Certificate

This is to certify that the ***Mr. Khan Saad Sameer, Mr. Khan Zishan Sultan, Mr. Shaikh Aman Mohd. Iliyas, Mr. Shaikh Hamza Shakeel*** from the Mechanical Engineering Department (Aided) of the Institute ***M. H. Saboo Siddik Polytechnic**, Byculla* having Enrollment No: ***1700020304, 1700020302, 1700020320, 1700020318 respectively,*** has successfully completed the **Report on the Problem Definition** having title ***Design and Fabrication of Tilting Trike using Parallel Four Bar Mechanism*** in a group consisting of ***04/Four*** persons under the guidance of the Faculty Guide **D.K. Ibrahim Sir.**

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(Mentor from the Industry)

ABSTRACT

Motorised and unmotorised tilting trikes are a relatively new transport development. This paper focuses on unmotorised tilting recumbent trikes (tilters). They are part of the family of recumbent cycles which can have lower wind resistance and travel faster for the same effort than more conventional cycles.

The paper finds that tilting trikes inherit leaning and dynamic stability characteristics from bicycles and the potential for static stability from trikes. Tilting removes the need for a trike to be wide and low to stay stable during cornering. This can make the trikes more visible and acceptable from a car driver's perspective compared to a standard, low recumbent trike.

High-end tilting trikes can have hybrid (human / electric) drives and meet the need for comfortable, sheltered vehicles capable of taking luggage on long commutes. These expensive high end tilters are not widely available in Australia. Less complex tilters can be better-than-bicycle practical vehicles with features such as stability when stopped, integrated luggage capacity, ease of starting and improved aerodynamics.

This paper aims to fill a knowledge gap concerning tilting trikes' advantages, disadvantages, likely cultural acceptance, motion physics and potential to modernise the fleet of pedalled transport vehicles. Examples are discussed and a new, simple design is introduced.

CONTENT PAGE

CHAPTER 01: INTRODUCTION

1.1 General Introduction

As city commutes by car become longer due to suburban sprawl, alternative-vehicle travel is becoming increasingly appealing. One recent Melbourne commuter race recorded car travel times of 97 minutes for 27km. In the same race, a slower but less obstructed cyclist travelled between the same points in 67 minutes (Dow, 2014). In many instances, one person on a bicycle is an appropriate use of transport, adding negligible traffic congestion compared with one person in a four-person car.

Transport needs to be sustainable not just from a noble "use resources sparingly" point of view, but also from a practical, personal perspective and increased use of cycles could help. All sorts of cycles could be in abundant use, and these include recumbent cycles, cargo bikes, velomobiles and electric bikes. These comparatively new "improved cycles" include tilting trikes and can be "better-than-bicycle" with combinations of enhancements such as having extra power available, good aerodynamics, larger load capacity, extra stability when stopped, and added weather protection.

Taken as a whole, “improved cycles” could increase the number of days of cycle use (in wet weather), range of cycle use (distance travelled on commute), range of participants and range of cycle uses. (holidays, shopping, ferrying kids to school, social visits etc.) These sorts of trips could replace car journeys, resulting in reduced traffic congestion for all (Cox 2009, p. 37, Nelson 2010, p. 47). While tilting trikes exist in the motorised transport space, this article focuses on the small but growing category of unmotorised recumbent cycle, the Tilting Three Wheeler, Tilting Trike, Tilter, or Narrow Tilting Vehicle. For this article, “unmotorised cycles” includes those that have up to 250W of electric assistance in line with Australian bicycle laws.

1.1.1 TRIKE: A vehicle in which one wheel at the front and two wheel at the rear is generally called as a trike similarly vehicles with two wheels at the front and one wheel at the rear is called Reverse trike. But the reverse trike configuration provides more stability and safety where it is required the most.

1.1.2 LEAN: Everybody who rides a two wheeler leans. That is because a vehicle in a turn experiences inertia that is proportional to the momentum of the vehicle. This is very similar to the centrifugal effect that a body in a circular motion experiences i.e., the body in the circular motion tends to develop a centrifugal force pushing it outwards from the centre of the circular path, the force being proportional to the momentum of the body. Similarly, the vehicle in a turn experiences a centrifugal force which tends to push the vehicle away from the turn tangentially. When the biker turns the bike without any lean, the inward force due to friction, will create a torque at the bike's center of gravity, acting outwards the curve. This will cause the bike and the rider to tip over. When the biker leans inwards the curve, as he turns, there will be an inward torque due to gravity. This torque, depending on the angle of lean, will balance the outward torque created by the centrifugal force. As far as the biker balances the two torques throughout the curve, he will make a proper and stable turn.

CHAPTER 02: COMPARISON AND CULTURAL ACCEPTANCE

2.1 COMPARISONS

Compared to standard trikes, tilters have the option of a high yet narrow design. This means they can be visible in traffic yet able to travel on bike paths. Although static stability is optional (via a tilt lock), tilters will almost always have better stability when stopped than a standard bike (Karnop 2004, p. 147, Nurse 2009, p. 35). Tilters need to have a specific tilting mechanism, and designers need to pay attention to this as well as standard cycle considerations of suspension, aerodynamics, ergonomics and weight. Without careful attention to design, complexity and cost could overwhelm the ability of a manufacturer to make a high quality, profitable trike. Costs for tilting trikes will inevitably be higher than the cost of mass produced bicycles due to relative complexity and / or low production volumes. This applies equally for recumbent bikes, trikes and velomobiles. Cost is less relevant when one considers that the buyer will probably value the cycle for enabling exercise or commuting. For these buyers, prices comparable to an inexpensive second hand car may be tolerable.

The footprint or size of tilting trikes is another factor. Similar to cargo cycles, tilters can be longer, wider and heavier than bicycles. Users and designers would need to develop workarounds for parking them at home or in public places, or carrying them by car and on public transport, where accommodation is almost always designed for the bicycle.

2.2 CULTURAL ACCEPTANCE.

Recumbent cycles are available within broad categories of recumbent bikes, recumbent trikes and velomobiles. Tilters can now be added as a new category. Because tilters are so new, considering their cultural acceptance means looking at the acceptance of other styles of recumbents. The availability of recumbents has increased in recent years with online purchasing, good competition between manufacturers in Australia, Europe, America, Taiwan and China and a thriving second-hand market (OzHpv 2015).

On the other hand, recumbents receive little press coverage and are seldom observed on cycle shop floors or on the road. They are generally only understood by the devotee. Observations are that recumbent riders are mostly male, of a high average age and that some riders only come to them as the result of injury. There can be a negative perception of recumbents as an older person’s vehicle (Koeppel, 2006).

Negative perceptions can be overcome, however. The power assistance electric bikes offer is enabling for daily commuting without sweat over distances of 15 to 20 kilometres. A few years ago, dependence on recharging,

lack of purity compared to a bicycle without a motor, increased weight and use of toxic chemicals were all been cited as drawbacks for these cycles (Nelson 2010, p. 47, Burrows 2008, p. 208).
More recent articles (Acott 2015, Haberfield 2014) indicate electric bike sales are increasing and that they have reached widespread acceptance. Although it is out of scope to analyse this, the recent uptake of electric bikes indicates that with the right engaging products at the
right price at the right time, new styles of cycles can succeed in the market. Compared to an electric bike, recumbents and tilters can be deemed a purer, less motorised form of high functioning cycle and could be promoted as such.

Another fact of the Project can be seen in the Acceptance in an aid for the Handicaps using the Trikes for Transportation, This Tilting Trike gives them a variety of angle to tilt on.

CHAPTER 03: MOTION PHYSICS AND CONTROL

3.1 AERODYNAMICS AND GENERAL CHARACTERISTICS.

Recumbent cycles including tilters can have lower wind resistance and travel faster for the same energy input than more conventional cycles. They hold most records for cycling speed and distance travelled but were banned from UCI (Union Cycliste International, a cycling governing body) sanctioned cycle competitions in 1934, removing them from mainstream sports coverage (Kyle 2004 p. 146, Van De Walle 2004 p. 59). Their main feature is often aerodynamics but this does not preclude other practical features.

Specific events and advantages can be used to illustrate. Peter Heal holds the record for the fastest unsupported lap of Australia with 15000km covered in 48 days on a highly efficient recumbent bike with built in luggage space (Oakman 2014). Recumbent trikes offer static stability, allowing riders to go as slow as they like without losing balance. Many modern velomobiles were developed from the Dutch “Alleweder” machine which won a 1993 magazine sponsored “Year-round-cycling” HPV competition requiring weather protection, low maintenance, a high average speed for an hour and 15kgs of luggage carried in an 80 litre storage space (Nurse 2009, p. 35, Berchicci 2005, p. 135).

