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Damper Wheel

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Abstract - *In the contemporary world that we live in, it's very difficult to say that we do not have some kind of technical aid to do some stuff. This is the age of inventions and innovations and transportation and communication have been the two fields in which the human race has seen the most advancement from mobile phones to hyperloop to aerospace technology to all the technology we are blanketed around with. Amidst all these going on, we seek to develop and to move one step ahead in the field of automobiles and introduce a new kind of wheel.*
The conventional wheel design has been the same for so long and has served well but that it is the answer to the question and it makes us ask has it served well enough and does it not need an upgrade really? We believe they do.
We belong to India and we all are aware of the basic challenges on Indian roads such as potholes and undulating road surfaces. We felt the need for a new design that could uplift the rider's experience and also increase the road safety. In this synopsis we will talk about our efforts and attempts to create our new design and will also talk about the outcomes and the future possibilities.

Key Words: **Automobiles, Conventional wheel design, Indian roads, Increase the road safety, uplift the rider's experience.**

1. INTRODUCTION

We have designed this wheel to improve the performance of the conventional wheel. It facilitates shock absorption and eliminates the contemporary limitations of the conventional wheel. We have made use of rods, ball bearings and coil suspension as the major components of our wheel which have replaced the same old spokes inside the rim to provide better shock absorption ability to the wheel. The main aim is to create a better wheel design without changing the conventional vehicles design.

The theme for the problem selection is "Smart vehicles", aiming at the drawback in the automotive industry with respect to the conventional wheel. The conventional wheel can absorb shock from only an intended direction which sets as a major drawback and compromises the performance of the wheel.

2. LITERATURE REVIEW

David Waters [1] studied about The Untold History of The Wheel and Its Evolution. In which he discussed about the importance of wheel in our day to day life and the era of automobile wheels as well. In his paper he briefly discussed about modern day wheel and also about advantages of wheels.

Maria Bondar [2] had discussed about Prehistoric Innovations: Wheels and Wheeled Vehicles. This paper tells us about the widespread of wheeled vehicles which leads to construction of roads.

Pranav A. et al. [3] had worked on Non Pneumatic Tyre. In which he briefly discussed about Pneumatic Tyre and Non Pneumatic Tyre. This paper also gives us the briefing of advantages and disadvantages of both pneumatic and non-pneumatic tyre and the material used in them. With the help of this paper, we can also conclude which vehicle is suitable for what kind of tyre.

Dishant et al. [4] studied about Suspension System. In which he tells us Suspension is an arrangement of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems must support both road handling and ride quality, which are at odds with one another. The suspension also guards the vehicle and any belongings from damage.

He also discussed about Different Types of Suspensions used in Automobile Industries which are Dependent Suspensions, Independent Suspensions and Semi-independent Suspensions.

We also get the information about Benefits of Shock Absorber from this paper.

Farah Z. Rusli [5] had discussed about the effect of hydraulic damper characteristics on the ride and handling of ground vehicle. In this paper he discussed about the ride quality of ground vehicle and handling performance of vehicle as well.

Assaad Alsahlani [6] has discussed about design and analysis of coil spring in vehicles using finite elements method. In his study, the simulation and analysis of coil spring were done with different materials using finite element method. The materials selected were steel structure, copper alloy, and carbon composite and also his study tells us about the properties of materials used for producing the coil spring

3. RESEARCH GAP

Problems with conventional wheels can be serious safety issue and failed wheel can render whole vehicle unfit for roads. Our country is home to several bad roads, be it metropolitans, the cities or villages. Bad road conditions are nothing new to India and that too with non-uniform traffic. Hence, accidents are very common event to be experienced on Indian roads. A car suspension is meant to maximize and enhance passenger comfort and steering stability. However occasionally a suspension will fail suddenly and dramatically.
This made us to research on the issue and come up with a solution, which could deal with those problems suitably and satisfactorily.

4. PROBLEM STATEMENT

4.1 PROBLEMS FROM SAFETY POINT OF VIEW:

4.1.1 ROAD HAZARDS:

The conventional wheel fails to react to the impact of road hazards. Suppose if you are driving down the road at 50 to 60 mph and hit a pothole or run over an obstacle in the road, the wheel takes full brunt of the impact. The impact is hard enough, the sidewall of tyre will compress and squeeze between the object and wheel flange. This shock can cause chunk to come off the tyre or a large crack to form on side wall where the cords have been broken. Crack is common occurrence in low profile tyre wheels. Sidewalls bulge from broken cords inside the tyre due to impact which is not hard enough to crack the rubber.

