# *ANALYSIS OF REAR AXLE SHAFT OF TRACTOR USING COMPOSITE MATERIAL.*

**This project investigates the stress and vibration characteristics of a tractor's rear axle shaft, a key component in power transmission and load-bearing. The study includes:**

- **Material Analysis: Examines properties of Carbon Fiber, E-Glass, Cast Iron, and Composite materials, focusing on density, Young's modulus, shear modulus, and Poisson's ratio to assess suitability for axle design.**
- **Torque Calculation: Computes engine torque under operational conditions to evaluate performance.**
- **Solid Modeling: Develops 3D models for structural and vibrational analysis.**

**The analysis provides insights into material behavior and structural efficiency, supporting improvements in axle shaft design for enhanced durability and reliability in agricultural machinery.**

**~Prince Gupta**

# ABSTRACT

Tractor is an off-road vehicle which is considered to be any type of vehicle which is capable of driving on and off paved or gravel surfaces. Off road condition includes uneven agricultural field surfaces and bumpy village roads on which the tractor has to operate. Thus it is important to analyze the rear axle shaft of the tractor so that we can solve problems regarding breakdowns and failures during field operations. In this project, the material of the rear axle shaft is to be modified with composite materials and its corresponding mechanical properties were to be determined using standard test methods as well as using softwares.

The rear axle shaft is a critical component in agricultural tractors, tasked with transmitting power from the engine to the wheels under varying operational conditions. However, the axle shaft is subjected to significant stresses and vibrations, potentially leading to fatigue and failure. This research employs a multidisciplinary approach, integrating principles of mechanical engineering, materials science, and vibration analysis, to comprehensively analyze stress and vibration patterns.

Advanced computational simulations, including Finite Element Analysis (FEA), and experimental testing are employed to quantify stress distributions, strain levels, and dynamic responses of the rear axle shaft. The study aims to identify potential areas of concern and propose design enhancements or maintenance practices to augment performance and durability. Through this analysis, insights will be gained to optimize the safety, reliability, and efficiency of agricultural tractors, impacting the agricultural industry positively.

# INTRODUCTION

Title: Analysis of Stress and Vibration on Rear Axle Shaft of Tractor

The rear axle shaft is a critical component in the drivetrain of a tractor, responsible for transmitting power from the engine to the wheels. It plays a pivotal role in ensuring the proper functioning and mobility of the vehicle. However, the rear axle shaft is subject to various external forces, including stresses and vibrations, during operation. These factors can lead to fatigue, wear, and ultimately, failure of the axle shaft if not properly addressed.

Understanding the dynamic behavior of the rear axle shaft is paramount for ensuring its longevity and reliability in agricultural operations. This analysis aims to delve into the intricate interactions between the tractor's mechanical components, load distribution, and external forces acting on the rear axle shaft. By comprehensively assessing stress and vibration patterns, we seek to identify potential areas of concern and implement design improvements or maintenance practices to enhance performance and durability.

This study is structured to encompass a multidisciplinary approach, combining principles of mechanical engineering, materials science, and vibration analysis. We will employ advanced computational simulations, finite element analysis (FEA), and experimental testing to quantify and visualize stress distributions, strain levels, and dynamic responses of the rear axle shaft under various operating conditions.

Agricultural tractors stand as the backbone of modern farming, facilitating a wide array of essential tasks from plowing to harvesting. Among its crucial components, the rear axle shaft plays a pivotal role in transmitting power from the engine to the wheels, enabling efficient movement across varying terrains. However, the harsh operational conditions to which tractors are subjected often subject this component to substantial stresses and vibrations.

Understanding the dynamic behavior of the rear axle shaft is paramount to ensure the continued reliability and longevity of agricultural machinery. This project endeavors to conduct a thorough analysis of the stress and vibration patterns experienced by the rear axle shaft during operation. By employing advanced computational simulations, finite element analysis (FEA), and experimental testing, we aim to quantify and visualize stress distributions, strain levels, and dynamic responses of the rear axle shaft under diverse operating conditions.

The primary objectives of this study encompass evaluating material properties, analyzing loads, conducting finite element analysis, investigating vibration characteristics, performing failure mode analysis, and formulating practical recommendations. Through this multidisciplinary approach, which integrates principles of mechanical engineering, materials science, and vibration analysis, we seek to identify potential areas of concern and implement design improvements or maintenance practices that will ultimately enhance the performance and durability of the rear axle shaft.

This research represents a critical endeavor to advance the field of agricultural engineering, addressing a fundamental component of tractor functionality. The insights gained from this analysis are poised to not only optimize the safety and reliability of tractors but also contribute to the broader agricultural industry's quest for enhanced efficiency and sustainability. By conducting this comprehensive assessment, we aim to provide valuable knowledge and actionable recommendations that will benefit tractor manufacturers, engineers, and agricultural practitioners alike, driving progress in modern farming practices.

# LITERATURE REVIEW

### [1] Evaluating For Rear Axle Housing Using Hybrid Aluminium Composites

Guruprasad.B,Arun.L, and Mohan.KDepartment of Mechanical Engineering, The Oxford College of Engineering, Bangalore.It is observed experimentally that the reinforced aluminium with Fly ash enhances mechanical properties in comparison with monolithic metal.The fatigue factor of safety is calculated for constant amplitude load varied from 1820 N to 91000 N. The fatigue factor of safety is calculated for fatigue strength corresponds to 8e5 cycles

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### [2] Analysis And Design Of Tractor Rear Axle Shaft Using Finite Element Method

Piyush. C. Chaudhari, Vimal. D. Sonara, and Dr.Pravin. P. Rathod1PG Scholar, Mechanical Engg. Department,

Gov. Engg. college, Bhuj-370001, India, Presented paper on Analysis and Design of Tractor Rear Axle using Finite Element Method The axle shaft is likely to break at 144233 km whereas the warranty is for about 150000 km.Fractographic features indicated that fatigue was the main cause of failure of the axle shaft. It was observed that the fatigue cracks originated from welded areas.