Commuting cycles can be compared with recumbents in quantitative terms using mathematical models. The scientific reason for the reduced effort when pedalling recumbents compared to other cycles is a reduction in the drag coefficient (Cd) and frontal area (A). Both are crucial elements of the equations governing cycle speed (Van De Walle 2004, p. 59). Drag coefficient and frontal area can be determined by wind tunnel testing, however for a particular cycle, estimates of these values can be made based on published tables (Gross 1983).

3.2 TILTING AND BALANCE.

Bikes require active balance to ride and are dynamically stable. In a straight line, the rider keeps the bike’s centre of gravity above the line between the two wheels by small steering inputs. Superimposed on this is leaning, i.e., keeping balanced when cornering by countering an outward centrifugal force with an inward gravitational force. The force on bike wheels is always close to 90 degrees to the wheel axis (Karnop 2004, p. 147).
Non leaning trikes are statically stable. They will tip when cornering shifts their centre of gravity outside of the “stability wedge” defined by the space above their

tyre contact points, but riders can forestall tipping by moving their centre of gravity, shifting body weight into the direction of a corner. Resultant forces on non-leaning trike wheels are not at 90 degrees to the wheel axis, and this increases the requirement for strength in trike wheels. For reasons of stability, non-tilting recumbent trikes are often low with a wide track, and their lack of height can make them hard to see in traffic.
Adding tilting to a trike can make it revert to bike-like handling, simplifying tight cornering and allowing a high, narrow vehicle to be dynamically stable.

3.3 STEERING, HANDLING AND GEOMETRY

The design of bicycles is mature. Riders and purchasers usually know how to ride and what to expect from the handling of racing bikes, mountain bikes and ladies-frame bikes. Recumbents and tilters are newer cycles, and customers require greater belief to accept them. Designers should make riding them as accessible as possible by taming and simplifying their ride characteristics.

Tilting human powered trikes can become intricate machines with elaborate engineering and mechanisms unless there is a “decoupling” of the various requirements for driving a wheel, steering, braking, tilting and suspension. The most complex set of these requirements is for a tadpole leaning trike, where the drive to the back wheel is straightforward, but tilting, reaction to camber, braking, Ackerman steering and reasonable suspension must all be resolved between two mechanically linked front wheels (See Figure 6 below). Riders “stand on the pedals” of bicycles as they traverse bumps, moving their body away from the seat, letting the tensed legs act as suspension. This can’t be done on a recumbent making suspension desirable, especially if there are small wheels or wheels right under the rider which promote jolting of the frame. Small wheels rise more quickly than large wheels over a given bump and due to a decreased lever distance, riders feel a greater proportion of the bumps traversed by wheels close to the body (Nurse 2009, pp. 9-11).

Most delta tilters use control which can be the same as bicycle tilting, while tadpole tilters use “lean to steer” like skateboard steering, or other manual control. The “Tripendo” tilting tadpole trike is described: “rider, frame and all three wheels lean in parallel by up to 26 degrees, and this is controlled by the right hand control lever”. (Davidson 1999, p. 101)

Trikes should have Ackerman steering geometry to ensure that wheels do not “fight each other” or scrub during cornering. This requires the lines perpendicular to the trike rims to be coincident whatever the steering angle (Nurse 2009, p. 39).

The phenomenon of braking a cycle affecting steering is called brake steer and it can be negated by having the steering axis or kingpin line of a trike wheel coincident with the tyre contact point, and similar principles apply to “bump steer”. These affects tadpole trikes only, most delta trikes have bike like steering where brake and bump steer is automatically cancelled. Superior leaning tadpole trikes have highly bespoke hub centre steering, which overcomes compromises in kingpin steering (Wineskin 2003).

CHAPTER 04: TECHNOLOGY REVIEW

This brief technology review gives examples of tilters which are on sale or have been developed and discusses the available information. This places the new "NV02" trike in context and should simplify further research. Motivations for building new styles of Tilter are not always commercial and range from wanting to win a race, to wanting to try a concept, to wanting to share a concept. Sharing of tilting trike related ideas on blogs, bulletin boards and on-line video sites is common and these are sources which researchers should not ignore. There seems to be no current production of tilting tadpoles without electric assist, possibly because they can be heavy, complex, less aerodynamic and are competing with simpler non-tilters. Manufacturers may struggle to sell these trikes at the high price required to offset costs. Simpler delta tilters are gradually coming into production, as are high-functioning, expensive electric assist machines.

4.1 TADPOLE TRIKES

In 1995, US patent 5762351 was filed for a tilting tadpole trike. This “Aileron” trike did not reach production. (Soohoo 1998) Several tadpole leaning trikes have followed to the “proposed manufacture stage”, and the dominant configuration for these is 2F3T. (see appendix 1) Amongst them are the German Tiefflieger (Kautt 2010) and FN trike (Fleiner 2011). Few trikes in this category reach full manufacture. The Tripendo is a notable exception, but even this trike was only made from 1999 to about 2010 (Davidson 1999, p. 101, recumbentblog.com, 2010).

4.2 DELTA TRIKES

Paul Sims who worked for Greenspeed in Australia designed and built a 1F3T front wheel drive tilter in 2000. This was an inspiration for a range of US and European designs of racing trikes including the John Morciglio fully faired tilter and the Munzo commercial lowracer (Sims 2000, jnyyz, 2012, Smit 2015). On the Sims trike, the back wheels stay parallel to the frame and tilt with it in corners, decoupling and simplifying many of the requirements for a tilter. It is a “virtual bike” with the rider experiencing bike-like handling.

Vi Vuong’s 2013 trikes are even simpler and work similarly way to Sims trikes, keeping the wheel’s parallel to the frame during a lean and providing a form of suspension. A pedal housing with cranks carries the set of two back wheels (Nurse 2013). Alexander Petraj from Greece and I have taken the Vuong design further by

building trikes using the same mechanism. In February 2015, Cruzbike company owners Jim and Maria Parker tested and raced a Cruzbike converted to a trike with a "Vuong trike adapter" (Vuong 2015, Parker 2015).
In 2015 Alan Page publicised the "Trivek" 1F1T tilter and is beginning manufacture in Perth, Western Australia. This trike uses "in and out", through the hub gearing which is functionally equivalent to a multigear Penny Farthing (Page 2015, Vittouris 2011, p. 13).

4.3 TRIKES WITH ELECTRIC ASSIST
The Drymer from the Netherlands is an expensive electric assist leaning tadpole recumbent trike costing from 5780 EU to 9000 EU in May 2015. It is a trike providing rain and wind protection sold in a cold climate. This adds real practical value to allow for low stress commuting in almost all weathers. It is possible the high cost of the Drymer can be absorbed because of perceived good value in a society that already values sustainable transport (Drymer 2015).

Canadian Georgie Georgiev is famous for building handcycles and record breaking speed bikes. His tilting trike has a 1F1T leaning Delta configuration, electric front wheel drive and a human powered rear wheel. The trike does not have weather protection but has many other requirements for a high end tilting trike including a simply accessible luggage storage area (Georgiev 2008).
The Velotilt is an experimental leaning Delta trike / velomobile and a high end fast machine aimed at making commutes at 40kph possible. The rear wheels are outside

the rider’s pod freeing up space for luggage. It is intended to be ridden fully enclosed but would seem to share some ergonomic issues with streamlined Velomobiles, i.e. getting in and out and accessing luggage could be difficult and a buildup of heat could cause issues. (Ruggiero 2015).

4.4 FURTHER READING

This survey covers only a few humans powered tilting trikes. Many more exist including upright / non-recumbent tilters. Outside of patents, there seems to be little public research on unmotorised tilters, however there are on-line sources of information. Henry Thomas has designed the Jetrike and lists trike patents on his website (Thomas 2007). Craig Cornelius has developed a set of criteria for light commuting vehicles (Cornelius 2015). Phillipe Girardi has designed motorised and unmotorised tilters and compiled tables of tilting trike patents (Girardi 2015). Peter Eland provides a guide to tadpole trike steering design for non tilters which can be supplemented by Rick Wianecki’s work on tilters (Eland 2015, Wianecki 2003). Lastly, a video compilation provides links to a large number of videos (tilting vehicles 2015).

There is a large body of public research and patents concerning motorised tilters. This research supports manufactured models such as the Piaggio MP3 and Toyota I-Road. These machines have complex tilting and “tilt lock to stay upright” systems controlled by electronics and actuated by hydraulics. Tilting and lockout can respond to manual switching and inputs from speed, road camber, engine rpm, and tilt angle (Karnop 2004, p147).

Online literature searches using terms “Tilting three wheelers” and “Narrow tilting vehicle” yield technical articles and patents on motorised trikes. “Leaning OR tilting AND "recumbent trike" OR "recumbent tricycle”” leads to unmotorised trikes where the majority of results are patent applications.