4.1.2 SUSPENSION FAILURE:

Since, the smaller vehicles don't have physical space for large crash absorption zones that exist in modern high-end vehicles and the packaging of drive system also takes up the valuable space. So if the collision occurs from front it can create enough pressure to bend or knock components out of place. So, the suspension system collapse and eventually the vehicles. Not only that, suspension system also collapses due to its alignment in one direction. When the vehicle collides or passes through potholes, since the suspensions are aligned at certain angle they tend to absorb the shock in that particular direction and eventually tend to resist the shock coming from other directions. Due to which wheel collapse.

4.2 PROBLEMS FROM COMFORT POINT OF VIEW:

The other problems with Indian roads are their poor geometrics, insufficient pavement thickness and bad riding quality. Lower driving comfort is also a limitation of using conventional wheel especially on Indian roads. They offer stiff or rough riding experience and make unevenness on road more noticeable, which comes out to be harmful and even fatal in several cases. For example: An Ambulance carrying a severely burnt (above 3rd degree) patient vibrates due to unevenness on roads. Due to which patient is made to suffer as after burning skin becomes very soft and bones start to fall into the skin, which can be fatal for the patient. It can also be very difficult for patients suffering complex fractures, etc.

5. OBJECTIVE

A. To design and improve the performance of the conventional wheel.
B. To facilitate shock absorption and to eliminate the contemporary limitations of the conventional wheel.

6. METHODOLOGY

6.1 DEVIATION FROM THE CONVENTIONAL DESIGN:

The conventional design of wheel is pretty good and efficient and it is being used for so long but as every piece of technology need an update and improvement, we also felt the need to bring some changes to the basic design of the wheel.
In all of the cases that we discussed before the basic limitation with the conventional wheel we found was the fixed spoke system. The new kinds of wheels display alloy and carbon wheel rims. Still the problem of being rigid and prone to failure exists.
In order to solve this problem, we looked at an alternative of putting in suspensions in place of spokes. This sounded good but this idea definitely had some limitations. In this report we will talk about all the issues and the solutions we found one by one.

6.2 ELIMINATING THE RIGIDITY:

Our primary aim was to eliminate the rigidity from the original design to facilitate shock absorption and dampening. We had to develop a system that could move within the circular rim in the vertical plane. For that we planned a system consisting of rods (arms) and ball-bearings.
The design we created was created to move in a complete circle within the circular rim. Further, it could hold the wheel's structural integrity together with providing damping capability.
Given below is the initial design that we created. It will help understand the structure and the functioning of the design.

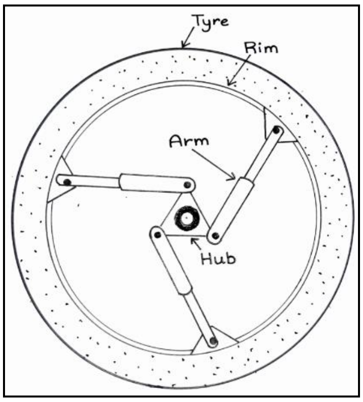

Fig: -6.1- Initial design

From this figure we can see how we thought to eliminate the rigidity. In place of spokes we decided to use arms in the form of telescopic suspension. We have decided to attach the arms to the hub and the wheel rim with ball bearing joint to facilitate the swivel movement in the vertical plane perpendicular to the wheel axel. With the help of this movement the hub will be able to move in a complete circle freely and then by the effect of telescopic suspension the hub come back to the original equilibrium state.

