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# DESIGN AND FABRICATION OF A MOTORIZED TRICYCLE FOR DISABLED

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## ABSTRACT
Mobility remains a significant challenge for physically disabled individuals, particularly in environments where conventional assistive devices such as wheelchairs and manually operated tricycles are inefficient or physically demanding. Manual tricycles commonly require substantial upper body effort, leading to fatigue and limited accessibility, especially on uneven terrains. This study presents the design and fabrication of a motorized electric tricycle aimed at reducing physical stress while improving mobility, comfort, and independence, with the integration of a dynamo system for on-motion battery charging to enhance energy efficiency. A design-based engineering approach was adopted, involving conceptual design, material selection, system integration, and fabrication using locally available materials. The tricycle was constructed with a mild steel frame and powered by a 24 V DC motor system. Key components include a battery, dynamo, speed controller, chain-sprocket drive, and mechanical braking system. Design calculations were performed for power requirements, shaft dimensions, torque, and chain drive parameters to ensure structural integrity and functional performance. Fabrication processes included welding, drilling, machining, and assembly, followed by performance testing under practical loading conditions. Results indicate that the tricycle operates efficiently with a power requirement of approximately 326–400 W and can carry a load of about 140 kg. The dynamo system was capable of recharging the battery within approximately 2 hours during motion, thereby extending operational usability. The tricycle exhibited low rolling resistance of about 5.9 N, contributing to improved efficiency and ease of movement, while also enhancing user comfort and reducing physical strain. In conclusion, the developed motorized electric tricycle provides a reliable, cost-effective, and energy-efficient mobility solution for physically disabled individuals. The integration of a dynamo-based charging system offers a sustainable approach to energy management, reducing reliance on external charging sources and making the system suitable for deployment in resource-constrained environments.

**KEYWORDS:**
Electric Tricycle, Assistive Mobility, Disabled Persons, Motorized Tricycle, Affordable Transportation

## 1.0 INTRODUCTION
Mobility remains a fundamental requirement for human independence, yet it continues to pose significant challenges for physically disabled individuals across the world. Persons with disabilities often rely on assistive devices such as wheelchairs, crutches, prosthetic limbs, and manually operated tricycles for daily movement. However, these conventional mobility aids are frequently limited in functionality, especially when used in rural or uneven terrains where accessibility and maneuverability become major concerns (Dwivedi et al., 2023). In many developing regions, including Nigeria, manually operated tricycles are widely used but demand considerable physical effort, thereby increasing fatigue and limiting mobility for users with reduced upper body strength.

The growing need for improved assistive mobility systems has driven research toward the development of motorized and electric tricycles tailored for disabled users. Electric tricycles provide enhanced mobility by integrating electric propulsion systems powered by rechargeable batteries, thereby reducing the physical strain associated with manual propulsion (Rathee et al., 2024). These systems not only improve accessibility but also offer increased travel range, efficiency, and convenience. For instance, studies have demonstrated that electric tricycles can achieve moderate speeds and maintain stability under controlled conditions, making them suitable for both urban and semi-urban transportation (Dwivedi et al., 2023).

Despite these advancements, several challenges persist in the design and implementation of motorized tricycles for disabled persons. Conventional designs often lack ergonomic suitability, affordability, and adaptability to different user needs, especially in low-income regions where imported assistive technologies are expensive and

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difficult to maintain (Botre et al., 2025). Furthermore, issues related to safety and stability, particularly at higher speeds or during cornering, remain critical concerns. Research has shown that tricycles are inherently prone to instability due to their three-wheel configuration, and improper weight distribution or narrow dimensions can significantly affect handling and rollover resistance (Shih-Che & Yao-San, 2024). In addition, many existing designs still depend heavily on external charging infrastructure, which may not be readily available in rural or underserved areas. This has led to increased interest in integrating alternative energy sources such as solar panels and onboard energy recovery systems. Solar-powered tricycles and hybrid charging systems have been explored as sustainable solutions that reduce dependence on fossil fuels and external electricity sources while enhancing operational efficiency (Hadiningrat et al., 2024; Nuriyah & Hadiningrat, n.d.). Similarly, the integration of dynamo-based charging mechanisms offers a practical approach to replenishing battery energy during motion, thereby extending the vehicle's operational range and reliability.