CHAPTER 05: PROPOSED DETAILED METHODOLOGY OF SOLVING THE IDENTIFIED PROBLEM

3.1 PROBLEM ANALYSIS:

Every product has disadvantages along with its advantages, and the disadvantages would be the problems faced by the user of the product.

3.1.1 LARGER TURNING RADIUS AT A GIVEN SPEED:

The radius of turn taken by a vehicle which doesn't lean would be always greater than the vehicle that turns with leaning. The figure below provides the paths taken by the vehicle to turn with (red) and without (green) leaning.

3.1.2 LOSS OF TRACTION OF THE TRANSMISSION WHEEL AT THE BUMPS AND POT HOLES

Whenever the vehicle with the convectional attachment hits a road with a lot of humps, bumps and pot holes the single rear transmission wheel losses the traction with the land due to the other stiff springs on the other two rear wheels of the attachment as the picture shows below

3.1.3 EXPERIENCING IMBALANCE AT CORNERING

When this vehicle hits a turn at a speed of more than 30kmph, due to the centrifugal force that acts towards the inner side of the wheel from the centre of the turn due to which the inner wheel tends to lift and creates imbalance to the rider at the corners. If the vehicle is taking a right turn, the vehicle’s right sided wheel is lifted as shown in the picture below

3.1.4 MILEAGE DROP

The conventional rear attachment attached to the vehicles totally makes it a four wheeler with added weight of the metal pipes and shock absorbers. The rolling friction of the vehicle is increased and thus more power is required to propel the vehicle and hence the mileage drops by 10-15kmph.

3.1.5 DISCOMFORTING RIDE

The experiencing of the imbalance at the corners, transmission of more shocks to the rider, need to slow down the vehicle to a very low speed during cornering, etc. all together would obviously give the rider a tiring and discomforting ride.

3.2Concept Development

The concept of the leaning attachment is brought out from the mere concept to reality initially by drawing some conceptual drawings of the attachment. The linkage of the conceptual attachment is modelled on chart paper to understand the relative movements of the links. After this is done, the actual conceptual drawing of the attachment is drawn until satisfaction and some of the conceptual drawings are shown below.

CHAPTER 06: OBJECTIVE

2.1 EASILY ATTACHABLE

The Leaning attachment is to be constructed such that it would be easily fastened to the chassis of any moped with slight modifications replacing the single front wheel of the stock vehicle and performs its dedicated function.

2.2 TECHNICAL ADVANTAGES

The attachment fastened to the vehicle gives the rider a lot of technical advantages in the ride such as

- Leaning is possible
- Turning radius at a given speed is lesser compared to the no lean ride
- Easy manoeuvring and cornering
- Comfortable ride
- Better Mileage

2.3 COST EFFECTIVE

When compared with the cost and functionality of the conventional rear attachment, our leaning attachment would be very much cost effective towards the function it performs and the comfortability it provides.

III. METHODOLOGY

3.1 Problem Analysis:

Every product has disadvantages along with its advantages, and the disadvantages would be the problems faced by the user of the product

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CHAPTER 07: COST CALCULATION

SR. NO.	PARTS NAME	QUANTITY	COST
1.	2 Wheeled Bicycle (26’’ x 1.90’’ Tire)	01	₹3,000
2.	Suspension	01	₹500
3.	1” x1” (2 mm) Square Tube – 01 Feet Length	08	₹1,000
4.	Nuts and Bolts (08 mm diameter)	12	₹150
5.	250W Motor Electric Kit	01	₹4,500
6.	12V 20Ah Battery	02	₹2,000
7.	26” Tyres	01	₹1,000

8.	Paint & Brush	Black (100 ml) Red (100ml)	₹100
9.	Fabrication	01	₹3,000
TOTAL			₹15,000

CHAPTER 08: FUTURE SCOPES

SCOPE FOR FUTURE WORK

1) ACTIVE LEANING:

The attachment being used by the differently abled, has to make the act of balancing the vehicle easy for them, so a mechanism is being suggested to be worked on.

The mechanism consists of the slot within which the top pipe of the frame moves, the two lengthier links which moves towards and away from each other varies the leaning of the vehicle, and the other two shorter links are connected to the actuator at one side and to the two lengthier links on the other side. The actuator should be programmed in a such a way that it actuates according to the speed of the vehicle, i.e., it should be given the input of speed such that the actuator is at its top end when the vehicle is at rest and at the bottom end when the vehicle is at faster speeds.

And the actuator must extend and retract proportionate to the speed of the vehicle so that the leaning is limited to only a few degrees during the lower speeds, while allowing for the maximum lean during higher speeds.

To the existing model of the leaning attachment, a platform is created on the lean lock on which an appropriate rating of the actuator is selected and is mounted on the platform. The actuator end is connected to the two links.

2) E-Bike

With its fast development and growing population, China is confronted by a severe energy crisis and environment pollution, and these negative effects will also propagate to other countries due to China's role in global economics.

Hence, it would be a great contribution to the global sustainability if China could achieve sustainable development.

To reach this goal, a sustainable form of transport is especially important, for the reason that the traffic sector is central to the manufacturing industry and closely related to people's social practices. Traditional methods of mobility depend on fuel to a great extent, which leads to a large consumption of energy and is hazardous to the environment. A promising alternative to fuel-based transport is the electric bicycle (e-bike), which has

developed rapidly in China in recent years and exhibited huge potential for its energy-saving and environmentally friendly features.
However, e-bikes have not drawn sufficient attention from academics and the government as they deserve. It is urgent to understand why and how the e-bike industry has developed in China in order to further boost its development.

<u>03. Trikes (Electric Trikes):</u>

Hero MotoCorp has recently launched a Three Wheeled Scooter in an Auto Expo 2020. The trike features a gyroscope-enabled auto-balance park feature which lets the scooter stay upright when stationary. Other notable features include a fully digital instrument cluster, mobile charger, walk assist, reverse assist (which is claimed to be up to 26kmph), app connectivity with real-time tracking and geo-fencing.

Hero Electric says the AE-3 electric trike comes with a 5.5kW electric motor and a 4kWh lithium-ion battery pack. The scooter uses a belt drive with a large pulley. The e-trike comes with a claimed range of 100km and a top speed of 80kmph. It takes five hours to charge the battery pack completely

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The AE-3 e-trike gets two telescopic forks up front and a disc brake on each front wheel. At the rear, it gets a petal disc and twin gas-charged shock absorbers. As far as the competition is concerned, there are none as it is the only scooter of its class in the country.

CHAPTER 09: LITERATURE SURVEY

In one aspect, the present provides a leaning vehicle having a frame having a front portion and a rear portion; a straddle seat supported on the frame; an engine supported by the frame; a shock tower having an upper end and a lower end, the lower end of the shock tower being pivotally connected to the front portion of the frame through a pivotal connection that defines a frame leaning axis about which the frame can lean to a right side and to a left side relative to the shock tower; a front left suspension assembly and a front right suspension assembly operatively connected to the front portion of the frame; a steering assembly having a steering column supported by the frame, the steering column being operatively connected to a handlebar to be grasped by a driver straddled on the straddle seat to steer the vehicle in a desired direction; and a rear suspension connected to the rear portion of the frame.

Each front suspension assembly includes a lower suspension arm pivotally connected to the frame at a first end and pivotally connected to a ground engaging member at a second end; and a shock absorber having an upper end connected to the upper end of the shock tower and a lower end connected to the lower suspension arm. An actuated lock locks the frame to the shock tower and prevents relative movement between the frame and the shock tower about the frame leaning axis. In an additional aspect, the actuated lock includes a locking pin adapted to engage a notch plate having at least one notch. The locking pin is mounted to at least one of the frame and the shock tower. The notch plate is mounted to another one of the frame and the shock tower. When the locking pin engages the at least one notch, the frame is prevented from moving relative to the shock tower. In a further aspect, the notch plate includes a plurality of notches corresponding to a plurality of locking positions of the frame relative to the shock tower.

In a additional aspect, an electronic control unit (ECU) operatively connected to the actuated lock. The ECU sends command signals to the actuated lock to lock and unlocks the frame relative to the shock tower. For the purposes of this application, terms used to locate elements on the vehicle such as front, back, rear, left, right, upper, lower, up, down, above and below are as they would normally be understood by a rider of the vehicle sitting on thevehicle in a forwardly facing, driving position. For the purposes of this application, the term “shock tower” means a supporting structure for a shock absorber assembly. Embodiments of the present invention each have at least one of the abovementioned aspects, but not necessarily have all of them. Additional and/or alternative objects, features, aspects and advantages of the embodiments of the present invention will become apparent from the following description, the accompanying drawings and the appended claims.A brake disk 138 shown in dotted lines is fixed to rotate with the hub. A brake caliper is fixed to be stationary with the spindle.

