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Modal Analysis Of Macpherson Strut Suspension System Using Ansys

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Abstract
A suspension system is one of the important elements of an automobile which directly influences its safety, comfort, and lifespan. It is used to enhance the efficiency of the vehicle by providing the smooth motion of the vehicle on road. Its function also includes giving support to the moving and vibrating parts of the braking system and overall vehicle. In the present work, Macpherson strut suspension system is designed using SOLIDWORKS software. In a further study, its modal analysis in ANSYS is performed to detect the range of deformation which is caused due to the vibrations. The Macpherson strut suspension system is preferred over the other suspension due to its overall simplicity of the design, reduced wear due to fewer joints, better handling and steering.

1. Introduction

In the present scenario, an automotive manufacturer aims to provide the customers with a vehicle that works at a higher rate along with providing the best possible efficiency in the given specific range. For the same cause, the weight of the vehicle must be on the lighter side and additionally, it must possess the qualities like it must be lightweight, must be durable, the cost must be on the lower side and should provide a good and effective riding experience. To design such automotive vehicles, it takes a lot of planning and new technologies that need to be implemented on the already available ideas. When the specification of the vehicle is examined, it is usually rated according to the power they are able to produce but contrary to this fact if the vehicle can't be moved and controlled according to the requirement and as per the situation then it is regardless that how powerful the engine is. This fact attracted the researchers to pay attention to the suspension system used in vehicles [Sharma et al, 2021].

The suspension system includes the combination of springs, shock absorber, and linkages which is used as a connector between wheels and vehicle. It finds its application during braking and helps in handling the vehicle during the braking [Bhardawaj et al, 2020]. The functions of the suspension system are to support the vehicle, provide a smooth ride to the passengers, keep the vehicle grounded while braking, provide stability to the vehicle and carry the static load on the vehicle [Sharma, 2017]. The suspension system also helps in maintaining proper steering geometry during the cornering of the vehicle.

The suspension system is mainly of two types: Dependent and Independent Suspension System. In Dependent Suspension System both the wheels are attached to the same solid axle, such that when one wheel hits a bump in the road, its upward movement would cause tilting of the other wheel. The main disadvantage of this is that it's not possible to accurately control the steering geometry. The Independent Suspension System allows the two wheels on the same axle to move independently of each other in the vertical direction which permits better steering control [Palli et al, 2017].

McPherson suspension system is an Independent front Suspension System widely used in modern automobiles and attracted several researchers for its analysis. A. Purushotham [2013] formulated the dynamic equations for determining the vibration characteristics of the sprung mass with McPherson suspension system. In further analysis, the two-dimensional practical model of McPherson suspension was carried out using Ansys software. Slavica et al [2018] analysed the stability and efficiency of the suspension system and the model analysis of the McPherson suspension system using CATIA software. The analysis includes the rotation, displacement, and vertical moment of the chassis for wheel assembly and uses the Von-Misses stress theory to calculate the stress and deformation in the function parameter. Lu Sun [2001], introduced the idea of a concept to road-friendly suspension design where the suspension forces are a function of pavement loads. The researchers used the direct update method stochastic process theory to determine the dynamic response of the suspension system.

M.J. Thoresson et al [2009], using ADAM software, evaluated the gradient-based optimization of an off-road vehicle suspension system. The optimised values of spring and damper parameters were evaluated using Dynamic-Q and successive approximation method. M. Mahmoodi Kaleibar et al [2013], utilised the ADAM software to determine the optimum method to design the off-road vehicle suspension system, to provide better vehicle stability and handling.

Husain Kanchwala et al [2014], using ADAMS software, determined that passive suspension control offers better vehicle handling, steering stability, brake control and a smoother ride with fewer efforts. S.C. Jain et al [2014], analysed and implemented a few modifications to the McPherson suspension system to provide a smoother ride and better handling. It was concluded that the modified suspension system provides better riding quality than the original suspension system. Jiao Wang et al [2016], determined that under rolling working conditions, the height of the roll centre is excessive, under the steering condition Kingpin Offset is excessive and the mechanical trail is negligible.

In the present work, Macpherson strut suspension system is designed using SOLIDWORKS software. In a further study, its modal analysis in ANSYS is performed to detect the range of deformation which is caused due to the vibrations.