### [3] Failure Analysis For Rear Axle Of Tractor With Loaded Trolley

A.K. Acharya et al.Failure analysis of rear axle of a tractor with loaded trolley" This paper describes the failure analysis of the rear axle at the root of the spline of a tractor with a loaded trolley used for haulage .The front wheel lifting and the failure of the rear axle at the root of the spline though mainly due to the transfer of weight, not sufficient attention. By reducing the hitching height and it was observed that by reducing the hitching height to 16.00 inches with reduction in the weight transfer factor by nearly 20%. G.K. Nanaware et al. Failures of rear axle shafts of 575 DI tractors "Studied on Rear axle shafts of 575 DI tractors manufactured by Mahindra and Mahindra Ltd"

# PROBLEM FORMULATION

The rear axle shaft is a pivotal component in the drivetrain of agricultural tractors, responsible for transmitting power from the engine to the wheels. However, this crucial element is subjected to significant stresses and vibrations during operation. These external forces, arising from factors such as uneven terrain, towing, and sudden accelerations or decelerations, can lead to premature wear, fatigue, and ultimately, failure of the axle shaft.

The overarching issue is to ensure the longevity, safety, and reliability of tractor rear axle shafts under these demanding operational conditions. There is a critical need for a comprehensive analysis that can unravel the intricate interactions between mechanical components, load distribution, and external forces acting on the rear axle shaft. This includes understanding stress distributions, strain levels, and dynamic responses of the component.

Moreover, identifying potential areas of concern, critical points of stress concentration, and resonance points due to vibrations is crucial. From this analysis, actionable recommendations need to be developed. These may encompass design modifications, material enhancements, and maintenance practices to mitigate stress and vibration-related issues and ultimately enhance the performance and longevity of the rear axle shaft.

The study aims to address this pressing problem in agricultural engineering, with the ultimate goal of providing valuable insights and practical solutions that can revolutionize the safety, reliability, and efficiency of agricultural tractors in demanding operational environments.

# CONCLUSION

The comprehensive analysis of stress and vibration on the rear axle shaft of tractors has yielded valuable insights into the behavior of this critical component under demanding operational conditions. Through advanced computational simulations and experimental testing, we have gained a deep understanding of the dynamic responses, stress distributions, and strain levels experienced by the rear axle shaft.

The findings highlight areas of concern, including critical points of stress concentration, potential failure modes, and resonance points due to vibrations. This knowledge is instrumental in formulating targeted recommendations for enhancing the performance and durability of rear axle shafts in agricultural tractors.

Proposed solutions encompass design modifications, material enhancements, and maintenance practices that aim to mitigate stress and vibration-related issues. These recommendations hold the potential to revolutionize the safety, reliability, and efficiency of agricultural tractors, ultimately benefiting the agricultural industry and the communities that rely on these indispensable machines.

By addressing this pressing issue in agricultural engineering, we aspire to contribute to a safer, more efficient, and sustainable future for farming operations. This research represents a significant stride forward in advancing the field of agricultural machinery design and maintenance, with far-reaching implications for the agricultural industry as a whole.

# FUTURE SCOPE

The analysis of stress and vibration on the rear axle shaft of tractors opens up several avenues for future research and development in the field of agricultural engineering. Some potential areas of future investigation include:

**1. Advanced Materials and Composites:**

- Research into the development of advanced materials and composites with superior fatigue resistance and enhanced mechanical properties for rear axle shafts.

**2. Smart Monitoring and Predictive Maintenance:**

- Integration of sensor technologies and IoT (Internet of Things) for real-time monitoring of rear axle shaft conditions, allowing for predictive maintenance strategies.

**3. Dynamic Load Modeling:**

- Further refinement of dynamic load models to accurately simulate and predict the loads experienced by the rear axle shaft in various operational scenarios.

**4. Optimization through Topology and Parameter Studies:**

- Utilization of optimization techniques to refine rear axle shaft designs for improved performance, efficiency, and durability.

**5. Incorporation of Damping Solutions:**

- Exploration of innovative damping solutions to mitigate vibration-related issues and enhance the overall performance of the rear axle shaft.

**6. Material Surface Treatments:**

- Investigation of surface treatments, coatings, or heat treatments to improve the wear resistance and fatigue life of the rear axle shaft.

**7. Integration with Vehicle Dynamics Studies:**

- Integration of rear axle shaft analysis with vehicle dynamics studies to gain a comprehensive understanding of the interactions between various components.

**8. Environmental Impact Assessment:**

- Evaluation of the environmental impact of rear axle shaft materials and manufacturing processes, with a focus on sustainability and resource efficiency.

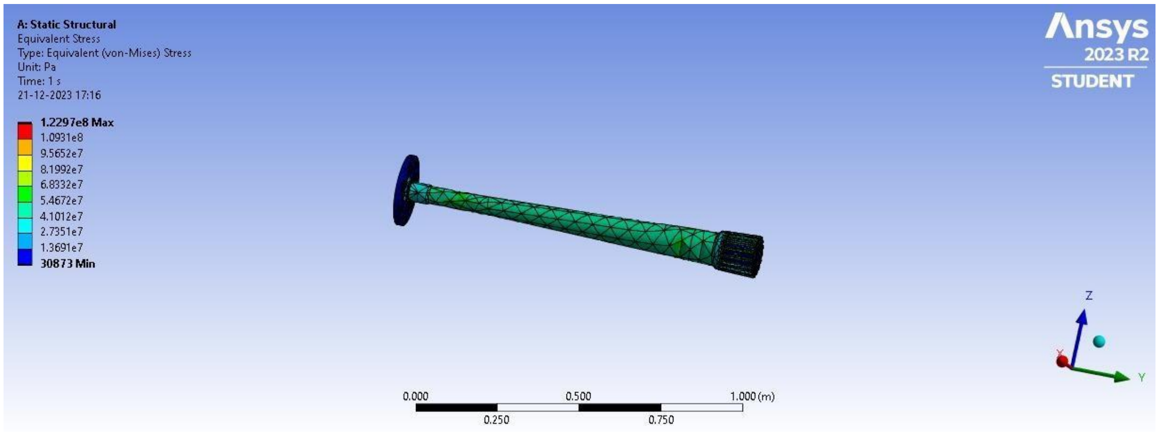
**9. Validation with Field Testing:**

- Conducting field tests on tractors equipped with modified rear axle shafts to validate the effectiveness of proposed design enhancements.