When the caliper applies a braking force to the disc brake to reduce the rotational speed of hub and thus wheel, the spindleis subjected to a torque in the direction of the arrow T (for a forward travelling direction of the vehicle). Because of the orientation of the axis and because the T-joint cannot rotate in the direction of the torque T relative to the lower suspension arm, all of the torque T will be transferred to the lower suspension arm. As mentioned above, the ball joint connections of the leaning rod do not resist any torque generated during braking, thus all the torque must be resisted by the lower suspension arm. Having all the braking forces pass through the lower suspension arm permits the leaning rod to have a small diameter and occupy very little longitudinal space when compared to an upper A-arm of a conventional double A-arm suspension designed to withstand braking forces such as lower suspension arm. This leaves ample space for the wheel to tilt inwards without contacting other components, particularly when simultaneously steering the wheel through large steering angles.

This design also allows for the necessary space to easily mount the shock absorber to the shock towerprior art designs having two A-arms, one situated above the other, allow the arms to be smaller since the torsion forces are distributed between the upper and lower Aarms. However this configuration limits the degree of leaning of the wheel. The single lower suspension arm of the present invention is bulkier than typical double A-arms systems but allows the leaning rod to be a small single rod thereby freeing space and allowing the wheels to lean farther than double A-arms systems.

The present configuration allows for sufficient space for all the front suspension components to articulate, lean, tilt and turnwithout interfering with one another. The shock absorber lies in a horizontal planesubstantially perpendicular to the frame leaning axis. The upright member of frame lies within a substantially vertical plane which is substantially parallel to plane in which the shock absorber lies.
Leaning rod and steering rod also lie within substantially vertical planes which are also substantially parallel to planes and in which the shock absorber and the upright member of framelie. It is to be understood that while the frame is leaning to the left or right, the wheels are also leaning to the left or right and could also be simultaneously turning.

The leaning of the frame and the wheels lowers the steering and leaning rods toward the lower suspension arm. Keeping the components in their respective substantially vertical plane throughout the leaning process ensures no interference between each component. Although the simultaneously turning of the wheel about axis while leaning the wheels about axis will cause some longitudinal movement of the steering and leaning rods the longitudinal distance between the components combined with the components remaining in substantially vertical planes ensures that there is no interference between the components.

With reference in operation, the driver turns the handlebars and leans the frame to the right side or left side in the direction of the arrow A to turn the vehicle, in a similar fashion to driving a two-wheeled motorcycle. The leaning rod, which is connected to the upright member of the frame at proximal end, applies a force to leaning arm of the spindle. This force causes the spindle to pivot at the T-joint about wheel tilting axis so that the wheel is forced to tilt in the same direction as the frame. The steering rod which is also connected to the upright member of the frame though the steering linkage, remains substantially parallel to the leaning rod such that no unwanted steering occurs while the vehicle is leaning. In a preferred embodiment, the wheel remains parallel to the frame (tilting right or left with respect with the ground) when the frame is leaning to the right or left, however the scope of the invention should not be so limited.

In the preferred embodiment, the wheel tilting axis is parallel to the frame leaning axis 100. Although, does not illustrate the wheel and its tire, the curved portion of the lower suspension arm allows for clearance between the wheel and the suspension arm when the wheel is leaning to the right. Obviously, the same can be said for the left suspension arm when the vehicle is leaning to the left. As can be seen in, when the vehicle is leaning into a corner, the shock tower remains upright while the frame is pivoting about the leaning axis 100 such that the shock absorber assembly of the front suspension is not directly involved in the leaning motion of the frame as in prior art leaning vehicles with tilting wheels. The operation of the shock absorber assembly is independent of the leaning motion of the frame. The motion ratio between wheel and the shock absorber assembly remains substantially constant while the frame is leaning to provide unaltered wheel dampening while leaning into a corner and travelling over rough terrain at the same time. The motion ratio is the ratio between the vertical movement of the wheel and the stroke of the shock absorber.

A person skilled in the art would recognize that a substantial change in motion ratio due to the leaning of the frame is not desirable. In a partially assisted mode, the actuator which is connected to the upper end of the shock tower and to the lower member of the frame at pivot point restrains and dampens the leaning motion of the frame to provide a smooth transition and provide a limit or maximum leaning angle between the frame and the shock tower to prevent the vehicle 10 from over leaning and damaging the suspension components. In a preferred embodiment, the maximum leaning angle φ is 50°but for safety and in absence of ECU we kept leaning angle 36°.

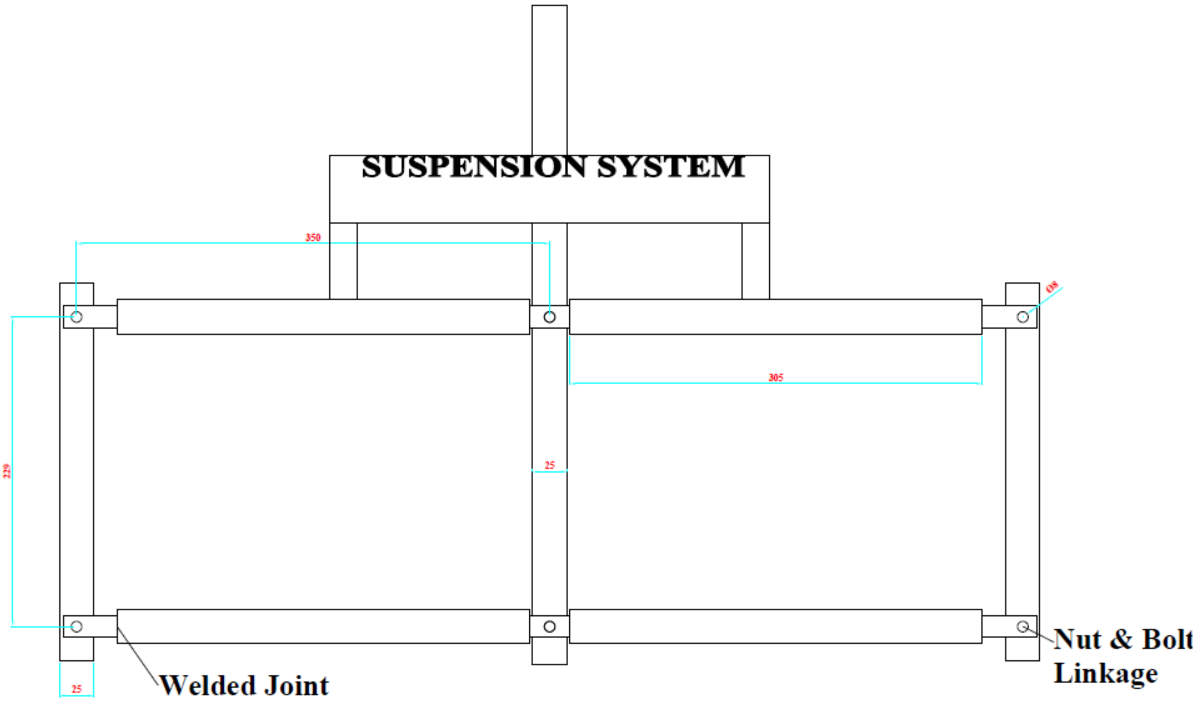
1} DESIGN AND FABRICATION OF THE TILTING FRAME

CHAPTER 10: CONSTRUCTION OF TILTING FRAME

For Easy Understanding the following constructions will be divided into Two Parts viz. (i) The Tilting Frame & (ii) Electric Bike

The Tilting Frame:

The Tilting Frame was purely made with Mild Steel Square Bars and Nut Bolt Linkages. The Frame which consists of 4x1 (Foot MS Square Pipe) can be seen in the Following Diagram:



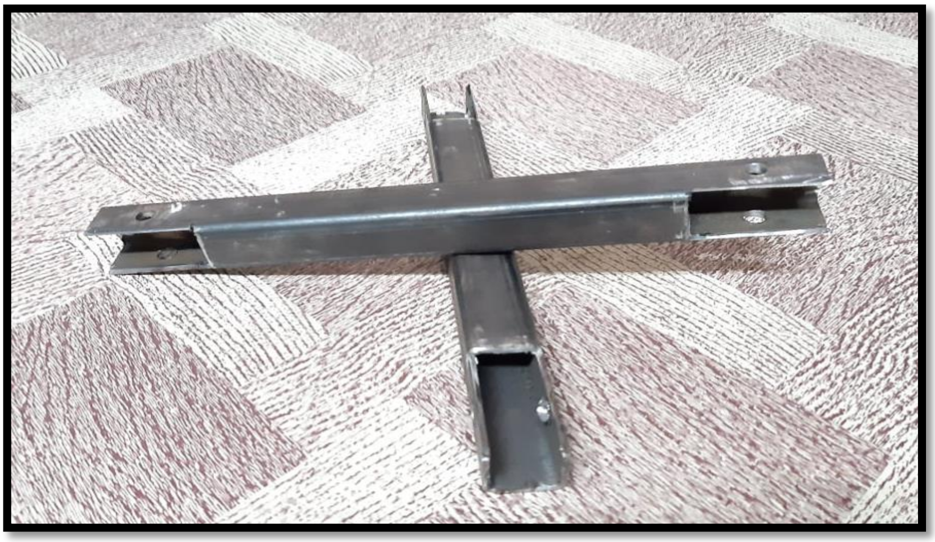
The First thing was to Bought the Materials. We bought the Square Pipe of Size One Foot and thickness around 2 mm. Total 8 Pieces of such Sizes were bought. A MS Plate of Thickness 2 mm was also bought.
After Marking all the Markings on the Plate, we started the Process of Cutting.