2. MACPHERSON STRUT SUSPENSION (MSS)-

2.1 MSS-Configuration and design layout

Macpherson Strut Suspension is an independent front suspension system which is used in various modern cars and motor vehicles where only lower wishbone is used. A strut that contains a shock absorber and a spring also carry a stub axle onto which our wheel is being mounted. The cross members are joined with and together they position the wheel as well as resists accelerating braking, and side forces (Figure 1). This system is much simpler when compared to the double-wishbone type in operation and is also lighter than the latter one. The unsprung weight is also on the lower side when compared with the double-wishbone type. Also, the camber does not change when the wheel moves up and down. The MacPherson Strut suspension provides the maximum space in the engine section it is the only reason that it is commonly being used on front-wheel-drive cars. The MacPherson Strut suspension also provides increased road safety, improved ride comfort and light, and self-stabilizing steering which means that the car continues along its chosen line of travel whenever the brakes are being applied irrespective of the road surface.

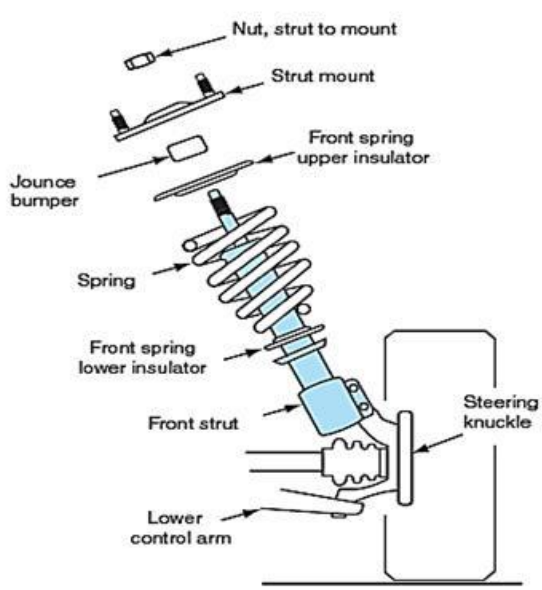


Figure 1. **MacPherson Strut Suspension System**

2.2 MSS-Material Properties

It consists of various parts made up of different materials according to the required properties. The different materials used are Chrome Vanadium, Brass, Chrome Silicon and CRPF. In the present work following materials for the different parts of the MacPherson Strut suspension assembly have been considered (Table 1).

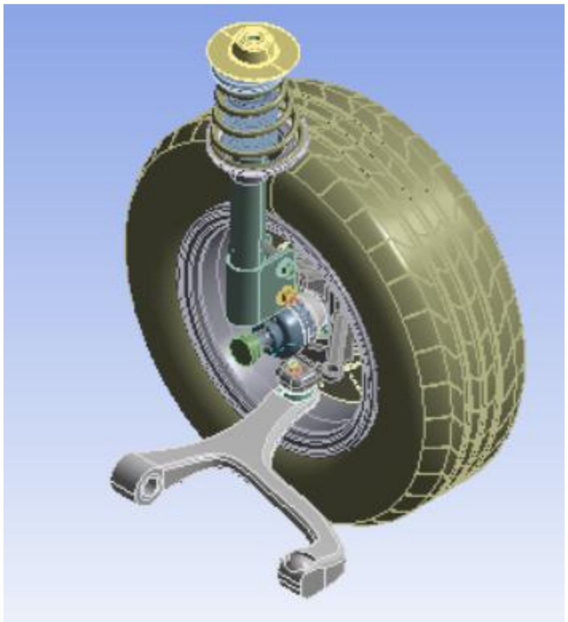
Table 1. **Different materials used in MacPherson Strut Suspension Assembly**

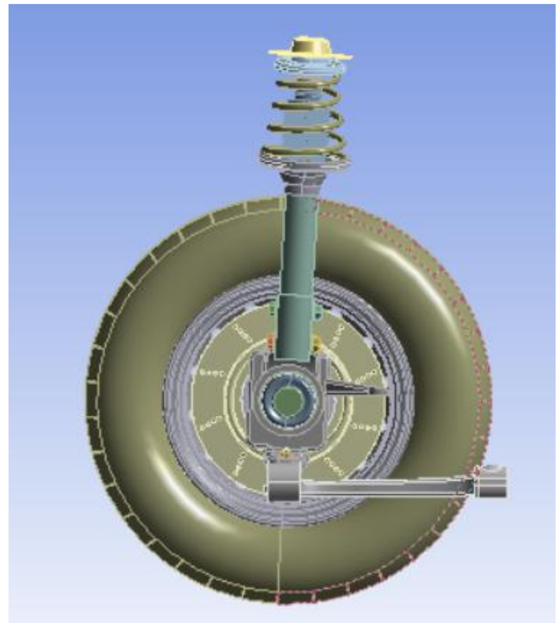
Sr No.	Material	Application of Materials	Poisson's Ratio	Density
1.	Monel Metal 400	Experimental rocket planes	0.315	8.80 g/cc
2.	Brass	Truck's leaf spring	0.310	8.49 g/cc
3.	Chrome silicon	Racing cars	0.270	7.86 g/cc
4.	Chrome-vanadium	Modern Truck's suspension	0.270	7.80 g/cc
5.	CFRP	F1 cars	0.300	1.90 g/cc