From a design perspective, modern tricycle development emphasizes user-centered approaches that combine mechanical efficiency, electrical integration, and safety considerations. Features such as Brushless DC (BLDC) motors, battery management systems (BMS), real-time monitoring, and improved structural configurations have been incorporated to enhance performance, durability, and user comfort (Botre et al., 2025). Additionally, innovations in frame design, suspension systems, and weight distribution have been shown to significantly improve stability and ride quality, making tricycles safer and more adaptable to diverse terrains (Shih-Che & Yao-San, 2024).

Given these considerations, there remains a clear need for a cost-effective, reliable, and energy-efficient motorized tricycle specifically designed to meet the mobility needs of disabled individuals, particularly in developing regions. This study therefore focuses on the design and fabrication of a motorized electric tricycle for disabled persons, with emphasis on reducing physical stress, improving mobility, and enhancing energy efficiency through the integration of a dynamo-based charging system. The proposed design aims to provide a sustainable and user-friendly mobility solution that addresses existing limitations while promoting independence and improved quality of life for persons with disabilities.

## 2.0 MATERIALS AND METHODS

### 2.1 Design Concept

The electrical Tricycle is designed with a single seat three wheeled vehicle. The cranking mechanism is on one of the rear wheel axle. The rear wheels are held on two different axles. The bearing housing of the rear axles are welded to the frame. The entire frame is made of mild steel square tube. Some other objectives of the project work include:

1) To provide sustainable green mobility vehicle
2) To reduce noise and environmental pollution
3) To provide and alternative of IC engine two wheelers
4) To provide most comfortable, safe and easy transport mode for all age group
5) To provide option instead of wheel chair to the production vehicle to handicap people with having disabilities in legs

Electrical energy usage for vehicle is been selected as it is non-polluted energy source for vehicle.

### 2.2 Machine/System Component

#### *2.2.1 List of components*

1) Battery
2) D.C Motor
3) Dynamo
4) Chassis
5) Speed controller
6) wheels
7) Seat
8) Chain
9) Sprocket
10) Brake mechanism

#### *2.2.2 Design Theory*

Keyserling *et al.* (2016) showed that trunk flexion, lateral bending that twisting increases muscular stress and in vertebral disc pressure, while long hours of sitting leads to increase risk of back pain and muscular fatigue, an

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adjustable seat was provided. Proper care was taken to ensure the comfortability not to worsen the condition of the disabled person.

Disabled persons are faced with the task of climbing high terrain or accelerating down it. This is actually due to the step-up drive of the tricycle since greater torque is required during hill climbing (Dreyfuss 2016). To alleviate this problem a chain sprocket drive has been included in the design so as to achieve a better torque. Some of the component parts of the tricycle are: chains, battery, wheel, seat, dc motor, sprocket and chain assembly, shaft, and brakes.

***2.2.2.1 Battery***

A system which converts chemical energy into electrical energy More correctly, a battery is an electrochemical cell: Galvanic Cells convert the energy from spontaneous chemical reactions into electricity Electrolytic Cells use electricity to drive non-spontaneous chemical reactions All galvanic cells produce electricity from reactions which involve the transfer of electrons from one species to another There are two components to each cell the species donating the electrons, and the species accepting them We write half reactions‖ to represent these two components, and to explicitly show the transfer of electrons The oxidation half-reaction shows the species which is donating electrons The reduction half-reaction show the species which is receiving electrons battery capacity determination includes:

1) Stall current is 35 amps (tested)
2) Current at top speed is 8.3 amps (tested)
3) Estimating average current from testing in typical start/stop use to be 15 amps
4) Assume average speed of 4 mi/hr
5) Objective requires 8 mile range

The battery capacity can be calculated using equation (3.1)

$$\text{Capacity} = \text{average current } x \text{ run time} \qquad \ldots(3.1)$$

$$\text{Capacity} = 15 \text{ amps } ({}^{8mi}/_{4mi/hr})$$

$$\text{Capacity} = 30 \text{ Ah}$$

We selected a 98 Ah, 12V, sealed lead-acid battery that can be obtained locally.

***2.2.2.2 Mechanical braking***

This is a rim brake in which friction pads are compressed against the wheel rims, hand operated brake lever, force is applied to brake levers mounted on the steering wheel, and transmitted via Bowden cables, which apply pressure to the braking surface, causing friction which slows the bicycle down.

***2.2.2.3 Speed controller***

Electric tricycles already do exist with different control systems. The purpose of the control systems is to act as an On/Off switch and as a speed controller. Our system Consists of a 24VDC (2 X 12VDC) battery and a 24V brushed DC motor. One switch operated the motor at a slow speed, running current through a power resistor, and the second resistor shorted out the resistor, giving full speed. Knowing the voltage and current we wanted to limit in slow speed, a value for resistance was calculated using Ohms law.