Cutting:

The Two Square Pipes of the Frame were cut down from 12 inch to 10 inches and the 20 Inch Bar into 16 Inch.

The Corners of the Bars were also cut by using Grinder.

CUTTING PROCESS



WELDING:

Welding was done as prescribed in the Drawing.
Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool causing fusion.

Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet, etc.), can be stronger than the base material (parent metal). Pressure may also be used in conjunction with heat, or by itself, to produce a weld.

Welding also requires a form of shield to protect the filler metals or melted metals from being contaminated or oxidized.

Many different energy sources can be used for welding, including a gas flame (chemical), an electric arc (electrical), a laser, an electron beam, friction, and ultrasound.

While often an industrial process, welding may be performed in many different environments, including in open air, under water, and in outer space. Welding is a hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

Until the end of the 19th century, the only welding process was forge welding, which blacksmiths had used for millennia to join iron and steel by heating and hammering.

Arc welding and oxy-fuel welding were among the first processes to develop late in the century, and electric resistance welding followed soon after.

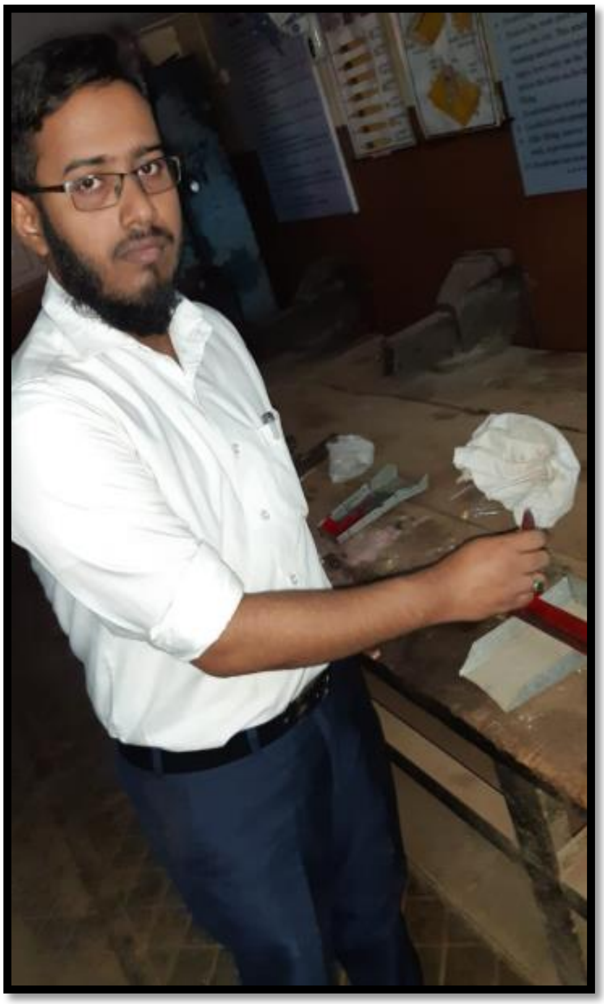
Welding technology advanced quickly during the early 20th century as the world wars drove the demand for reliable and inexpensive joining methods.

Following the wars, several modern welding techniques were developed, including manual methods like shielded metal arc welding, now one of the most popular welding methods, as well as semi-automatic and automatic processes such as gas metal arc welding, submerged arc welding, flux-cored arc welding and electro slag welding.

Developments continued with the invention of laser beam welding, electron beam welding, magnetic pulse welding, and friction stir welding in the latter half of the century. Today, the science continues to advance. Robot welding is commonplace in industrial settings, and researchers continue to develop new welding methods and gain greater understanding of weld quality.

PAINTING:

Oil Paint was used in the Painting Process.



2} ADDING ‘E’ CONCEPT TO OUR PROJECT

CHAPTER 11: INTRODUCTION TO 'E' CONCEPT

As worldwide population is growing day by day and there is increase in manufacturing and using of fuel powered. This vehicle require fossil fuel to run and it a limited source of energy which will be over after some period and to cop up with this need, the revolution for the eco-friendly cycles were the most depended modes of transportation, along with this the consideration of the increase in fuel price and the environmental factors we must admit that it is far more better to use a cycle over a motor vehicle for short distance travelling. Imagine how useful would the cycle be if even the small effort applied by man for riding on rough terrain.

This project is based on combination of the standard geared cycle with an electric power motor. The system is modified in such a way that the rider can make choice of which mode he prefers i.e. he can either choose the cycle to be driven completely with the electric motor or he can choose it to be driven manually by himself.

The idea of mounting the motor and it's support assembly onto a geared cycle was to reduce the effort to-be applied for extra little weight that the rider will have to take along with the cycle. The unit has been designed in such a way that people of any age group can depend on it. Our idea of implementation of the project was mainly biased towards providing inter college transportation.

E-Bicycle typically incorporates a battery, which can be charged at an ordinary domestic power socket, linked to an electric motor in the Bicycle transmission system. The rider have the power to controls the output power from motor i.e. speed using a handlebar mounted throttle and controller. The term 'e-bike' is generic and includes a combination of different electrically powered two-wheelers some of which function by simply turning a throttle.

This Bicycle is designed and made in very less cost as compared to original cost, so any one can afford this Bicycle. As we know that due fuel powered vehicles, the emission of toxic gases is increasing day by day, due to this 4.3 million people Vol-5 Issue-2 2019 IJARIIE-ISSN(O)-2395-4396 10076 www.ijariie.com 2577 die or survive from dangerous diseases all over the world. To overcome this problem and to travel from one place to another an ecofriendly

Bicycle with manually and motor power controlled Bicycle is made with all the accessories similar to bike. E- Bikes are difficult to compare directly across different types. Normally in every electric

Bicycles there are two common parts which is consider while making it i.e. motor and manually operated paddle. Our Bicycle consists of 6 gear speed, through which any person can drive this Bicycle manually with the help of this gears easily without any fatigue. At a same time there is another arrangements is made in which battery powered motor is use to drive the Bicycle. For power transmission from motor shaft to the sprocket chain drive is use.

This chain is connected is such a way that it can be fixed according to vary in chain cause due to environmental or mechanical problems which creates tension in chain. Apart from all motor & battery arrangement three is an indicators, tail light, gearing arrangement, horn & front light.

The electric bicycle is an electrical-assisted device that is designed to deliver the electromagnetic momentums to a present bicycle therefore relieving the user of producing the energy essential to run the bicycle.

It contains a strong motor and enough battery power that just needs charging to help in hill climbing, generate greater motoring speeds and provide completely free electric transportation. Electric vehicles price more and perform poorer than their gasoline counterparts.

The aim is that mainly because gasoline cars have promoted from a century of intensive development; electric cars have been virtually overlooked for several years. Even today, gasoline cars profit from billions of dollars of research every year while electric vehicles receive a small fraction of that quantity of money.

The primary principle for the Universities‟ support of the electricpowered over the petrol powered has been towards improving air quality, though air quality alone is not a satisfactory justification to mandate electric bicycles. The single biggest advantage of electric bicycle is that it is cost operative as it mainly only entails building cost as running cost would only require the charging of the battery.

An Electric bicycle would, however offer other solid benefits that are overlooked by the marketplace. These include the intense reduction in oil consumption that its widespread use would bring about. Much less oil would be needed because only a tiny proportion of electricity is generated from oil. The further major non-market benefit would be lower greenhouse gas emissions.

CHAPTER 12: LITERATURE SURVEY

The Bicycle, in its present upright form, called a “Safety Bicycle” and introduced by the Rover model in 1885, is a relatively cheap method of extending the range, increasing the speed, and improving the energy efficiency of human powered transport. It can coast down hills, roll easily along the flat, and make use of gearing to tackle steep hills.

Many Bicycle alternatives exist, ranging from recumbent models to chunky off-road machines; however the “safety Bicycle” shape remains most common. Electric Bicycles, with more than a century of commercial history (the first patents for electric Bicycles were granted in the 1890s), have long been available, and found adopted in small numbers in many countries.