2.3 MSS-CAD Modeling

Three-dimensional CAD model of a McPherson strut assembly is developed in Solid Works 2018. The developed CAD model of the McPherson strut assembly is then imported in the analysis software ANSYS, and then we have performed modal analysis. The total number of nodes and elements in the model are 57,240 and 27,470, respectively

For the modelling of 3-dimensional CAD model of a MacPherson Strut Assembly is shown in Figure 2 and 3.





a) Isometric view **b) Front side view**

Figure 2. **a) Isometric view & b) Front side view of McPherson Strut assembly**

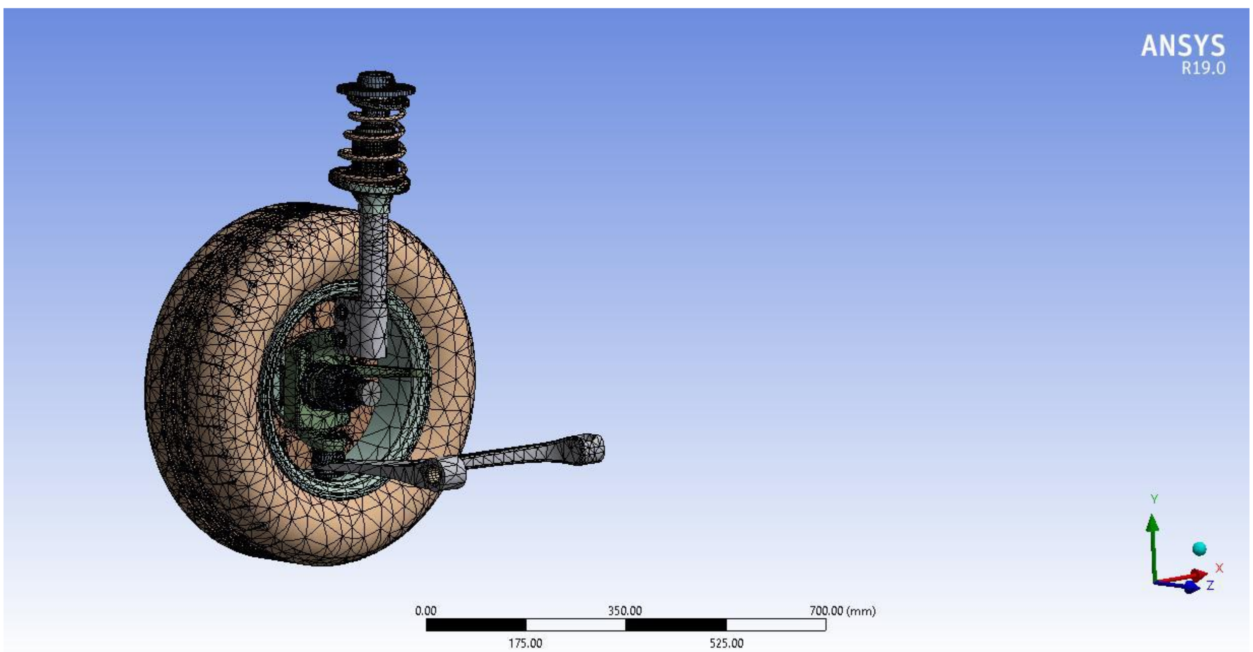


Figure 3. **Mesh model of McPherson Strut assembly in ANSYS**

2.4 MSS-Vibration Analysis

Vibration Analysis is basically the technique of calculating vibration in order to find out the irregularities in mechanical components. This technique more or less identifies all the faults or irregularity that a machine can possess. Due to which, we have various techniques for analysis to confirm a diagnosis of fault or irregularity. The most common faults that can be identified by vibration analysis are listed:

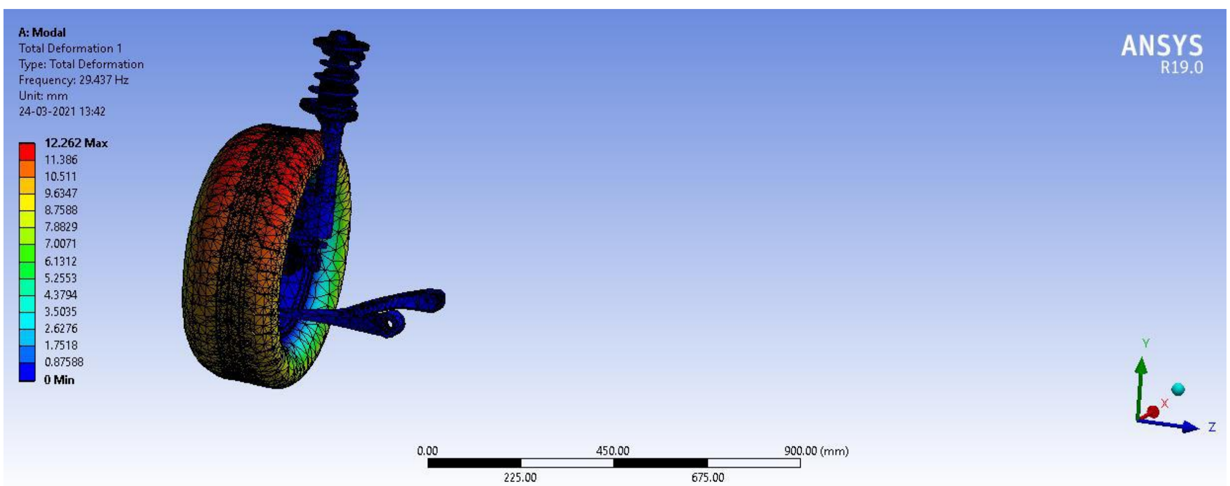
1. Imbalance
2. Mechanical looseness
3. Misalignment
4. Resonance and natural frequencies
5. Critical speeds

The primary goal of performing the vibration analysis is to identify faults in the mechanical component and then convey the information such that the needed action could be taken. Mostly all the shortcomings take place when the required frequency of the data collection is not in alignment of the maintenance strategy.

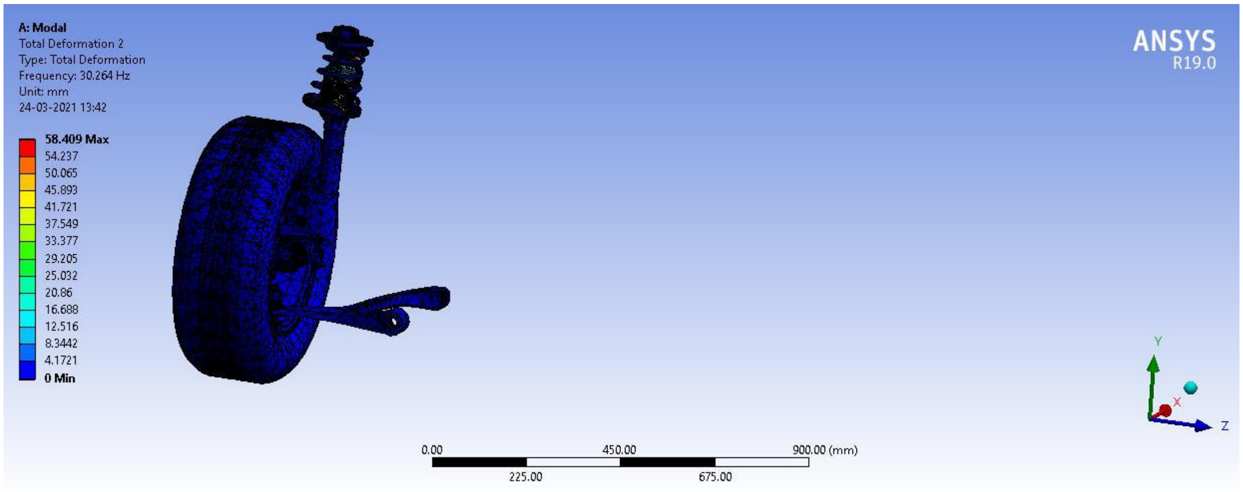
3. RESULTS AND DISCUSSION

Modal analysis is performed on the of McPherson Strut assembly under the boundary conditions which is keeping the spring portion of the assembly as fixed.