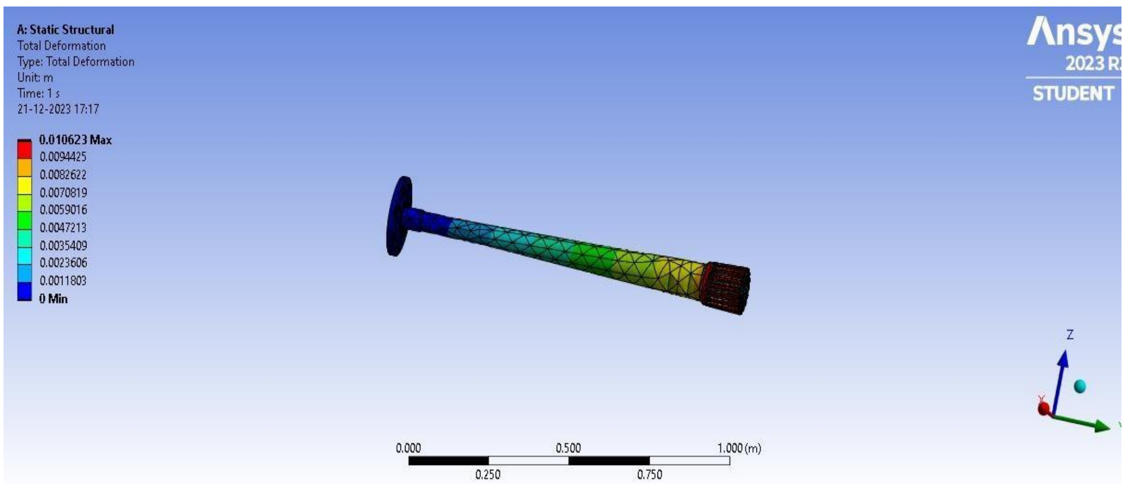
# EXPERIMENTAL DATA

## 1. CARBON FIBRE

### 1.1. STRESS

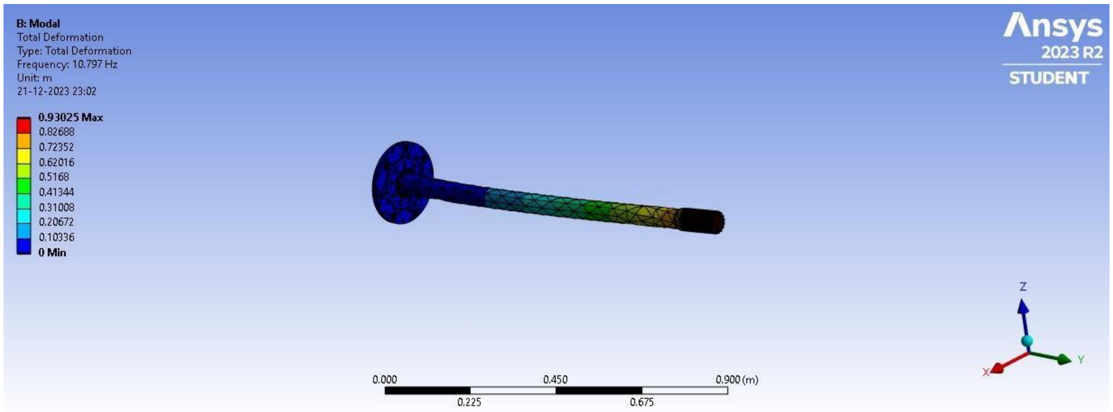



### 1.2. DEFORMATION

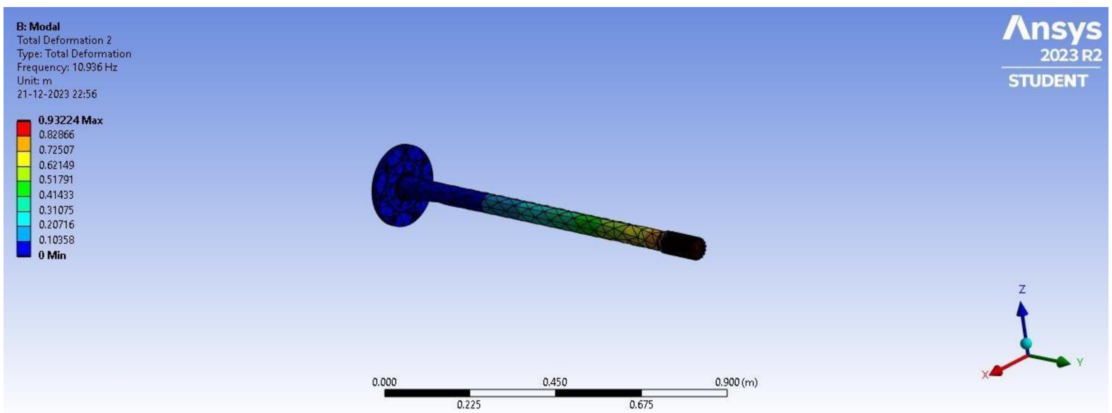


## 1.3. DEFORMATION WITH FREQUENCY

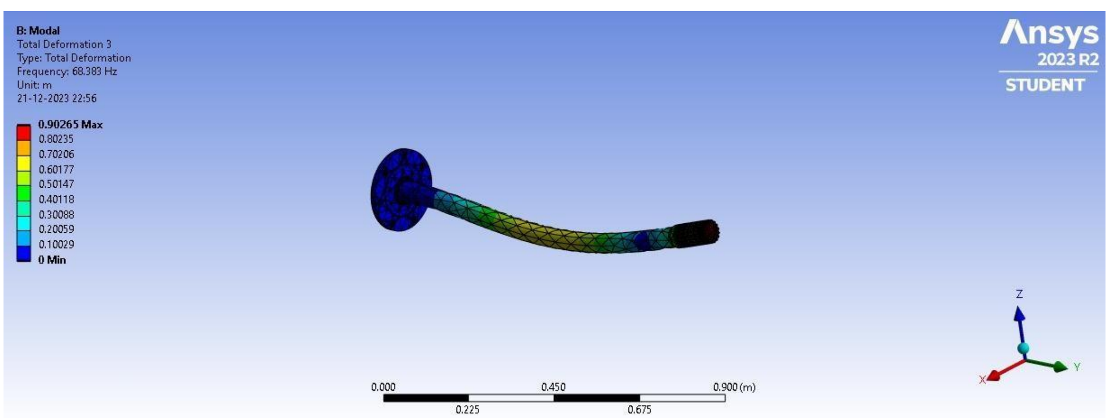