Ohms Law states V = IR, therefore, $R = \frac{V}{I}$ , where V = Voltage, I = Current, R = Resistance.

***2.2.2.4 Chassis/Motor mount***

The motor mount was designed and made using materials that we know are available, square steel tubing and angle iron. Two pieces of angle iron are welded to section of cylindrical steel tubing. Two other sections of cylindrical steel tubing are used as spacers between the tricycle frame and the motor mount to position the motor to align with the jackshaft sprocket. The motor mount is bolted to the frame, making installation easily reversible.

***2.2.2.5 DC motor***

The Motor power can be determined by Equation (3.2)

$$P = F\,x\,v \qquad \ldots(3.2)$$

$$P = (22ib)(7mi/h)(5280ft/mi)(1h/3600s)14$$

*P = 257 ft-lb/s = 0.47 hp = 351 Watts*

P: Motor power

F: Rolling resistance force = μr*N; μr is coefficient of rolling resistance; N is weight of tricycle and rider with batteries. F was measured with a force scale pulling the tricycle at a set velocity, and was confirmed by doing deceleration tests.

V: Desired velocity of tricycle

Assuming a transmission efficiency of 80%, our power requirement comes out to be 600W*0.8 = 480W. A slightly larger motor than is necessary was chosen to improve reliability by not running the motor at maximum

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power all the time. We selected a Currie Technologies 600W, 24VDC, 2600 rpm, brushed electric motor to provide more than adequate power.

***2.2.2.6 Motor torque determination***

Testing done on a 10% (5.7°) grade using torque wrench on hand crank axle:
Front axle torque = *26 lb-ft = 312 lb-in = 35.5 N-m*
Rear axle torque = *34 lb-ft = 406 lb-in = 46.2 N-m*
Required gear ratio > rear axle torque / motor stall torque
Motor stall torque = 4 *x* P/? ; P is motor power,? is motor free speed in rad/s
Motor stall torque = 78 lb-in

***2.2.2.7 Wheel***

The wheel of a tricycle is show in the figure below


***Figure 3.1 wheel of a tricycle***

As in the generic definition, a rod that serves to attach a wheel to a bicycle and provides support for bearings on which the wheel rotates. Also sometimes used to describe suspension component. Quick release- a lever and skewer that pass through a hollow axle designed to allow for installation and removal of the wheel without any tools. Nut - the axle is threaded and protrudes past the sides of the fork/frame. Bolt - the axle has a hole with threads cut into it and a bolt can be screwed into those threads. Thru axle - a long axle, typically 20 mm (110 mm width), [they can be 9 mm (100.33 mm width) in diameter for durability], onto which the fork/frame clamps.

***3.2.2 Design of Calculation***

***3.2.2.1 Shaft design***

Table 3.1: Shaft design

| s/n | Initial | Formula/calculation | Results |
|---|---|---|---|
| 1. | Torque=?<br>Power = 100w<br>N=150pm | Torque = $\frac{Px60}{2\pi N}$ | Torque = 6.4 |
| 2. | Diameter of Shaft d =?<br>Torque T = 6.4<br>Shear stress = | D=$\sqrt[3]{\frac{16T}{\pi\tau}}$ =$\sqrt[3]{\frac{16x6.4}{\pi x500}}$ = 0.04m= | D = 4cm =40 mm |
| 3. | Length of Shaft | As specified in the design of frame | L=0.8 |
| 4. | Length of Shaft | As specified in the design of frame | L=0.8 |

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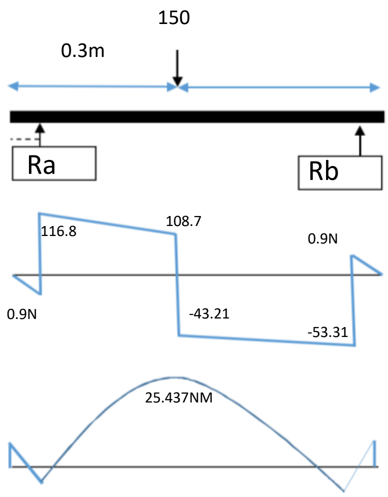
| | | | |
|---|---|---|---|
| 5. | Shear force and bending moment |  | Maximum shear Force = 116.89<br>Maximum bending Moment= 25.437Nm<br>Maximum deflection =<br>3.83/E1 |

***3.2.2.2 Chain Driver Design***

Department on the speed requirement output shaft is carry a sprocket with 12 teeth.

