously considered to balance and optimize the solar power system of the solar three-wheeler.
d. Draw-backs of the available manual three-wheelers as well as needs and requirements from the disabled people (users) are seriously considered while making definite improvement in designing.

The overall designing of the solar three-wheeler is done through different phases as: recognition of the needs, definition of problem, synthesis, analysis and optimization, evaluation and presentation. Firstly, the demand or requirements from the disabled people are identified. Then the human requirements are translated to technical requirements, which include all the specifications or characteristics for the solar three-wheeler to be designed. Then the solar three-wheeler under design has been analyzed to whether it complies with specifications. Once complied, then it was optimized and leaded to a successful design. Sometimes, the analysis may reveal that the system is not an optimum one. In evaluation phase, testing of the solar three-wheeler is done and finally it is presented to others.

5.3 Design Flow Chart

The main concept is to build a control circuit that can store the solar energy and discharge the energy to the load. So the main elements that are necessary for this project are a solar cell which will convert the sunlight to electrical energy, a control circuit for different operations such as not overcharging or deep discharging the battery, a battery to store the solar energy and a motor which is connected to the vehicle wheel act as a load. There has some other functions of control circuit such as charging and discharging can be done simultaneously. The basic block diagram of the whole system is given below.

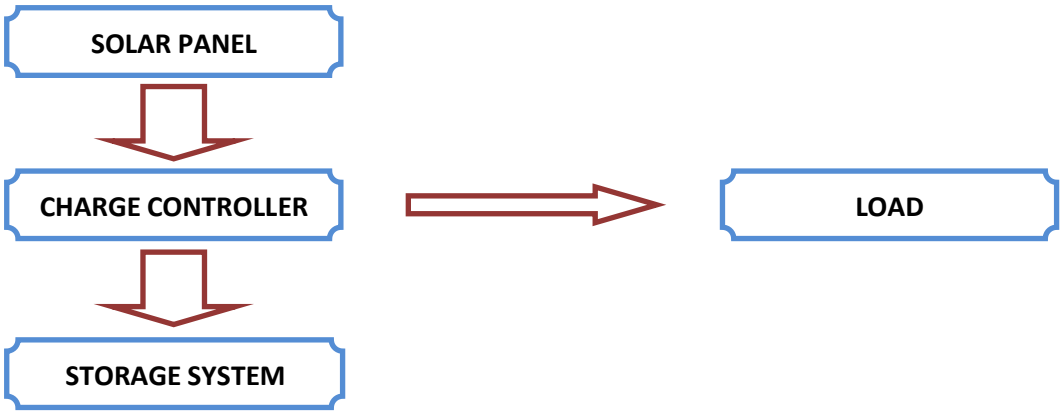

Figure 5.3.1 : Block Diagram of the System

The solar power system of the solar three-wheeler consists of solar panel (100W), MPPT solar charge controller, Lead-acid battery (12V-80Ahr.) etc. The typical solar power system is shown in Figure 5.2.