### a) Frequency=10.797Hz



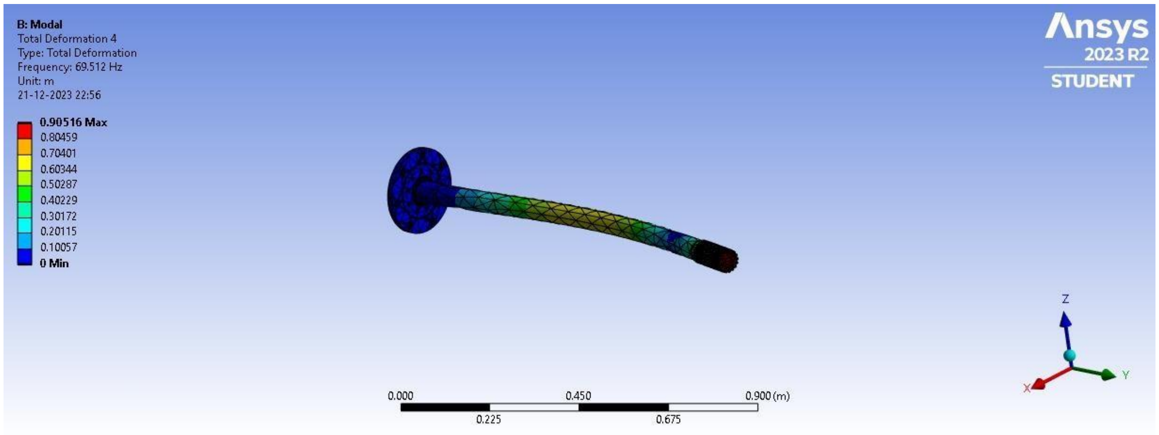

### b) Frequency=10.936Hz



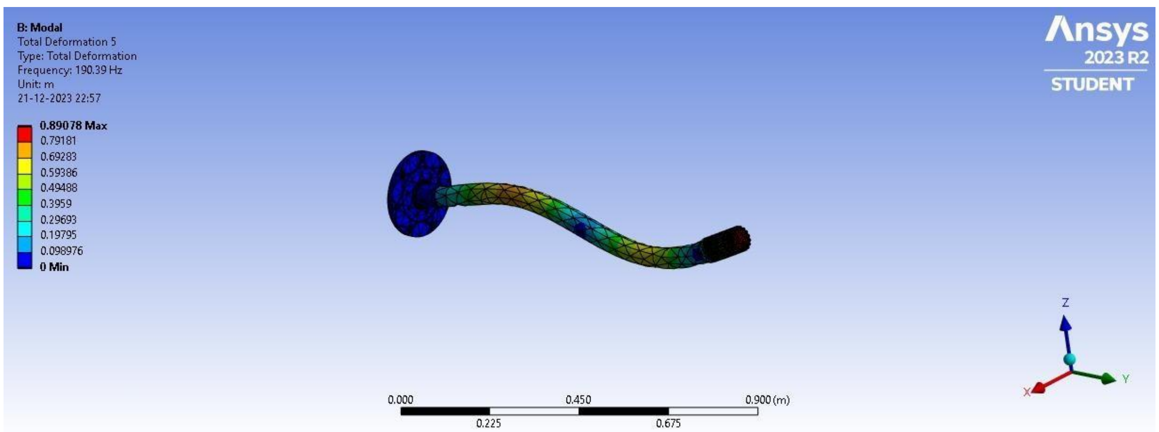

### c) Frequency=68.383Hz



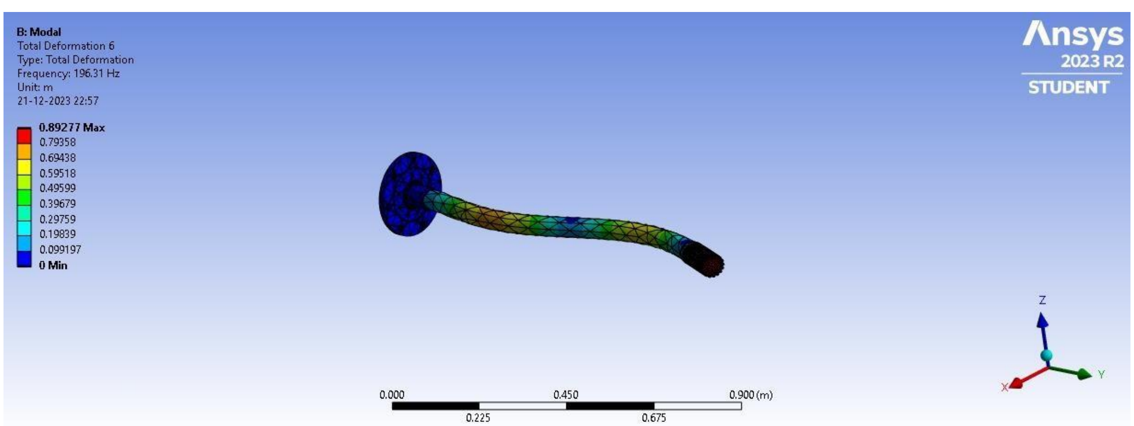