Velocity ratio 1:3

Table 3.2: Chain driver design

| S/N | Initial | Formula/calculations | Result |
|---|---|---|---|
| 1. | No. of teeth of bigger sprocket<br>$T_2$<br>$T_1 = 12$<br>$N_1 = 3$<br>$N_2$ | $T_2 = T_1 x N_1$ —<br>$N_2$<br>$N_1$ —<br>$T_2 = K_2 15 x N_2$ | T2 = 36<br>Due to availability And cost a sprocket With 46 number of teeth selected |
| 2. | Service factor<br>$k_1$<br>$k_2$<br>$k_3$ | $k_s = k_1$<br>$k_s = k_2$ | $K_s = 1.875$ |
| 3. | Design Power Rated power Service factor<br>$k_s = 1.875$ | Design power = Rated power x 1.875<br>100 x 1.875 | Design Power = 187.5<br><br>0.1875kw |

From catalogue (Indian standard- IS: 2403-1991) the following specification is selected Chain type: roller with link type

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P = 100wD =4mm$W_B$ = 2890$w$
CHAIN DRIVE DESIGN CALCULATION TABLE

| S/N | PARAMETERS | FORMULA/CALCULATION | RESULTS |
|---|---|---|---|
| 1 | Pitch Diameter of smaller sprocket $d_1$<br>Pitch p = 1.2 ( pitch P=1.2cm,<br>Teeth $T_1$ = 60 ) | $d = p\ \text{csch}\left(\frac{180}{T_1}\right)$<br>$d = 1.2\ \text{csch}\left(\frac{180}{60}\right)$ | $d_1$ =6cm |
| 2 | Pitch Diameter of smaller sprocket<br>$d_2$ Pitch p=1.5 | $d_2 = p\ \text{csch}\left(\frac{180}{T_2}\right)$<br>$d_2 = 1.5\ \text{csch}\left(\frac{180}{36}\right)$ | $d_2 = 8.61\text{cm}$ |
| 3 | Line Velocity of smaller sprokect<br>$V_1$ | $V_1 = \frac{\pi + d_1 + N_1}{60}$<br>$V_1 = \frac{\pi \times 6 \times 100}{60}$ | $V_1 = 31.46\text{cm/s}$ |
| 4 | Load on Chain W<br>*Rated power* | $W = \frac{rated\ power}{pitch\ line\ velocity}$ | Depends on rated power |
| 5 | *Pitch line velocity* | V = $\frac{100}{2.9}$ | V= 34.38 cm/s |

Compared the value x from standard table and take the appropriate value.
Table 3.4: Chain drive design (continue)

| S/N | INITIAL | FORMULA/CALCULATIONS | RESULTS |
|---|---|---|---|
| 9 | Center distance between sprocket C<br>Pitch p = | $C$ = y x p<br>$C$ = 38 x 1.2 | $x$ = 45.6cm |
| 10 | Early sag correct distance | Correct distance = (c – x)<br>(45.6 – 5) | Correct distance = 40.6cm- |

### *3.4.2 Manufacturing Process*

The first stage of the manufacturing is the proper selection of materials which suits the requirement of the project. Different materials were selected based on the design specification and requirements. The following were considered for the selection of the materials.

#### *3.4.2.1 Cost of the materials*

The cost of the materials serves as one of the most important factor in the manufacturing process the project was constructed using locally available materials.

#### *3.4.2.2 Availability of Materials*

Volume-10 Issue 05, May -2026 ISSN: 2456-9348
Impact Factor: 8.232

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The availability of material is also an important factor in the manufacturing process; because the manufacturing processes require a lot of links (components) interrelated to give the required motion. The project aimed at using locally available materials.

***3.4.2.3 Suitability***

The project aimed at designing and fabricating the tricycle to suit the Environmental and Economic factors.

***3.4.4.4 List of materials***

Materials used for constructing the electric tricycle are cylindrical pipes, plywood, bicycle headset, metal sheet, bolt and nuts, chain, sprocket, tires, dynamo, battery, speed controller.

***34.4.5 Construction of the Tricycle***

The objective of the construction of the chassis of the electric tricycle was achieved with appropriate compliance with the design results in this chapter of the report. Materials for the chassis were acquired promptly after the design speculations.

Machine and hand tools used for the fabrication are electrical arc welding machine for metal forming operations, bolting and riveting machine for joining metals, drilling machine for making holes, grinding machines for surface finishing, metal cuttings processes by metal cutting machine and hack saws, bending machine for metal deformations. Others include harmers, spanners, pliers e.t.c.