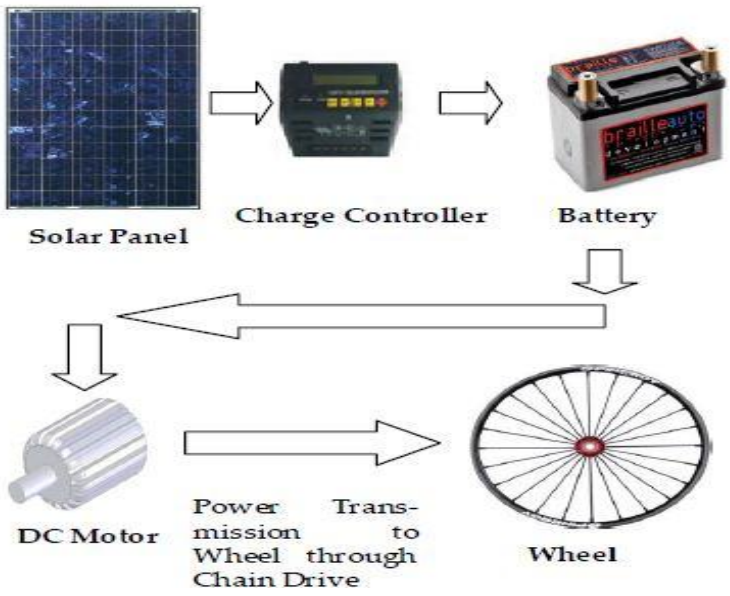

Figure 5.3.2 : Diagram of solar power system

5.4 Major Components

The main components of the solar three-wheeler are: Chas-sis/Frame, Wheels, Body, Seat, Solar panel mounting frame, Solar Panel, Charge controller, Battery, Motor, Chain, Steering System, Speed Controller, Break System, lights etc. The main features of the solar three-wheeler are:

- Automatic (solar powered) and environment friendly.
- A Standalone system- can be used at remote places where there is no electricity.
- Biomechanics- comfortable and suitable for the health of the disabled.
- Having better safety, stability, maneuverability and modularity in design.
- Suitable for Bangladeshi-terrain and having protection from sunshine, rain etc.
- Economic as no power cost and easy maintenance.

5.5 Selection of Wheel Chair and its Characteristics

The present work involves in design and fabrication of solar powered wheel chair. A motorized wheelchair, power chair, electric wheelchair or electric-powered wheelchair (EPW) is propelled by means of an electric motor rather than manual power. They can also be used not just by people with 'traditional' mobility impairments, but also by people with cardiovascular and fatigue based conditions. Power chairs are generally four-wheeled and non-folding, some folding designs exist and other designs have some ability to partially dismantle for transit. Manual wheelchairs are fitted with an auxiliary electric power system. This can take one of three forms: integrated with the hub of hand-propelled wheels, so that any force on the push rims is magnified by the drive system, or mounted under the wheelchair and controlled as for a power chair, but with the motive force either transmitted to the main wheels via a friction drive system, or delivered directly through an auxiliary drive wheel.

The electric motors of power chairs are usually powered by 4 or 5 amp deep-cycle rechargeable batteries, similar to those used to power outboard boat engines. These are available in wet or dry options. Dry-cell batteries are preferred for power chair due to shipping problems. Many power chairs carry an on-board charger which can be plugged into a standard wall outlet which is a hassle for the user. In order to overcome this disadvantage an alternative system is designed such that the batteries can be charged even without a wall outlet. Non-Conventional Energy Source is one best alternative.

5.5.1 Mechanical Design

The Chassis/Frame of the presently available three-wheeler is heavy and wheels are of big sizes. So while designing, unnecessary weight is reduced to meet the requirement. Comparatively smaller wheels are selected; keeping in mind that the weight of the solar three-wheeler should be as low as possible and must have required strength. The solar three-wheeler chassis is designed by using steel pipes reinforced with angle bars where necessary. The chassis can withstand necessary loads as well as absorbs shocks. The overall length and width are also reduced to some

extent. Finally, the chassis is made by steel pipes having 19 mm diameter with 2 mm thickness. Reinforcement in bends etc. is done by 19 mm×19 mm angle bars as necessary.

To avoid accidents and ensure safety, the sharp edges, bends etc. are rounded. Total weight of the loaded solar three-wheeler (with a person) will be 205 kg. Four iron pipes (Steel ASTM-A36) are to bear the load as frame/chassis and the maximum static deflection of the used pipes will around 0.66 mm, which is acceptable. Due to shock, these pipes will also deflect more and act as a shock absorber .Overall road condition including bumps, pot-holes etc. around the country is duly considered while choosing the wheel as well as it's size. All the three wheels are of equal size having the diameter of 40 cm each. All terrain tires are used for better traffic ability. The body of the solar three-wheeler is made of pipes, steel sheets of minimum possible thickness. Two leaf springs are added to the rear axle for better suspension. An adjustable waterproof cushioned seat is attached with the chassis. The solar panel is set on the top (over head) with panel mounting frame made of light steel pipes duly attached to the main frame/chassis. While modeling; sharp edges, bends, nails are avoided to avoid accidents and ensure better safety. The basic size and dimensions of the solar three-wheeler are set to: Length: 132 cm, Width: 86 cm, Height: 137 cm with the ground clearance of 18 cm at the front and 15 cm at the rear.