6.3 DESIGN FINALISATION (INITIAL STAGE):

In this design we can see that we have opted for a triangular design as it has its benefits.
The major advantages are:
1. Triangular design gives a stable structure. (Each arm supports the other two)
2. Impact from any angle gets dampened and the structure attains the equilibrium position on its own.
3. Adding any additional arm crowds the central hub and also restricts the rotational movement of the hub which is very crucial for our design.
4. Keeping minimum number of arms reduces the complexity of the design and also reduces the cost of production.
Given below are the drawings to explain how our design works:

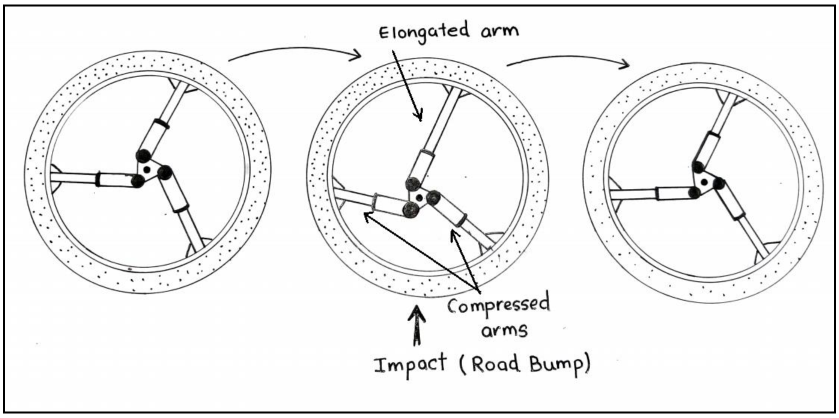

Fig: -6.2- Design's expected working

In the above picture we can see the expected reaction of the wheel to simulated bump on the roads. We can see how the hub shifts itself in order to adjust the wheel according to the undulations of the road and then comes back to the initial equilibrium state. All this is expected to be achieved only mechanically and hence this makes the system very reliable.

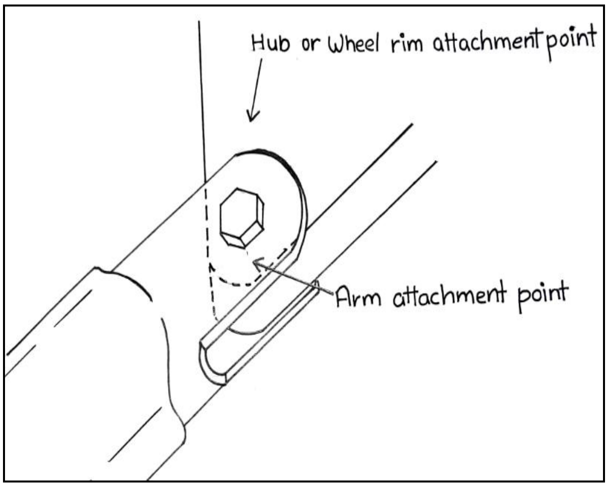

Fig: -6.3- Ball bearing attachment

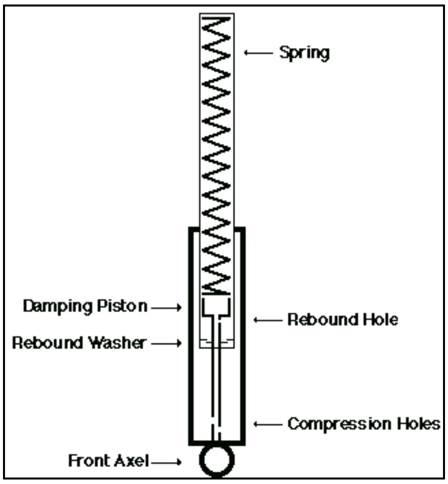

Fig: -6.4- Telescopic suspension

6.4 TESTING AND INITIAL CONCLUSIONAL RESULTS:

We tested the initial model and these were the major take away from the project:
1. Unlike the conventional wheels these wheels could take up shocks by absorbing them and changing the orientation of the arms and then came back to their original position.
2. As discussed earlier even in contemporary automobiles the wheels are not made to take shocks from the front and the rear end of the vehicle but our design could take shocks from all the directions equally effectively.
3. As it can be seen in the picture, we created a set of bumps to mimic the actual bumps on the road and the speed bumps and we could see that the wheels were adjusting themselves according to the bumps and the retracted back to the equilibrium state.
4. We opted for coiled spring and we used in the form of telescopic suspension so that even after compression the springs stayed confined in the tubes.
5. Other major reason to use coiled springs was that it offers lesser reaction time and faster operation than leaf type suspension systems.
6. Coiled springs proved to be useful for our project as they have a wider range for compression and elongation.
7. We could evidently see that our assumption was right. When any one of the arms got compressed, the other two elongated.
8. The wheels also held up very well and despite the flexible design were pretty solid and the new design did not tamper with the wheel integrity much as the wheel still had the basic long gone and proven design with just the exception that now the arms (spokes (conventionally)) could dampen and swivel about their respective axes.
9. One very important thing that we concluded that the new design needed no additional components to be fitted in the vehicle. Just in some cases the mudguards will have to be moved higher as the wheel rim shifts towards and then away from the direct

impact and which can be road bump in most of the cases. Hence, we need to shift the mudguards higher or equip the vehicle with a larger radius mudguard and the system is expected to work perfectly fine.