***3.4.4.6 Construction Processes***

The following construction processes was used during this project, welding process, drilling process, riveting process, machine tools operations was also used.

***3.4.4.7 Assembly***

The machine construction was completed by jointing all the previous machined components together using the four types of assembly

i. Bolting (Temporary Joint)
ii, Welding (Pavement Joint)
iii. Force or tight fitting (Temporary Joint)
iv. Clearance fitting (temporary Joint)

***3.4.4.7.1 Bolting***

This temporary joint was used in area where in due operational life of the machine may require any form of servicing.

***3.4.4.7.2 Welding***

This permanent type of joint was used in areas that will require any serving. This include the frame, the motor mount housing, the chassis.

***3.4.4.7.3 Force or Tight Fitting***

This type of temporary joint was used mainly in the following area of the machine.

i. All the bearing were force fitted into their bearing housing using table clamp
ii. All the shafts were also force-fitted into the bearing holes to allow receptive motion only between the shaft and the inner hole of the bearing.
iii. All sprocket were force fitted into the shaft
iv. The shaft will also tight-fitted into the motor socket

***3.4.4.7.4 Finishing***

In order to give a fair industrial finishing applied in the construction of this machine are mainly the surface clearing using an Iron brush and finally painting to protect the machine part from corrosive reaction with the environmental.

***3.3 Performance Testing***

Tricycle Weight = 40kg
Individual's Weight = 100kg (Approx.)
Add up to Weight = 40+100=140 Kg
Ordinary response on each wheel = Weight of Tricycle/Number of Wheels = 40/3 = 13.33 Kg
Power Requirement = 326W
Battery Voltage = 24 V (12 Volts, 2 Nos.)
Power = V × I
$I = \frac{P}{V} = \frac{326}{24} = 13.58$ Ah
A.C. Adapter = 12V, 12A
Add up to Time required for finish battery charging

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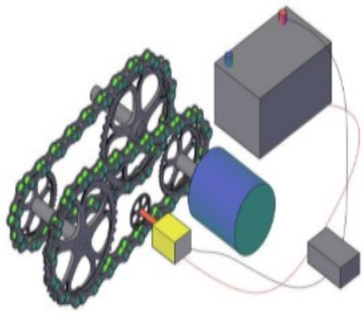
$P = V \times I = 12 \times 12 = 144$ W

Time $= \frac{288}{144} = 2$ Hrs.

*Figure 4.1 Tricycle*

#### *4.1.1.2 Isometric drawing*

The isometric drawing of the drive is shown in figure 4.2



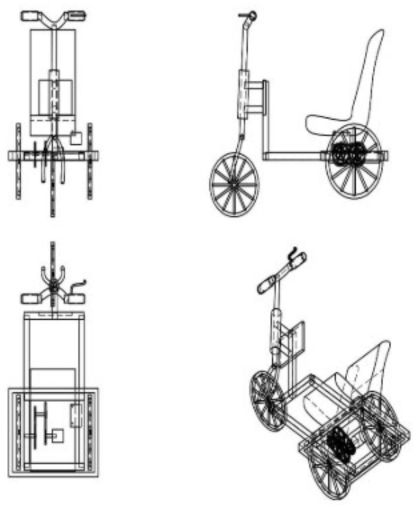


*Figure 4.3 tricycle orthographic projection*

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### 4.2 Discussion of Results

The results obtained from the performance evaluation of the motorized electric tricycle indicate that the designed system is capable of providing reliable and efficient mobility support for disabled persons. The charging analysis revealed that the battery can be replenished within approximately 2 hours while the tricycle is in motion through the integrated dynamo charging system, thereby improving energy sustainability and extending operational time. The tricycle requires approximately 400 W of power for effective operation, which demonstrates that the selected DC motor and powertrain configuration are adequate for the intended application.

Furthermore, the throttle voltage was observed to be 0 V at idle condition, while the braking voltage reached 12 V during braking operation, confirming the effective functionality of the control and braking systems. The tricycle was also found to have an estimated load-carrying capacity of about 140 kg, indicating its suitability for accommodating users and light loads under normal operating conditions. In addition, the calculated total resistance force of 5.90016 N on a flat road surface suggests low rolling resistance and smooth motion characteristics, which contribute to improved efficiency and reduced power losses during operation. Overall, the results demonstrate that the developed electric tricycle is functional, energy-efficient, sustainable, and suitable as an assistive transportation system for physically challenged individuals.

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