A normal handle bar decorated with brake lever, accelerator, switches, led head light etc. are attached with front wheel is used here as steering. The speed of the solar three-wheeler is controlled by accelerator through continuous change in voltage by a twist throttle. Due to voltage change the motor power also changes and thereby speed is controlled by increasing or decreasing the voltage. Normal friction type braking system (as used in bi-cycle) is used in front as well as in rear-left wheel of this solar three-wheeler for better safety. The hand liver attached with handle/steering is used to actuate the brake. One headlight, indicator light attached to the solar three-wheeler, which get power from the battery. High-grade wires are used to make necessary circuits/wirings for electrical system of the solar three-wheeler.

5.5.2 Main Frame

This is the skeleton of the wheel chair. This carries entire load of the person using the chair. This is made up of hollow cast iron rods of 35mm diameter. The rods are cut into different lengths, and are arc welded so that it gains the strength to withstand the load as well as the capacity to resist the vibrations during the travel. The height of the frame is 105cm, width is 57cm, and seating area is 41X41 cm^2.

Figure 5.5.2.1 : Main frame (Front view)

Figure 5.5.2.2 : Main frame (Back view)

5.5.3 Wheels

These are called wheel hub motor, (also called wheel motor, wheel hub drive, hub motor or in-wheel motor) an electric motor that is incorporated into a hub of a wheel and drives directly.

Figure 5.5.3.1 : Front wheel

Figure 5.5.3.2 : Back wheel

Hub motor electromagnetic fields are supplied to the stationary windings of the motor. The outer part of the motor follows, or tries to follow, those fields, turning the attached wheel. A purported advantage of this design is that no additional transmission system is needed, increasing the efficiency of the drive system. The wheels used are alloy wheels with a diameter of 50 cm and a thickness of 7.5 cm. The capacity of the motor is 240 W and speed 500 rpm at no load.

5.5.4 Selection of Motor and its Characteristics

In considering the physical condition of a disabled person, over all terrain condition, safety etc., the speed of the solar three-wheeler is set to 6 km/hr or 100 m/min. This speed will ensure better stability as well as comfort for the user. Practically it is experienced and measured that the total force (F) required for moving the loaded solar three-wheeler on smooth road is almost 6kg. Here rear wheel diameter is 0.4 m; speed of the three-wheeler is 6 km/hr or 100 m/min. So, wheel rpm

and torque will be 80 rev./min and 12 N-m respectively. Finally required power is 134W. If power loss due to chain drive is 10% then desired power requirement for driving the solar three-wheeler will be around 149 W.

The prime mover to be used in this solar three-wheeler is a permanent magnet D.C. motor. The main reason for using this motor is that it is highly efficient and the flux density does not decrease with time. It's performance characteristics suite very well to the requirement of our solar three-wheeler. At standard load condition, the motor needs 149Watts. This power will cover the required power needed to run the solar three-wheeler at a speed of 6 km/hr. If the load increases or the three-wheeler climbs up-ward slope, then the current will also increase and power output of the motor will also increase. However, considering standard power requirement and the safety, the designed motor power capacity is set to 200 W.