Fig: -6.5- Our initial tested model

6.5 DESIGN IMPROVEMENT:

In order to make our design much more practical and usable we had to come up with new ideas for the design structure and arrangement.
In order to perform in actual scenario our wheel had to be sturdy and also flexible and we had to restrict the motion of the central hub so that it does not give jerk while starting or braking of the vehicle.
Following were the changes that we made in the original design that helped us achieve the improved design.

1. The central hub of the wheel was completely redesigned and we added stoppers and custom grooves for the arms to fit in more perfectly and to restrict the swivel movement of the arms.
2. The single strut was replaced with complex two-piece custom arms and the improved struts to add more strength and rigidity to the structure.
3. The arm pieces were redesigned and oriented in a triangular shape so that the struts along with dampening, also could opposed the jerk seen in the original design.
4. All the joints were redesigned so that they could be sturdier and stronger in order to perform better in terms of stability.

6.5.1 COMPONENT LIST AND COMPONENTS:

All the parts were fabricated by hand and only nuts, bolts, springs and ball-bearings were taken pre manufactured from the market.
Here is the list of components required for the improved model design:

A. Wheel rim (wooden (stacked plyboard))
B. Central hub (wooden)
C. Arm piece 1 (attached to the rim)
D. Arm piece 2 (attached to the central hub)
E. Coil spring strut (fabricated by hand)
F. Ball bearings
G. Nuts and bolts
H. Frame (wooden)
I. Axle (metallic)
J. Artificial bumps (wooden)
Now we will look at all the individual components.

A. WHEEL RIM:

The rim was made by cutting round rings of the plyboard and they were then stacked on to one another to improve rigidity and strength. The joints were then reinforced with resin glue.

Fig: -6.6- Wheel rim

B. CENTRAL HUB:

We had to develop a custom central hub with anchor points which are used to support the arms on the two extremities of the swivel. The hub is designed to deal with the jerking problem and to facilitate smooth shock dampening action.

Fig: -6.7- Central hub

C. ARM PIECE 1:

This piece is attached to the ball bearings in the wheel rim and this is the main extension arm that gives our wheel the strength and sturdiness. It is attached to the arm piece 2 on the other end.

Fig: -6.8- Arm piece 1(top view)

Fig: -6.9- Arm piece 1(side view)

D. ARM PIECE 2:

This piece is attached to the central hub and it is the main functional piece of the design. This piece facilitates the swivel movement and it also restricts the movement of the arm too much and prevents the jerk using the anchor points in the hub. The other end is attached to the arm piece 1.

Fig: -6.10- Arm piece 2(top view)

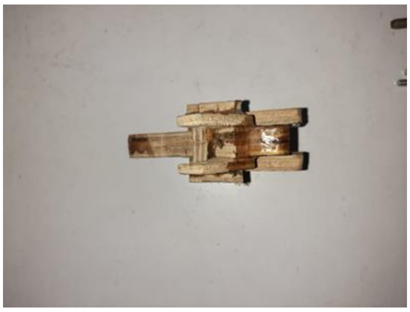

Fig: -6.11- Arm piece 2(top view)

E. COIL SPRING STRUT:

These struts were made out of wood and the spring was used to dampen the shocks. The strut has a rod and a tube which are just touching each other and hence provide sufficient strength even while contracting and elongating. Both attachment points of the strut go to both the arms.

Fig: -6.12- Coil spring strut

F. BALL BEARINGS:

Ball bearings are a very important part of our system as they allow the desired movement of the hub and the arms. For this purpose, we have used high quality ball bearings with guarded balls so that dust and dirt does not get accumulated in the cavity.

G. NUTS AND BOLTS:

We used nuts and bolts so that the whole structure remains modifiable and customizable.

H. FRAME:

We prepared a frame to set up the wheel onto. The frame was made up of plyboard and it could support the wheel so that it could be tested.