Their relative lack of popularity until recently may be attributed to technological or economic factors, however the fact of their existence means that they are already covered by legislation in most countries. In terms of personal electro-mobility alternatives, there are a plethora of amazing inventions ranging from the Segway, the Yike Bike, Ryno, various electric scooters, skateboards, power skates, and electric quad bikes and so on. Ignoring the fossil-fuelled variants, recent alternatives have been released which are powered by compressed air, flywheel, fuel cell and probably other unusual power sources.

However the vast majority of experimental machines use a combination of electrical motor and battery. Battery solutions tend to be limited to the robust but weighty lead-acid cells in cheaper or older systems, through surprisingly few NiMH variants, to Lithium Ion (predominantly LiFePO4 or LiMn2O4 based cells) in more modern and expensive variants .

The Segway is one of the most imaginative and innovative personal mobility solutions to have been developed in recent years, with a loyal following of users, and several niche application areas.

However the Segway has not attracted widespread adoption on campus to date. General Motors have used the Segway as the foundation for their P.U.M.A. (Personal Urban Mobility & Accessibility) project which effectively adds car-like features to the Segway; a seat, roof and steering wheel.

Whilst this is exciting and extremely attractive from a technological point of view, it leads to a very expensive transport solution, requires significant thoroughfare space, and may require licensing for use in certain locations (for example, even the basic Segway is not currently legal for use in public areas within Singapore).

Electric quad bikes are likewise expensive, bulky to park and have few advantages over an electric Bicycle. In fact, all of the devices mentioned are expensive, certainly significantly more so than a standard Bicycle, and most work on the premise of simply adding a motive power source to a Bicycle- type system (or scooter/skateboard/skates).

However it is by no means certain that lack of such power assistance is the main reason why Bicycles may not have been more widely adopted in many campus environments. Thus, adding motive power alone may not lead to the more widespread adoption of electric Bicycle-type transport

CHAPTER 13: OBJECTIVES

- To develop a simple vehicle model and simulation for sizing of powertrain components followed by selection of powertrain components.

- To propose and develop a simple control strategy for the plug-in hybrid electric two-wheeler suitable for city driving conditions.

- To assess the annual saving of gasoline and reduction of co2 emission for the span of next 10 years.

- To give the maximum travelling by Bicycle of 15-20 km/hr without peddling of Bicycle.

- To reduce the air pollution and too keep our region pollution free and to keep the e-Bicycle noise free.

- To give benefit of having accessible, affordable and sustainable transportation for customers.
- To give maximum efficiency with a minimum weight of e Bicycle.

<u>CHAPTER 14:</u> WHAT IS ELECTRIC BIKE?

The Electric bike is a bike which is driven with the help of battery which is coupled to electric motor.

<u>MAIN PRINCIPLE:</u> It works on the principle that the electromotive force of an A.C. motor which receives electrical energy stored in D.C. battery is converted with the help of D.C. to A.C. converter.

<u>WORKING MEDIUM:</u> Here for the motivation of prime mover the chemical reaction takes place from which an energizing current is evolved which is responsible for the working. The working medium is sulphuric acid which is separated into columns of H ions and negative SO4 ions when mixed with water. If the poles of the cell are connected by a load, the flow of the electrons is from negative to positive.

A bivalent positive lead is produced from neutral lead when combined with bivalent negative of SO4 group to form lead sulphate. This results due to scarcity of electrons at negative pole. Through the electron supply a bivalent positive lead is produced at positive pole from quadrivalent positive lead. A combination of SO4 comes into existence thereby ruling the combination of O_2 which leads to formation of $PbSO_4$. The atoms of oxygen and hydrogen from electrolyte are released together to form water thereby decreasing the density of battery acid.

OPERATION: In this a DC waveform which is obtained id made sinusoidal due to operational transistorized D.C. to A.C. amplifying circuit by switching the electric energy in the form of electric current which flows from battery to D.C. to A.C. converter circuit. By using amplifier circuit the small A.C. current is amplified again. In order to drive the circuit through the condenser, this amplified current is fed to the stator winding of the A.C. motor.

The condenser which is used acts as a storage of electric energy and delivers at the time of requirement. The sprocket wheel installed on motor shaft is driven by the motive power of the electric energy. The rear sprocket wheel is being rotated by the chain drive mechanism on which the other two remaining sprocket wheels are installed. The wheel is driven by the rear wheel installed on the rear sprocket. Thus the electric bike is mobilized by using electric power.

CHAPTER 15: COMPONENTS OF E –BIKE

1.DC MOTOR:

The motor is having 250 watt. Capacity: 3000 rpm. Its specifications are as follows:

Current Rating: 7.5amp

Voltage Rating: 24 Volts

Cooling: Air – cooled

Bearing: Single row ball

A DC motor is one of a class of rotary electrical machines that converts direct current electrical power into mechanical power. The most mutual types rely on the forces created by magnetic fields. Nearly all types of DC motors have specific internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in portion of the motor. DC motors were the first type commonly used, since they could be powered from present direct-current lighting power distribution systems.

A DC motor's speed can be controlled over a extensive range, using either a variable supply voltage or by changing the strength of current in its field windings. Tiny DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for convenient power tools and appliances.

Bigger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The arrival of power electronics has made replacement of DC motors with AC motors possible in many applications.

Working Principle:

A motor is an electrical machine which translates electrical energy into mechanical energy. The principle of working of a DC motor is that "whenever a current carrying conductor is placed in a magnetic field, it practices a mechanical force".

Fig.1 Working of Electric DC Motor.

In many traditional electric Bicycle when Motor is started it gives initial torque very high when we use to transmitted the power of motor to the sprocket through chain then there will be chances of failure of bracket due to motor torque.

To overcome this problem a new type or self-design arrangement which is similar to an letter ‘T’ is done which is shown in Fig. This arrangement is built in such a way that if there is any deflection is there in chain which connects the sprocket can be adjusted by tightening or loosening of nut. On the given ‘T’ slot Dc motor is fixed with the help of 2 mm thin long strip as shown in fig.

The given figure shows the 2 Dimensional view of the motor and T arrangement assembly.
There are many changes and modification has taken place. The motor is mounted on the Bicycle with the help of ‘T’ arrangement as shown in Fig. The reason behind

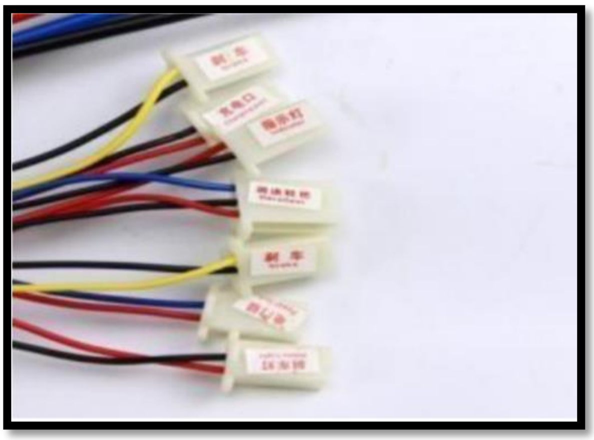
this arrangement is that there is high initial torque of motor due to which another arrangement failed in front of this motor torque .this arrangement is bolted to the Bicycle axel with the help of 6mm ID nut and wiser. But the motor having very high initial torque there the arrangement is welded at the end of resting face of motor.

As it is shown the battery is located in the middle of Bicycle, there are two batteries with rectangular frame to hold the battery properly due to which it can be easily fixed or removed. Natural cooling is provided hence it is safe. Below the batteries there is ECU is placed with the help of nuts and it is mounted with black cello tape which will prevent it from dust & water. ECU consists of all the electrical connection from key port to motor. Apart from battery and motor there are many connections are done.

2. ELECTRONIC CONTROL UNIT

Digital technology furnishes an extensive array of options for open and closed-loop control of automotive electronic systems.

A large number of parameters can be included in the process to support optimal operation of various systems.



After receiving the electric signals transmitted by the sensors, the ECU processes these data in order to generate control signals for the actuators. The software program for closed-loop control is stored in the ECU's memory.

The program is executed by a microcontroller. The ECU and its components are referred to as hardware. The Motor ECU contains all of the algorithms for open and closed-loop control needed to govern the engine management processes. Shows the image of typical ECU used in Bicycle Overview the PMDC motor had to be regulated by a mechanism which involved a DC motor driver.

This driver had specifications able to withstand up to 14A which was key to this project as varying loads would undoubtedly draw more current. So the rated current rating had to be high enough to withstand this. As this electric

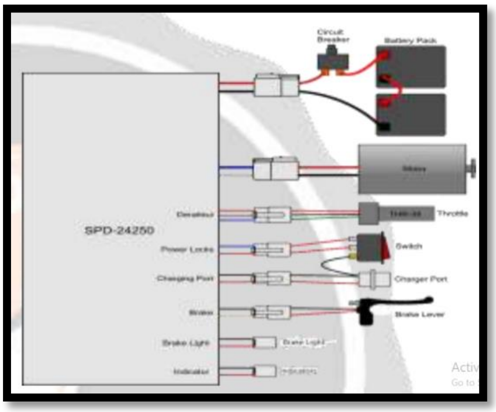
Bicycle consists many electrical control accessories due to which there will be varying current require to each part. Fig. shows the connection of ECU to the different accessories.