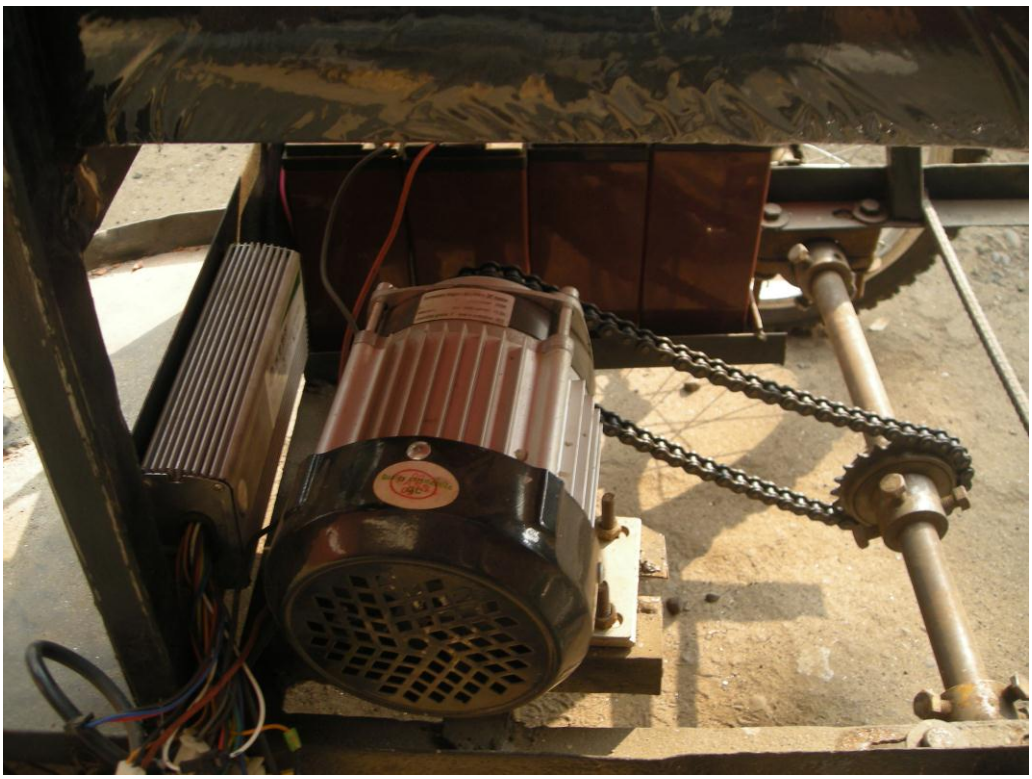

Figure 5. 5. 4 : a. Motor

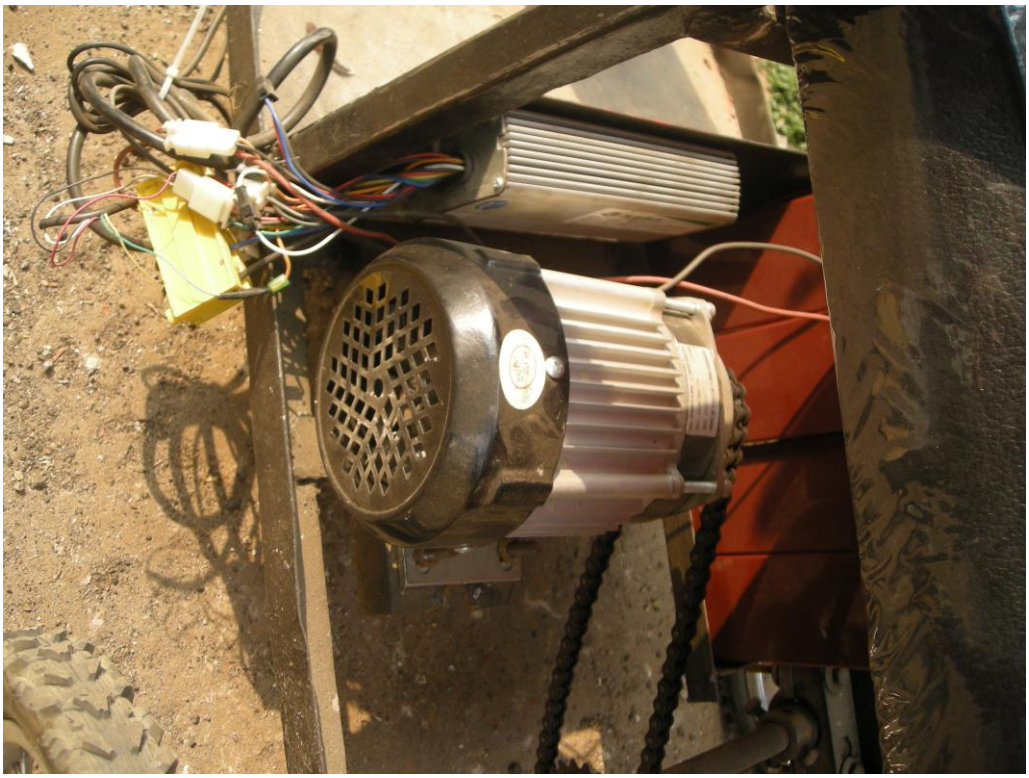

Figure 5.5.4:b. Motor with Control Unit

5. 5. 5 Selection of Battery and its Characteristics

To charge a battery, the charging voltage must be higher than the battery voltage or at least equal. As per the motor power requirement, a 12 V- 80 A-hr. lead acid battery is very much feasible for the solar three-wheeler. “Trickle charging” (charging in low amps, 2 to 10 amps) is always better for any battery charging; it increases battery life and decreases electricity pilferage. Here, the charge controller will charge the battery at around 16.2 volts and 6 amps. A full day of sunlight (6 hours) will charge it fully if it’s not fully discharged when hooked up.

Figure 5. 5.5: Battery

5. 5.6 Break System

For safety we used hand break like bicycle. This break cut off the motor connection as soon as the break is pressed. There by it stops the wheel chair even the pickup is twisted more. As soon as the break is relised the motor get connected again.

Figure 5. 5.6: Break system

5. 5.7 Charge Indicator

We used a charge indicator at the front with the handle which indicates the presence of charge. There are four lights which indicate the presence of 100% charge. Each light represent 25% of the charge.

Figure 5. 5.7: Charge Indicator

5. 5. 8 Control unit

We used a control unit to get the power from the motor and regulate the system of the wheelchair. It also converts the motor from 500w to 250 w when need and vice versa directly.