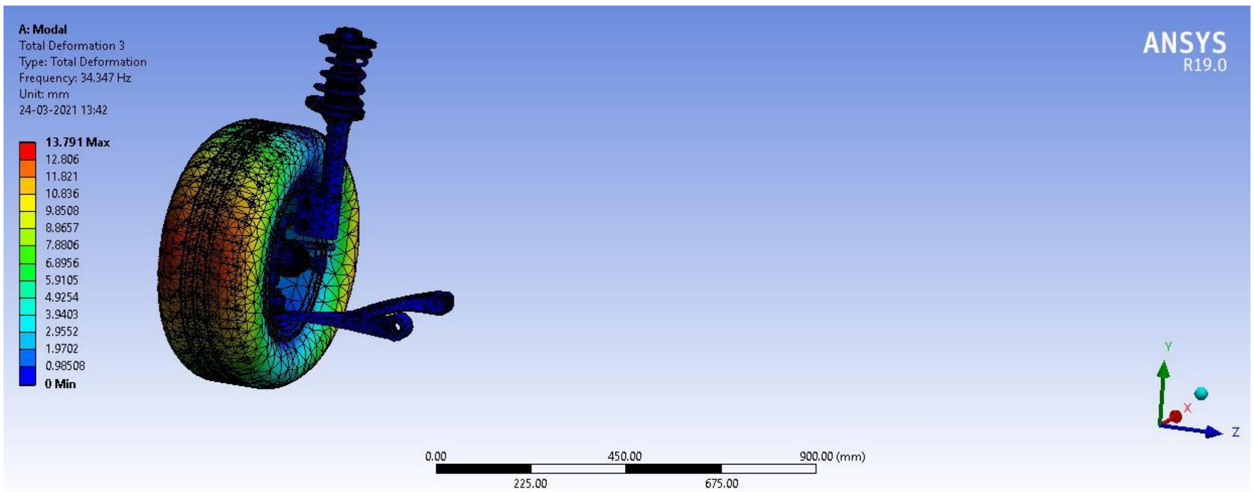
The modal analysis is performed on first 4 mode shapes. In first mode shape maximum deformation is 12.262 mm, in case of second mode shape maximum deformation is 58.409 mm, in case of third mode shape maximum deformation is 13.791 mm, and in case of fourth mode shape maximum deformation is 15.699 mm. The results for various cases of deformation under ANSYS modal analysis are shown in Figure 4.