## d) Frequency=69.512Hz



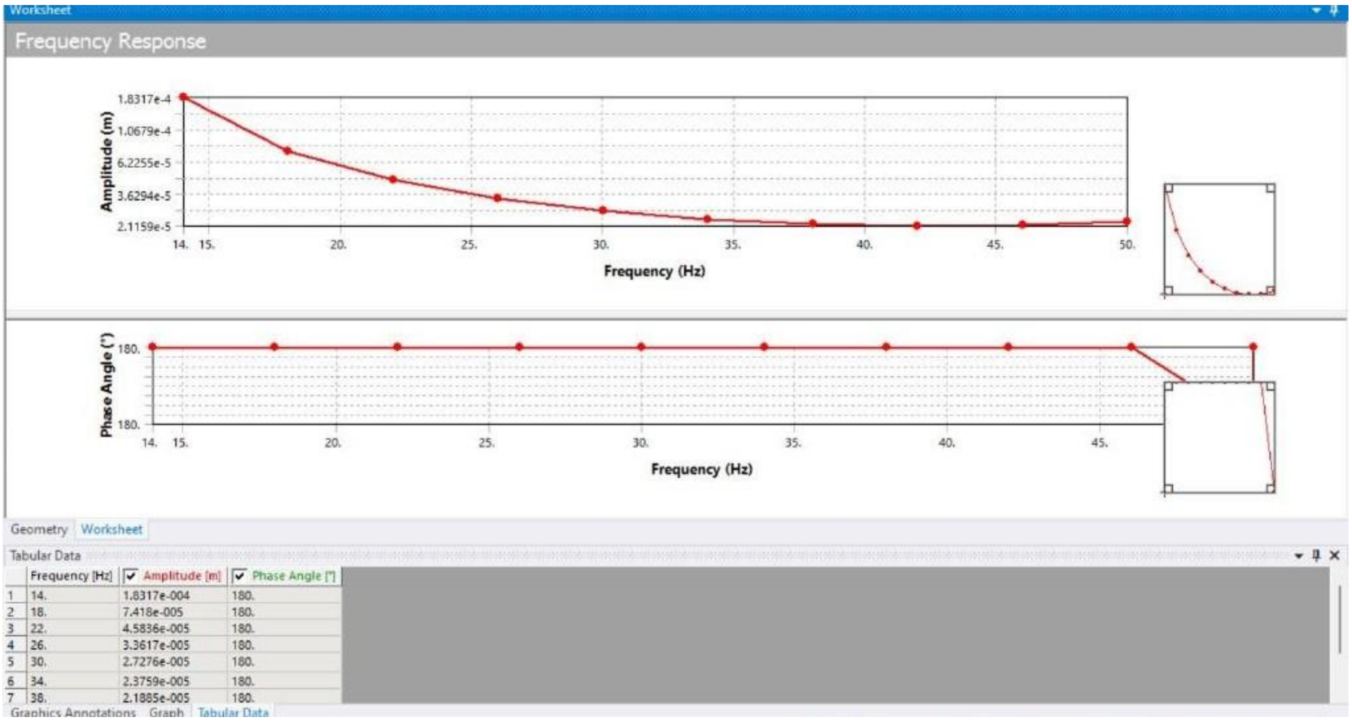

## e)Frequency=190.09Hz




## f)Frequency=196.31Hz

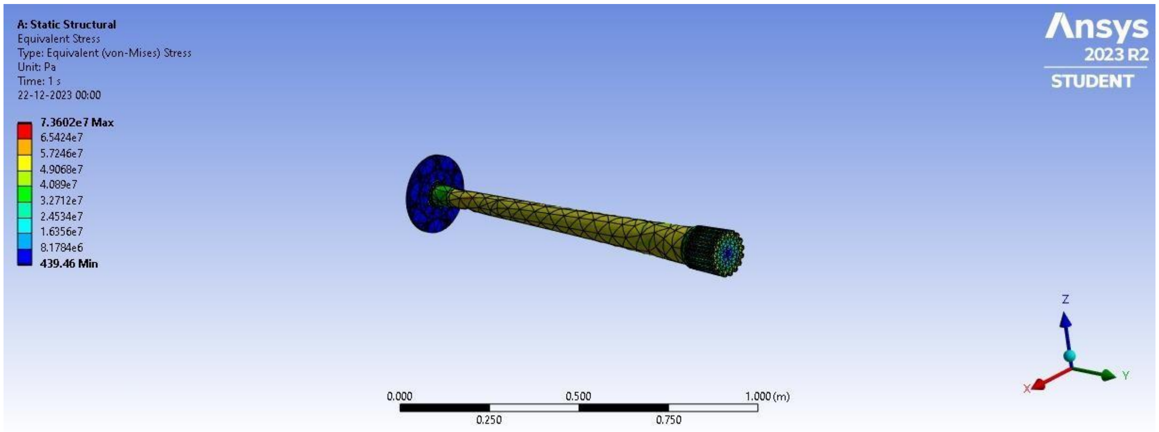


# e) Amplitude Vs Frequency

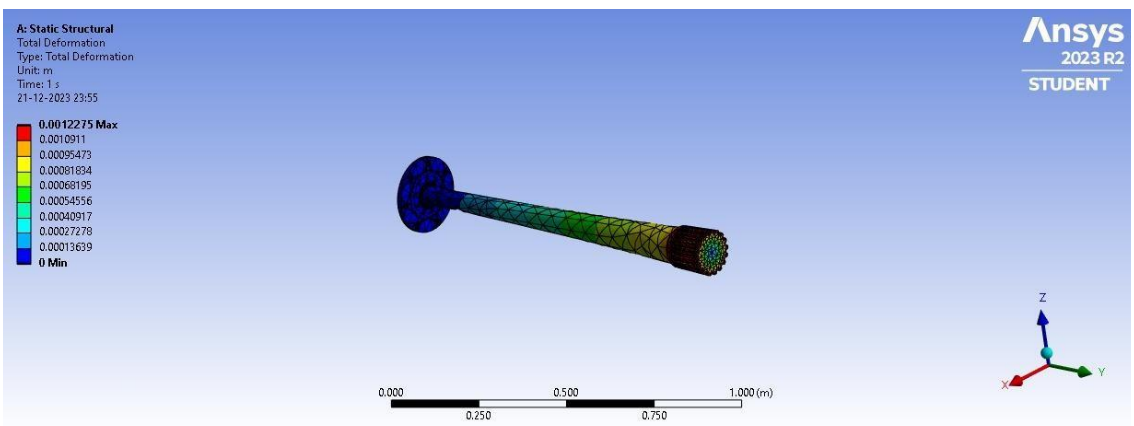