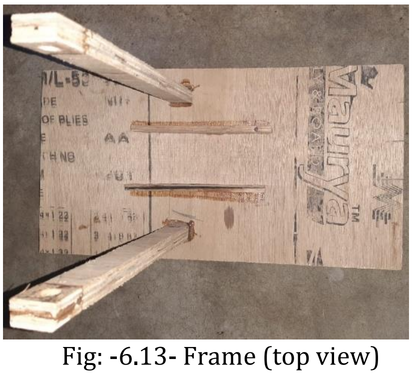

Fig: -6.13- Frame (top view)

Fig: -6.14- Frame (side view)

I. AXLE:
The axle that we used was made of aluminium and it was used to support the wheel on the frame.

Fig: -6.15- Axel (side view)

J. ARTIFICIAL BUMPS:
We created a set of artificial bumps with plyboard to simulate the undulations and bumps on the roads.

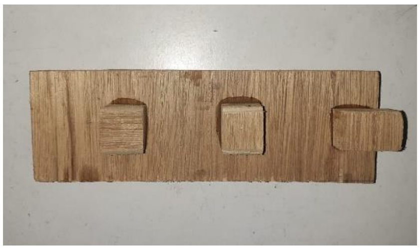

Fig: -6.16- Artificial bumps (top view)

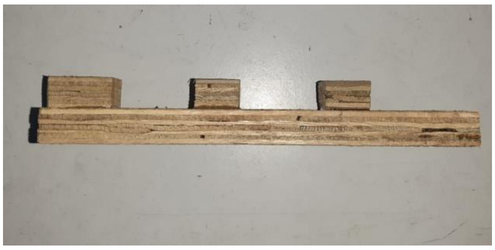

Fig: -6.17- Artificial bumps (front view)

6.6 FINAL ASSEMBLY:

This is the final assembly of the design and the basic function has been tested and it has proved to be working in the same way as it was intended to:

Fig: -6.18- Final arm assembly

Fig: -6.19- Final model assembly

This system is fabricated by us in accordance with tackling of the original disability/limitations of the previously fabricated model by us.

6.7 BILL OF MATERIALS:

Given below is the bill of materials used for the final model:

S. No.	Part used	Material used	Quantity (no. of units)
1.	Wheel rim	wood (plyboard)	1 unit
2.	Central hub	wood (plyboard)	1 unit
3.	Arm piece 1	wood	3 units
4.	Arm piece 2	wood	3 units
5.	Strut for suspension	wood	3 units
6.	Coil spring	stainless steel	3 units
7.	Ball-bearing (Bore dia-6mm)	stainless steel and plastic	9 units
8.	Ball-bearing (Bore dia-15mm)	stainless steel and plastic	1 unit
9.	Bolt (dia-5mm)	steel	9 units
10.	Bolt (dia-3mm)	steel	6 units
11.	Nuts (bore dia-5mm)	steel	3 units
12.	Frame	Wood (plyboard)	1 unit
13.	Axle	aluminum	1 unit
14.	Artificial set of bumps	Wood (plywood)	1 unit

6.8 FINAL TEST AND TEST RESULTS:
6.8.1 TESTING PREPARATION AND PROCEDURES:

Given below is the preparation and method of testing:
1. We created a set of bumps and we also made a passage for the bump to slide easily under the wheel that was fixed on the towers supporting the axle on the frame.
2. In the new improved design we have also made two attachment points for the suspension struts and hence this same suspension setup can be used in smaller wheel rims also and this makes the whole design very customizable.

3. To perform the testing, the wheel was fixed on a height of 20mm from the base of the frame and the axles were fixed on the towers of the frame so that they could not move anywhere in the vertical plane.
4. Then the artificial bump which had a height of 40 mm, were made to slide back and forth repeatedly under the wheels and the wheel's reaction to this testing was recoded.
5. It was assured that the various parts of the frame and other components were strong and prepped up.
These were the testing preparations.