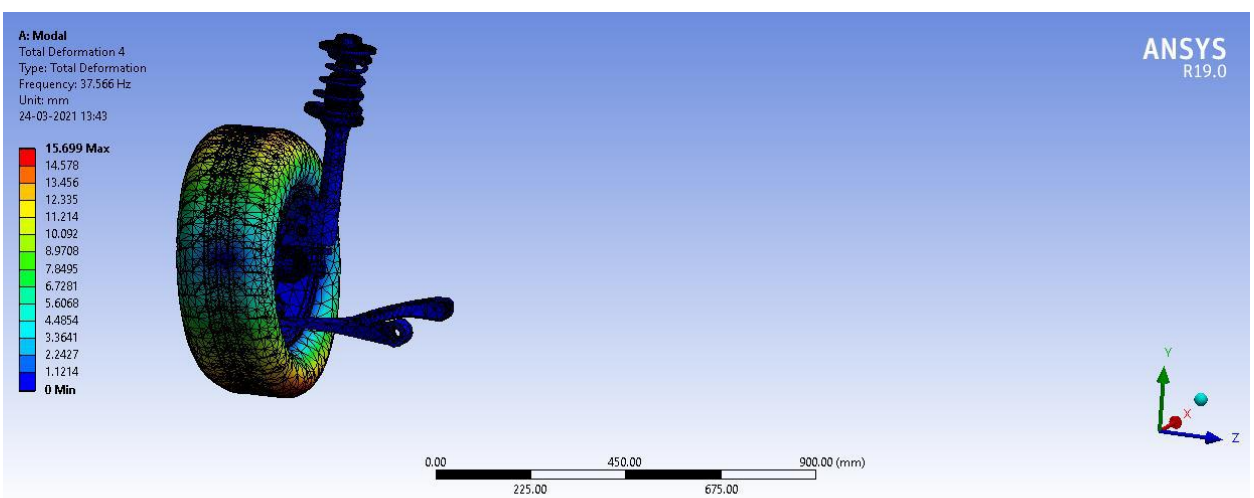
(a) First mode shape



(b) Second mode shape



(a) Third mode shape



(d) Fourth mode shape

Figure 4. Total Deformation for various modes of McPherson Strut assembly

Table No. 2 – Maximum Deformation and Natural Frequency for various Mode Shapes

Sr. No	Mode Shape	Maximum Deformation	Natural Frequency
1	First Mode Shape	12.262 mm	29.437 Hz
2	Second Mode Shape	58.409 mm	30.264 Hz
3	Third Mode Shape	13.791 mm	34.437 Hz
4	Fourth Mode Shape	15.699 mm	37.556 Hz

4. CONCLUSION

In the present work, a three-dimensional CAD model of a McPherson strut assembly is developed in Solid Works 2018. The developed CAD model of the McPherson strut assembly is then imported in the ANSYS software for the model analysis. In first mode shape maximum deformation is 12.262 mm and the natural frequency is 29.437 Hz, in case of second mode shape maximum deformation is 58.409 mm and the natural frequency is 30.264 Hz, in case of third mode shape maximum deformation is 13.791 mm and the natural frequency is 34.437 Hz, and in case of fourth mode shape maximum deformation is 15.699 mm and the natural frequency is 37.556 Hz while tyre was the part which was facing maximum deformation is all cases.

REFERENCES

- R.C. Sharma, S. Sharma, S.K. Sharma, N. Sharma N and G. Singh. 'Analysis of bio-dynamic model of seated human subject and optimization of the passenger ride comfort for three-wheel vehicle using random search technique', Proceedings of the Institution of Mechanical Engineers, Part K: Journal of Multi-body Dynamics. 2021, vol. 235, issue 1, pp.106–121.
- S. Bhardawaj, R.C. Sharma and S.K. Sharma. 'Ride Analysis of Track-Vehicle-Human Body Interaction Subjected to Random Excitation', Journal of the Chinese Society of Mechanical Engineers. 2020, vol. 41, issue, 2, pp. 229–238.

- R.C. Sharma. 'Ride, eigenvalue and stability analysis of three-wheel vehicle using Lagrangian dynamics', International Journal of Vehicle Noise and Vibration. 2017, vol. 13, issue, 1, pp. 13–25.
- Palli S, Sharma RC and Rao PPD. Dynamic behaviour of a 7 DoF passenger car model. International Journal of Vehicle Structures and Systems. 2017, vol. 9, issue1, pp. 57–63.
- Purushotham, 'Comparative Simulation studies on MacPherson Suspension System', International Journal of Modern Engineering Research. Vol.3, Issue.3, May-June. 2013 pp-1377-1381.
- Slavica MAČUŽIĆ, Jovanka LUKIĆ, Dragan RUŽIĆ Three-Dimensional Simulation of the McPherson Suspension System, Vol. 25, Issue.5, 1286-1290, 2018.
- Lu Sun,' Optimum design of ''road-friendly'' vehicle suspension systems subjected to rough pavement surfaces', Applied Mathematical Modelling 26, 2002, pp 635-652.
- M.J. Thoresson, P.E. Uys, P.S. Els, J.A. Snyman,' Efficient optimization of a vehicle suspension system, using a gradient-based approximation method', Mathematical and Computer Modelling, 2009, pp 1421-1436.
- M. Mahmoodi Kaleibar, I. Javanshir, K. Asadi and A. Afkar, A. Paykani,' Optimization of suspension system of off-road vehicle for vehicle performance improvement', central south university press and springer verlag berlin Heidelberg 2013, 2013, pp 902-910.
- Husain Kanchwala, Wu Nan, and HarutoshiOgai,'model Building, Hard point Optimization & Experimental Correlation of a Single Seater EV- Toyota COMS', International Conference on Research in Science, Engineering and Technology, 2014, pp 66-73
- S.C.Jain, P.K. Sharma, D. Vadodaria, 'McPherson Suspension System', International Journal For Technological Research In Engineering Volume 1, August-2014, pp 1496-1498.
- Jiao Wang, Xuekai Qu, Jiapeng Hanand and Shuai Xing, 'The K & C Analysis and Optimization of McPherson Suspension', International Journal of Applied Science and Mathematics Vol 3, 2016, pp 205-210.