# 2-E-GLASS

## 2.1. STRESS




## 2.2. DEFORMATION



## 2.3. DEFORMATION WITH FREQUENCY

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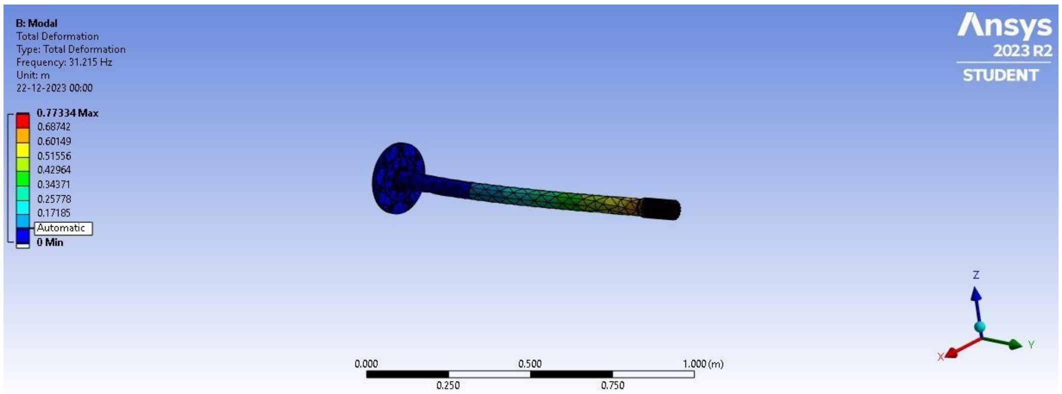
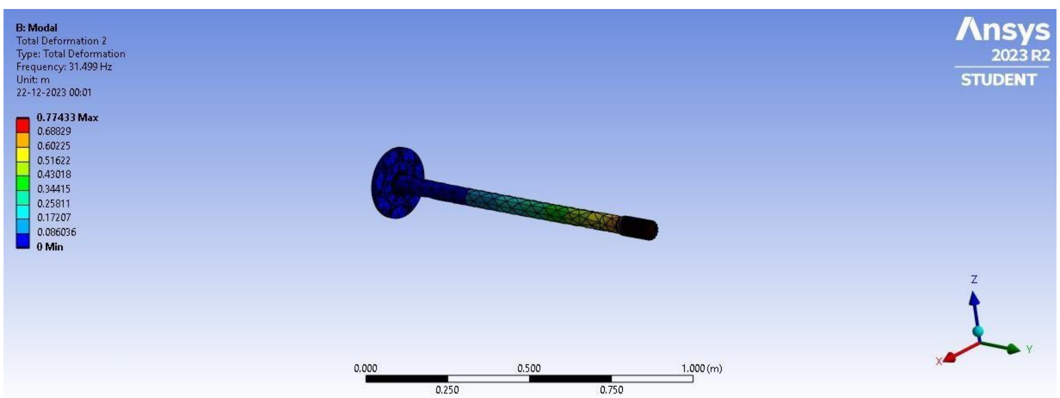
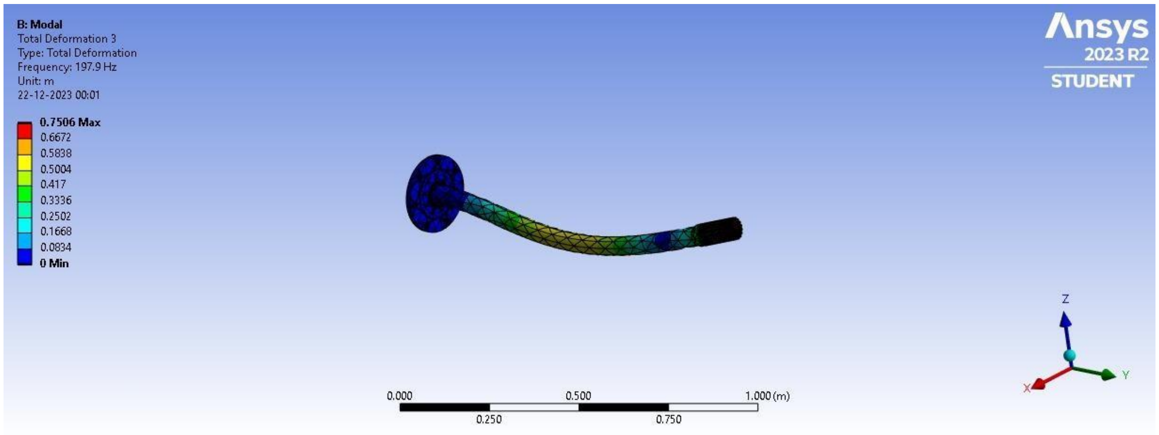