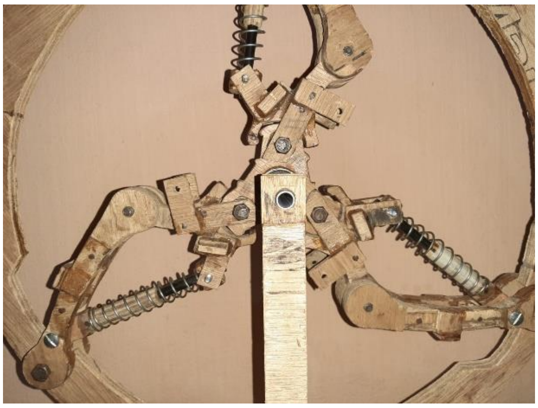

Fig: -6.20- Wheel under normal condition

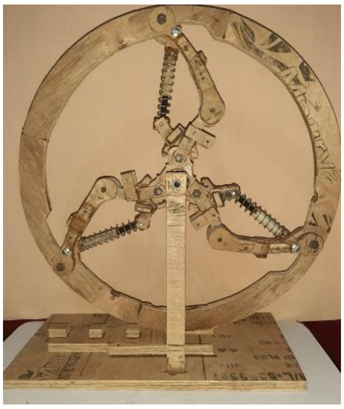

Fig: -6.21- Wheel and bump initial position

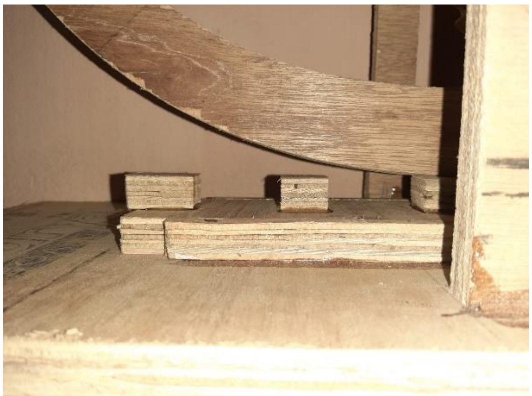

Fig: -6.22- Bump silded under the wheel

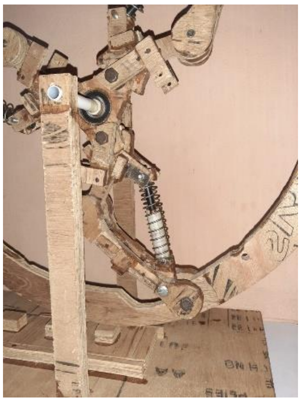

Fig: -6.23- Under impact strut (compressed)

Fig: -6.24- Struts not under impact (other two elongated)