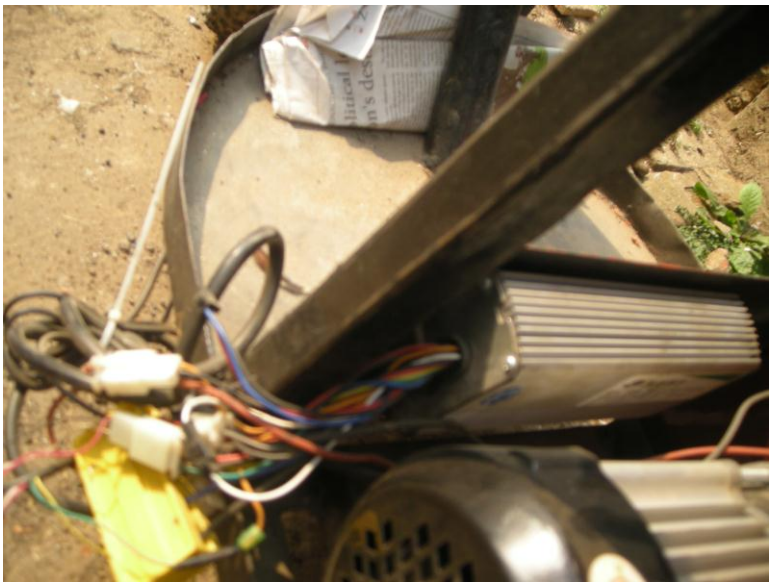

Figure 5.5.8 : a. Control Unit

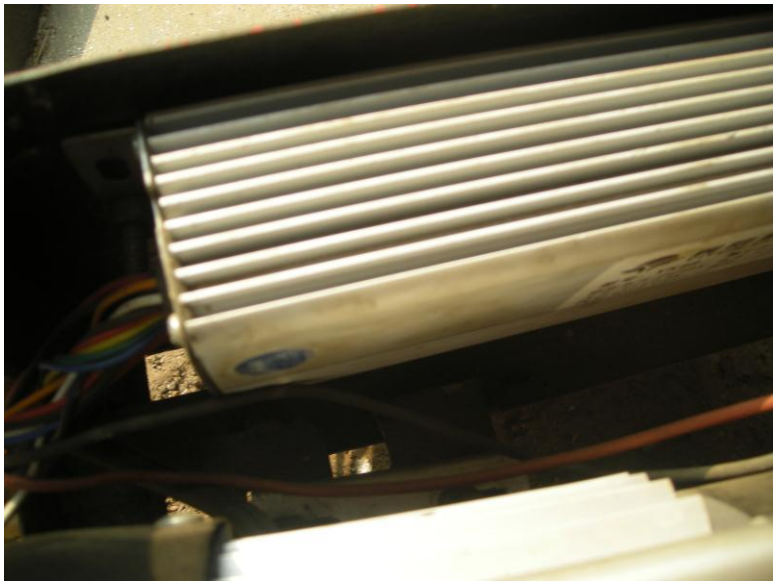

Figure 5. 5. 8: b. Motor with Control Unit

5. 5.9 Pickup

We used the pickup similar to motorbike which disconnected as soon as the break is pressed.

Figure 5. 5.9: Pickup

5. 5.10 Head light

For driving at night we fixed LED at the front with the handle.

Figure 5. 5.10: Head light

5.5.11 Horn

We fixed a horn for safety with the pickup.

Figure 5.5.11: Horn

5.5.12 Solar panel

We used two solar panels. Each of these having 12 volt and 60 watt.

Figure 5.5.12: Solar panel

5.5.13 Charge Controller

We used a charge controller to charge the battery through solar panel.

Figure 5.5.13: Charge controller

5.5.14 DC-DC converter

We used a DC-DC converter to convert 24v of the solar panel into 48v. The need for that showed below:

Battery Capacity=30A/hr.

Required Current Rating=3A.

So it runs, 30/3=10hrs

Battery Voltage=12(each).

Four Battery are used in series.

So, Total Battery Voltage=(12*4=48v).

We have two panels,

Each= 60 watt, 12v, 3.75A

So, two panels provides: 120watt, 24v and 3.75A

But our battery voltage is 48v

So, we need to convert panel voltage from 24v to 48v to keep tranquility with (48v) battery voltage. A DC to DC converter converts 24v into 48v.

Table 5.1: Major specifications of the proposed solar three-wheeler

Serial	Item (each)	Quantity
Battery		
1	Volt (v)	12 v
2	Current Rating	30A/hr
3	Weight	7 kg
Motor		
1	Volt (v)	48v
2	Power (w)	250/500 w
3	Current (for 250)	Max 5.6 amp
		Average 2.9 amp
4	Current (for 500)	Max 13.5 amp

Control Unit

1	Volt (v)	42 ± 0.5 (AC) 48 (DC)
2	Power (w)	500

Solar cell

1	Volt (v)	12
2	Power (w)	60

Charge Controller

1	Volt (v)	48
2	Current (amp)	

Wheel

1	Diameter (inch)	Outer : 15” Inner :10.6”
2	Width (inch)	1.8”
3	Radius (inch)	Outer : 7.5” Inner : 5.3”

Ground Clearance

1	18 cm Maximum
2	15 cm Minimum

5.6 Complete Project Picture

Figure 5.6.1: Front view of the wheel chair

Figure 5.6.2 : Side view of the wheel chair

Figure 5.6.3 : Back view of the wheel chair