All the components of the Bicycle are assembled in such a way that, the Bicycle will not look messy and the weight of components does not affect to the Design of Bicycle.

Key port is given in middle of handle bar which controls all the electrical circuits as shown in shows the fully assembled Bicycle which is actually an Electric Bicycle.

<u>Speed Control Basics</u>:- The speed controller of an electric bike is an electronic circuit that not only controls the speed of an electric motor but also serves as a dynamic brake.

This controller unit uses power from the battery box and drives it to the motor. Different forms of controllers are used for brushedand brushless motors. For adaptive e-bikes, a conversion kit is used and the controller is the core component of that kit.



<u>Function:-</u> The electric bike speed controller sends signals to the bike's motor in many voltages. These signals detect the direction of a rotor relative to the starter coil.

The suitable function of a speed control depends on the employment of various mechanisms. In a purpose-built electric bike, Hall effect sensors help detects the location of the rotor.

If your speed controller does not include such sensors and the speed controller on an adaptive bike may not the electromotive force of the un-driven coil is calculated to get the rotor orientation.

The mechanism of an electric speed controller differs depending on whether you own an adaptive or purposebuild electric bike. An adaptive bike includes an electric drive system installed on an normal bicycle.

A purpose-built bike, more expensive than an adaptive bike, provides easier acceleration and affords extra features

Plugs:

1.Red & Black (large cable) : Battery connections

2.Yellow & Blue : Motor connections

3.Red & Blue : Key Switch(power lock) (If there is no power door locks, red connection to blue)

4.Yellow & black : brake

5.Red & Yellow: Brake light

6.Red&Black(small cable) : indicator light

7.Red, Black & Blue: Speed Regulator 1-4 V Throttle (Red : +5v, Black : - , Blue :Signal Wire)

8.Red & Black (small cable): Charger

3. BATTERY

Rechargeable batteries are produced in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network.

Several different combinations of electrode materials and electrolytes are used, including lead–A rechargeable battery, storage battery, secondary cell, or accumulator is a type of electrical battery which can be charged, discharged into a load, and recharged many times.

This battery is mounted on a rectangular frame made up of mild steel strips. As motor require 24V voltage therefore 2 batteries are connected in series.
Two lead acid rechargeable batteries of 12v, 7 amp are used which are connected in series position. It basically stores the electrical energy generated and utilise it to run the motor.

A battery has a positive terminal called cathode and negative terminal called anode. The terminal marked positive is at higher electric potential energy and the terminal marked negative is source of electrons when connected to external circuit will flow and deliver energy to external device Rechargeable batteries are recharged multiple times

4. CHAIN DRIVE

A Chain is an array of links held together with each other with the help of steel pins. This type of arrangement makes a chain more enduring, long lasting and better way of transmitting rotary motion from one gear to

another.

The major advantage of chain drive over traditional gear is that, the chain drive can transmit rotary motion with the help of two gears and a chain over a distance whereas in traditional many gears must be arranged in a mesh in order to transmit motion

5. BRAKING SYSTEM:

For the braking system it is convenient to use braking system used in band brake system which consist of spring loaded friction- shoe mechanism, which is driven with the help of hand lever.

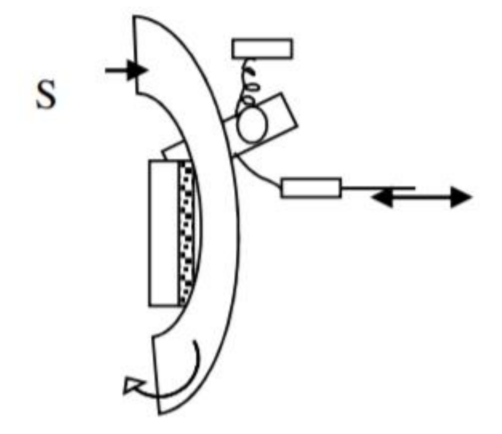


Figure 4 Braking System

6. SPROCKETS:

The chain with engaging with the sprocket converts rotational power in to rotary power and vice versa. The sprocket which looks like a gear may differ in three aspects::

Figure 5 Various types of Sprockets

Sprockets have many engaging teeth but gears have only one or two. • The teeth of a gear touch and slip against each other but there is basically no slippage in case of sprocket • The shape of the teeth are different in gears and sprockets

7. FRONT LIGHT AND HORN

Bicycle lighting is illumination attached to Bicycles whose purpose above all is, along with reflectors, to improve the visibility of the Bicycle and its rider to other

Fig. 6 Front Lights and Horn

road users under circumstances of poor ambient illumination. A secondary purpose is to illuminate reflective materials such as cat's eyes and traffic signs.

A third purpose may be to illuminate the roadway so that the rider can see the way ahead. White LEDs have a higher luminous efficacy than halogen lights and are sufficiently powerful to provide the front light for a Bicycle.

8. CHARGING SYSTEM

Electric chargers are used for recharging the battery. There are different kinds of chargers which are suitable for different batteries.

Fig. 9 Charging Socket

Fig. 10 Charger

Every new electric Bicycle should come with its own designated charger. Proper charging will ensure a long battery life. Plugging in the charger will recharge the battery to full capacity at any time.

You can partially charge and disconnect the battery even if the green light has not come on and use the battery, just be aware that you will not have a full charge capacity.
You can charge the battery when it disconnected from the e-bike, and you can charge the battery when it connected to the bike just be sure that the e-bike is not turned on.

The electric Bicycle charger standard power-source is the wall AC socket. But, because of the very low power demands of a typical e-bike, other alternative sources of energy can also become handle

CHAPTER 16: DESIGN AND CONSTRUCTION OF ELECTRIC BIKE

Here we have used permanent magnet self generating motor with 250 watt power and 3000rpm. The motor runs on 24volts and 7.5amps power source. This motor can reach a peak current during starting equal to 15 amps.

P = 2 x 3.14 x N x T /60

250 = 2 x 3.14 x 3000 x T /60

T = 1.13 N m = 1136 N-mm

Reduction in chain drive

R chain = 66/11 = 6:1

Torque at wheel shaft = T x R chain = 1136 x 6 = 6820 N mm

Speed of wheel shaft = 2100 /6 = 350 rpm

BENDING:

The force which develops across a specific cross section of the shaft, it generates stress at that point of cross section that are subjected to maximum loading. This internal or resisting moment gives rise to the stress called as bending stresses.

Torsion: When the shaft which is twisted by the couple such that the axis of that shaft and the axis of the couple harmonize, that shaft is subjected to pure torsion and the stresses generated at the point of cross section is torsion or shear stresses.

Combined Bending and Torsion: In actual practice the shaft is subjected to combination of the above two types of stresses i.e. bending and torsion.

The bending stresses may occur due any one of the following reasons:

1. Weight of belt

2. Pull of belts

3. Eccentric Mounting of shafts/gears

4. Misalignment of shafts/gears Design and Fabrication of Electric Bike

On contrary, the torsional movement occurs due to direct or indirect twisting of the shaft. Hence at any given point on cross-section of the shaft, the shaft is subjected to both bending and torsional stresses simultaneously.

Following stresses are taken in consideration while designing the shaft:

Shaft design

T = 36000 N mm

T = 3.14 / 16 x σs x d3

Fs allowable = 80 N/mm2

6820 =3.14 x σs x d3 /16

σs = 34.73 N/mm2

Material = C 45 (mild steel)

σ ut = 320 N/mm2 ------------ PSG design data book.

factor of safety = 2 σt = σb = σ ut/ fos = 320/2 = 160 N/mm2

σs = 0.5 σt = 0.5 x 160 = 80 N/mm2

σs is less then allowable so our shaft design is safe.

Design of Sprocket and Chain for Electric Bike

We know, TRANSMISSION RATIO = Z2 / Z1 = 66/11 = 6

For the above transmission ratio number of teeth on pinion and the number of teeth sprocket is in the range of 21 to 10, so we have to select number of teeth on pinion sprocket as 11 teeth.

So, Z1 = 11 teeth

SELECTION OF PITCH OF SPROCKET

The pitch is decided on the basis of RPM of sprocket. RPM of pinion sprocket is variable in normal condition it is = 3000 rpm.