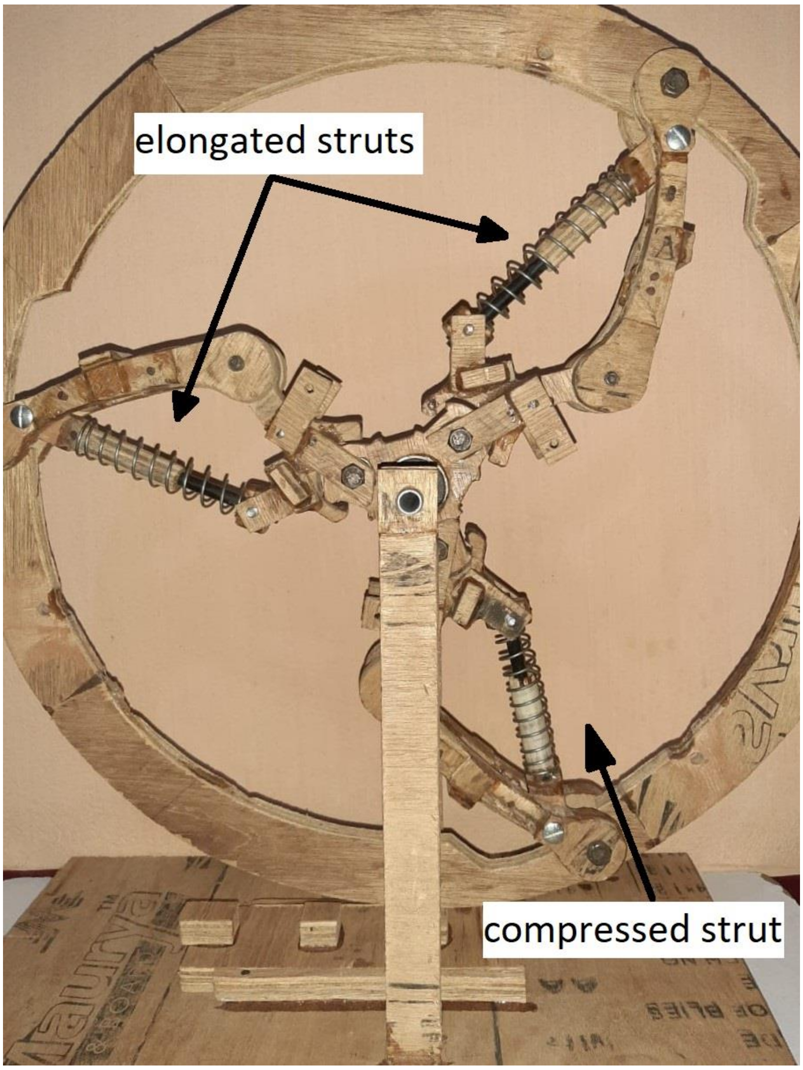

Fig: -6.25- Final model under bumps' impact

6.8.2 TESTING RESULTS:

Given below are the testing results that we recorded:
1. The artificial bumps were able to slide through the wheels effortlessly.
2. We could see that the wheels handled the dampening and shock absorption very well.
3. The suspension arms of the wheel could be seen to be expanding and compressing in accordance with the bump beneath them and the continuous bumps were taken very well.
4. By the effect of the specifically oriented arm pieces and struts, the wheel jerk was eliminated and the wheel performed more stably.
5. After the impact of bumps, the central hub was observed to regain its original position before the impact.
6. Shocks could be absorbed from any direction and the original central hub position was seen to be attained after the impacts of the shock.
7. Finally the drawbacks of the initial design were tackled and eliminated.

These were the results of the testing.

7. PROPOSED APPLICATIONS:

On the basis of our test results, we can say that our new design can prove to be very useful in various fields such as:

7.1 MEDICAL AID:

Sadly, in India condition of roads is not very good in most of the areas. Mainly in rural areas people fail to receive medical help only due to lack of accessibility due to remoteness of their location. In many urban areas also condition of roads is not very good and ambulance drivers find it very difficult to reach and attend the patients safely.

Hence, we propose that our new innovative wheel can be the solution of this problem. These can come in very handy for ambulances. These wheels can be used in the ambulances without changing its design much and for cost cutting these can be used in only remotely located medical facilities. As they will provide a much more comfortable and shock proof experience to patients at high speed on unevenness road and help keep the patients more stable. Also combined with the leaf spring suspensions of the vehicle they can offer high load bearing capacity while providing greater comfort and shock resistance.

7.2 TRANSPORTATION:

These wheels can prove to be very useful in heavy transport vehicles as in India the heavy transport rules are not as firm as most of the developed countries. Unchecked operating ours and long riding hours on Indian roads with heavy traffic and irregular roads lead to a very exhausting lifestyle. Our design can give the drivers a better road experience and can reduce fatigue and improve the total quality of the job.
Prevention of accidents and reduction of accidental impact to the rider is another important aspect where these wheels can prove to be useful and this can be understood in the following headings.

7.2.1 ROAD ACCIDENTS:

Indian roads are known for their non-uniform traffic. Hence, accident are a very common event to be experienced on the Indian roads. The conventional wheel fails to react to the impact during accidents in a very desired and efficient way. Actually, they are made to fail during a crash so that the impact faced by the passengers gets lessened.

But our design will do the job of taking the hit and controlling the impact through all the shockers and it will also not fail against moderate impacts but dampen the impact add an extra protective feature for the passengers.
This will help with the safety point of view and also be economic if the wheels won’t fail during an accident.

7.3 SPORTS:

These wheels can also be used in competitive motor sports and it can add a very new experience to the riders and it will also make the sport safer.
Example: In recent years it was witnessed that in a formula one race, an F1 car’s suspension arms failed and the wheel completely detached from the chassis. The accident was horrible and the vehicle was completely destroyed but thankfully the driver survived. This could have been fatal for the driver as well as for other racers.
The major problem here is the overworking of the suspension arms as there is so much vibration in the arms also the F1 race car wheels do not have treads so the suspension takes on more shocks. If we employ our wheels then the shocks will be taken by the wheels also and hence the suspension arms will have to take less or already dampened shocks and can help in reducing such failures.

We know what kind of stresses and damages the wheels take in competitive motor sports. Our design can offer a new set of customized options and also increase the safety to the sportsperson.
These are some of the applications that we think our design can have.

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