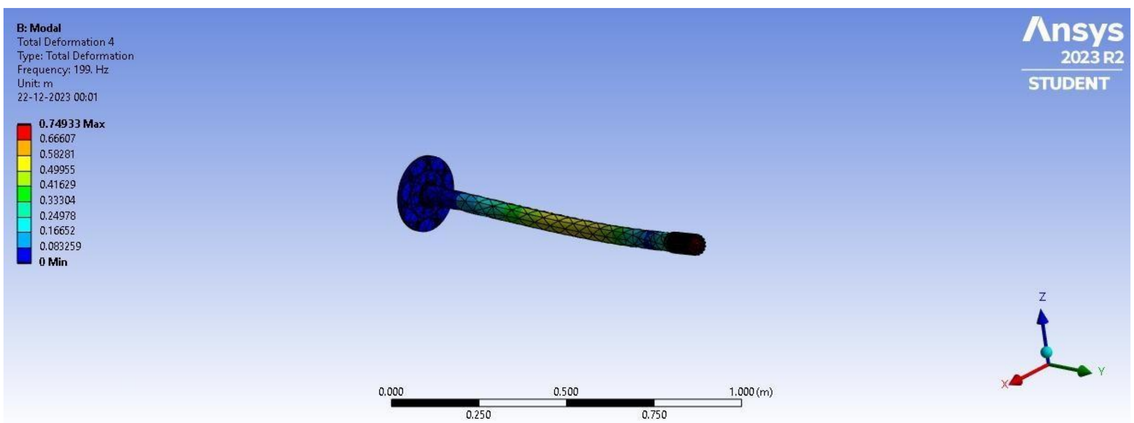

### b) Frequency=31.499Hz



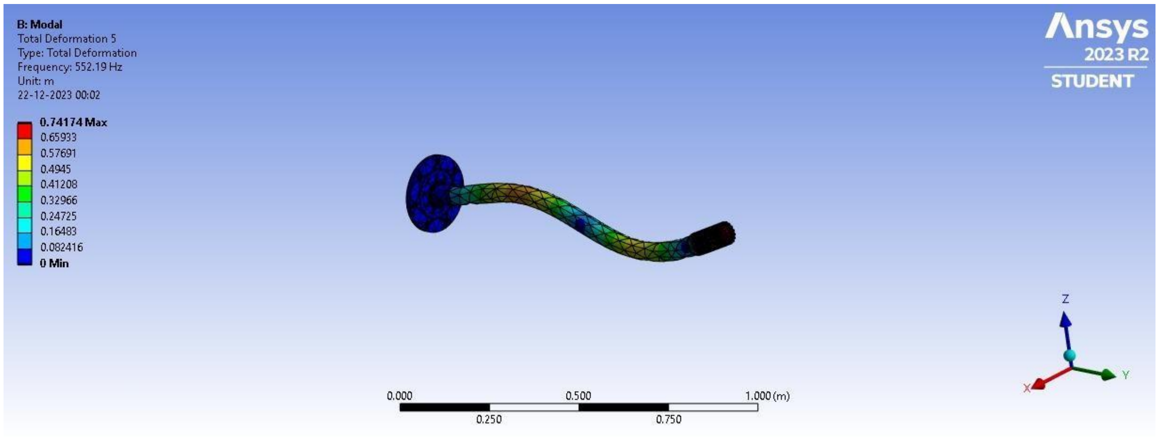
## c) Frequency=197.9Hz



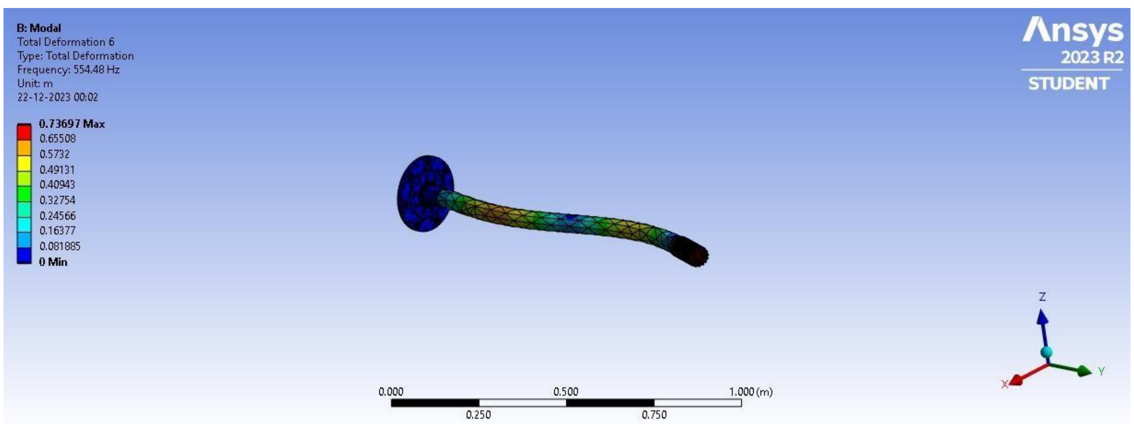

## d) Frequency=199Hz



# e) Frequency=552.19Hz

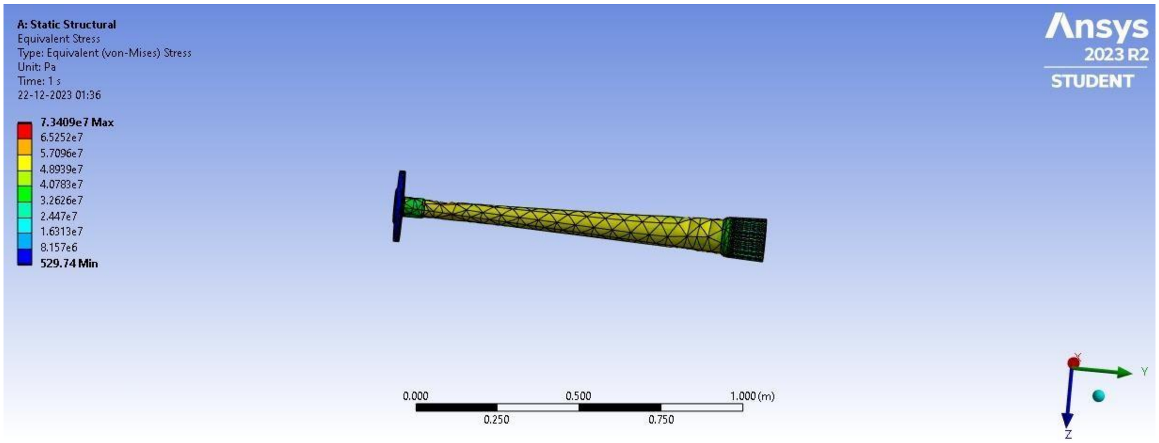



# f) Frequency=554.48Hz

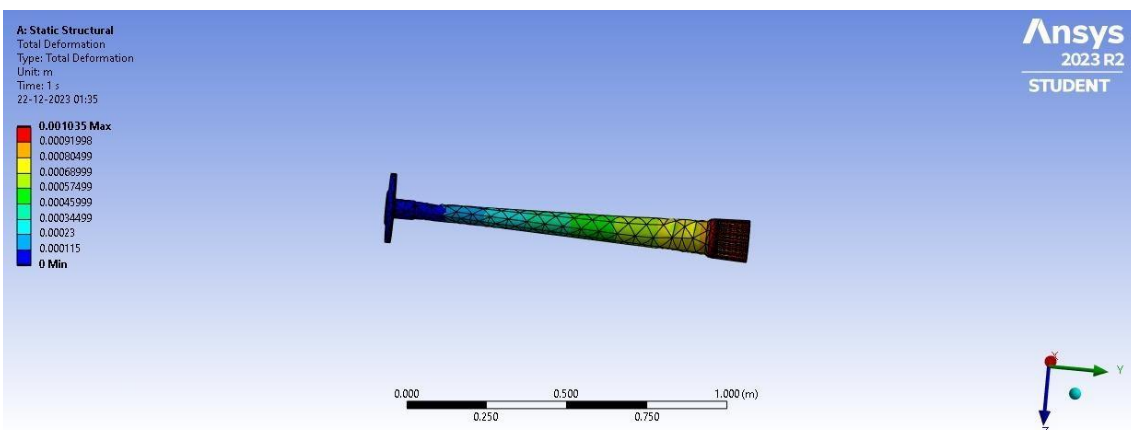