For this rpm value we select pitch of sprocket as 6.35mm from table. P = 6.35mm

CALCULATION OF MINIMUM CENTER DISTANCE BETWEEN SPROCKETS

The transmission ratio = Z2 / Z1 = 66/11 = 6 which is less than 7 Dia. of small sprocket, Periphery = $\pi \times$ dia. Of sprocket 11 $\times$ 6.25 = $\pi \times$ D D = 11 $\times$ 6.25 / π D = 21.8 mm Dia. of sprocket, Periphery = $\pi \times$ dia. Of sprocket

CONSTRUCTION

ALL THE PARTS OF THE E BIKE WERE GATHERED AND ASSEMBLED CAREFULLY.

CHAPTER 18: REFERENCES/BIBLIOGRAPHY

References:

Acott, K. 2015. Cycling bodies want city ring path [Online]. Perth, Western Australia: The West Australian Newspaper. Available: https://au.news.yahoo.com/thewest/a/26696247/cycling-bodies-want-city-ring-path/ [Accessed May 29, 2015 2015].

Aust_standards 2010. AS/NZS 1927 Pedal Bicycles - Safety Requirements.

Berchicci, L. 2005. The green entrepreneur's challenge: the influence of environmental ambition in new product development, TU Delft, Delft University of Technology

Berote, J., Plummer, A. & Darling, J. Lateral dynamics optimisation of a direct tilt controlled narrow vehicle. 10th International Symposium on Advanced Vehicle Control (AVEC 2010), 2010. University of Bath.

Blake, E. 1932. Water sled. US Patent 1872230 A Google Patents

Cornelius, C. March 14, 2015 2015. Transcending the Pedicar, Ecovia Part 3. The Left Handed Cyclist [Online]. Available from: http://lefthandedcyclist.blogspot.com/2015/03/transcending-pedicar-ecovia-part-3_14.html [Accessed 28/5/2015 2015].

Cox, P. 2009. Energy and the Bicycle – Human powered vehicles in perspective. Seventh International

Conference on the History of Transport, Traffic and Mobility, 48.
Davidson, A. & Mcgurn, J. 1999. Encyclopedia: The Guide to Alternatives in Cycling, Open Road Limited.
Dow, A. 2014. Wyndham council's race to the CBD shows cyclists are on a winner [Online]. The Age. Available: http://www.theage.com.au/victoria/wyndham-councils-race-to-the-cbd-shows-cyclists-are-on-a-winner-20140402-35yw9.html [Accessed June 4 2015].
Drymer. 2015. Drymer Website [Online]. Drymer p/l. Available: http://www.drymer.nl/en/ [Accessed May 29 2015].
Eland, P. 2015. Tricycle Steering Geometry - Introduction [Online]. Available: http://www.eland.org.uk/steer_intro.html [Accessed June 1 2015].
Fiell, C. 2003. Industrial design A-Z, Köln, London, Köln, London : Taschen.
Fleiner, R. 2011. FN Trike Website [Online]. Available: http://www.fn-trike.de/Reinhold/HTM/seite1.html.
Georgiev, G. 2008. Varna bicycles and tricycles [Online]. Available: http://www.varnahandcycles.com/cycles.htm [Accessed May 29 2015].
Girardi, P. The Tilting Three Wheelers [Online]. Phillipe Girardi. Available: http://www.troisroues.com/english.html [Accessed Mach 29 2015].
Gross, A. C., Kyle, C. R. & Malewicki, D. J. 1983. The aerodynamics of human-powered land vehicles. Scientific American, 249, 142-152.
Haberfield, G. 2014. E-Bike, Cycling's Evolution [Online]. Australia: RACV. Available:

http://www.racv.com.au/wps/wcm/connect/royalauto/home/motoring/bicycle/e-bikes-cyclings-e-volution [Accessed May 29, 2015 2015].
Jnyyz. 2012. HPV Racing at Waterford, MI. Biking in a Big City [Online]. Available from: https://jnyyz.wordpress.com/2012/05/20/hpv-racing-at-waterford-mi/.
Karnopp, D. 2004. Vehicle stability, New York, N.Y. : London, New York, N.Y. : Marcel Dekker London : Taylor & Francis distributor.
Kautt, B. 2010. Tiefflieger [Online]. Available: http://www.tieffflieger.de/ [Accessed May 28 2015].
Knott, S. 2013. Design in the Age of Prosumption: The Craft of Design after the Object. Design and Culture, 5, 45-67.
Koeppel, D. 2006. Taking it lying down.(recumbent riders). Bicycling, 47, 71.
Kyle, C. & Weaver, M. 2004. Aerodynamics of human-powered vehicles. Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy, 218, 141-154. Tilting Human Powered Trikes: Principles, Designs and New Developments.
14

Nelson, R. 2010. Moral sustainability and cycling : an ecology of ambition for a hyperactive planet, Fitzroy, Vic., Fitzroy, Vic. : Ellikon.
Nurse, S. 2011. Front Wheel Drive Recumbent Bicycle with Human Body Steering Limiter (Patent Application).
Nurse, S. 2013. Leaning Trikes using Rear Axle Pedal Crank Mechanism [Online]. Available: http://hupi.org/HPeJ/0020/0020.html [Accessed 20 7].

Nurse, S. & Durbridge, G. 2009. An Illustrated Guide to the Cycle Zoo, Stephen Nurse.
Oakman, D. 2014. Peter Heal's Recumbent Bicycle [Online]. Available: http://www.nma.gov.au/collections/highlights/peter_heal_recumbent_bicycle [Accessed March 24 2015].
Ozhpv. 2015. OzHpv for Sales Page [Online]. OxHpv. Available: http://www.ozhpv.org.au/forsale/forsale.html [Accessed May 29, 2015 2015].
Page, A. 2015. Trivek Tilting Trike [Online]. Available: http://www.hiele.co/trivek.
Parker, J. 2015. Tilting Trike Prototype Testing. Jim Parker's Blog [Online]. Available from: http://cruzbike.com/tilting-trike-prototype-testing [Accessed May 29 2015].
Recumbentblog.com. Recumbent Blog [Online]. Available from: http://www.recumbentblog.com/2010/05/03/tripendo/ [Accessed May 29 2015].
Ruggiero, A. 2018. Future of Human Powered Transort is a Trike [Online]. Available: http://gearjunkie.com/velotilt [Accessed May 29 2015].
Sims, P. 2000. Tilting Tricycle. Huff OzHpv Magazine. Australia: OzHpv. Available: http://www.ozhpv.org.au/HUFF/docs/huff16.pdf [Accessed May 29 2015].
Smit, B. Munzo TT tilting trike [Online]. Available: http://www.fastfwd.nl/index.php?id=57 [Accessed May 29 2015].
Soohoo, W. J. 1998. Multi-track vehicle with lock and drive lean control system. Google Patents.
Thomas, H. 2007. Jetrike [Online]. Available: http://jetrike.com/ [Accessed May 28 2015].

Tiltingvehicles. 2015. Tiltingvehicles. Tilting Vehicles Blog [Online]. Available from: http://tiltingvehicles.blogspot.com.au/ [Accessed May 29 2015].
Van De Walle, F. 2004. The velomobile as a vehicle for more sustainable transportation. Master of Science Thesis at The Royal Institute of Technology in Stockholm, Sweden.
Vittouris, A. & Richardson, M. Designing vehicles for natural production: Growing a velomobile from bamboo. 34th Australasian Transport Research Forum (Dr Peter Tisato, Mr Lindsay Oxlad, and Professor Michael Taylor 28/09/2011-30/09/2011), 2011. PATREC, 1-20.
Vuong, V. Openbike Ilean [Online]. Available: http://en.openbike.org/wiki/~iLean.
Wianecki, R. 2003. Rick Wianecki's Leaning Trike Project [Online]. Available: http://www.recumbents.com/wisil/wianecki/leaning_trike.htm [Accessed May 29 2015].
[1] “Fundamentals of Vehicle Dynamics” by Thomos D Gillespie
[2] “Dynamic stability of three wheeled vehicles in automotive
type applications” by Robert Q Riley with tilting three wheeler contributions by tony
[3] “Research paper on design and analysis of double whishbone
suspension system using finite element analysis” by Savan
Thacker PG student, Gujarath Technological University, India
[4] “Automobile Mechanics” by Khanna publications, 8th edition

[5] “Reverse Engineering of Steering system with a developed equation for steer angle” by ShyliKeshvani and A.M Surendra Kumar, Dept. of Mechanical Engineering, BITS Pilani

[6] “DESIGN OF INDEPENDENT SUSPENSION MECHANISM FOR A TERRAIN VEHICLE WITH FOUR WHEELS DRIVE AND FOUR WHEELS STEERING” by ShpetimLajoj, Stanislav Pehan

[7] “The Physics of Braking Systems” by James Walker, Jr. of scR motorsports

[8] “REVIEW ON TADPOLE DESIGN” by PalashPatodi, Vinay Saxena, Yogesh Rathore