# 3-CAST IRON

## 3.1. STRESS

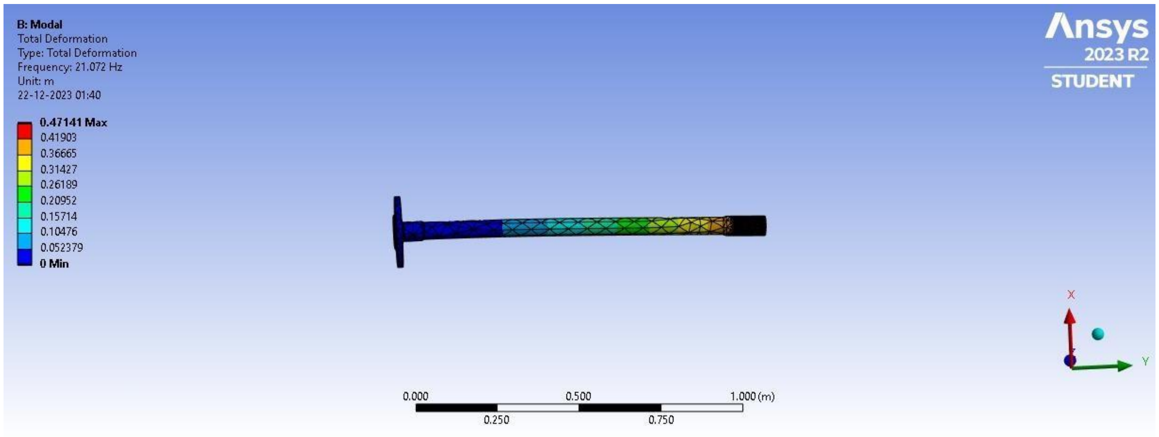



## 3.2. DEFORMATION

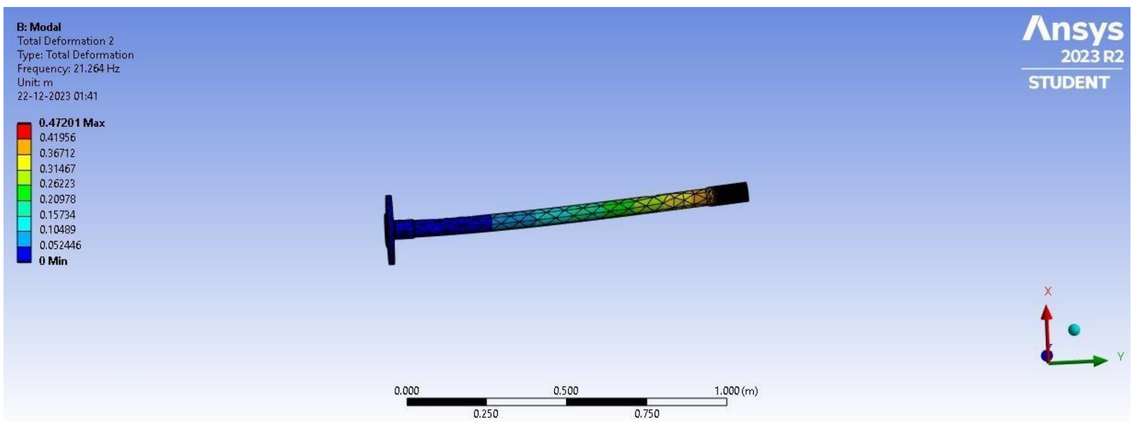


## 3.3. DEFORMATION WITH FREQUENCY

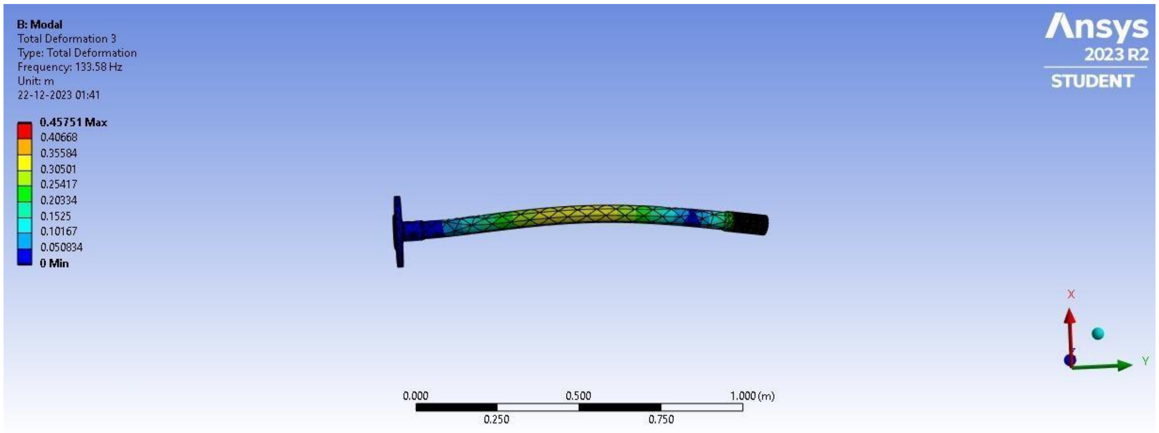
### a) Frequency=21.072Hz



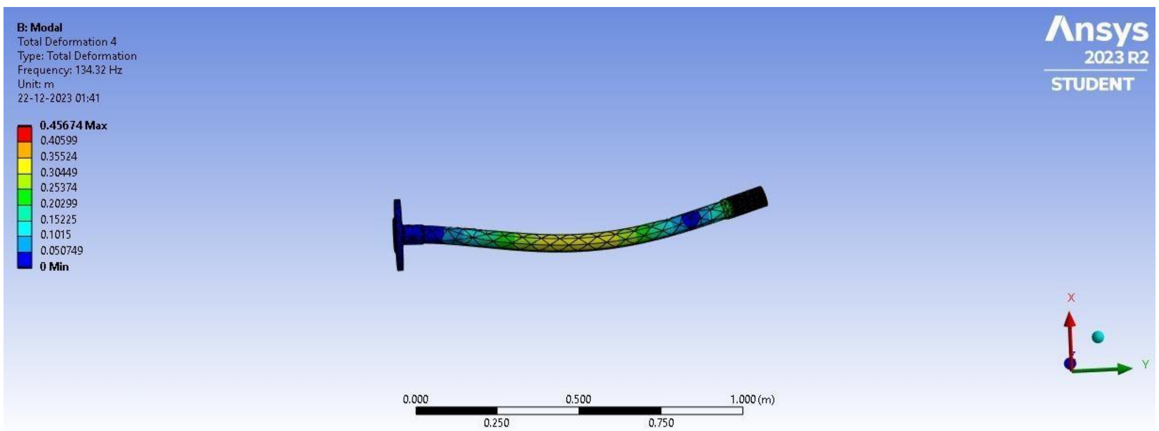

### b) Frequency=21.264Hz



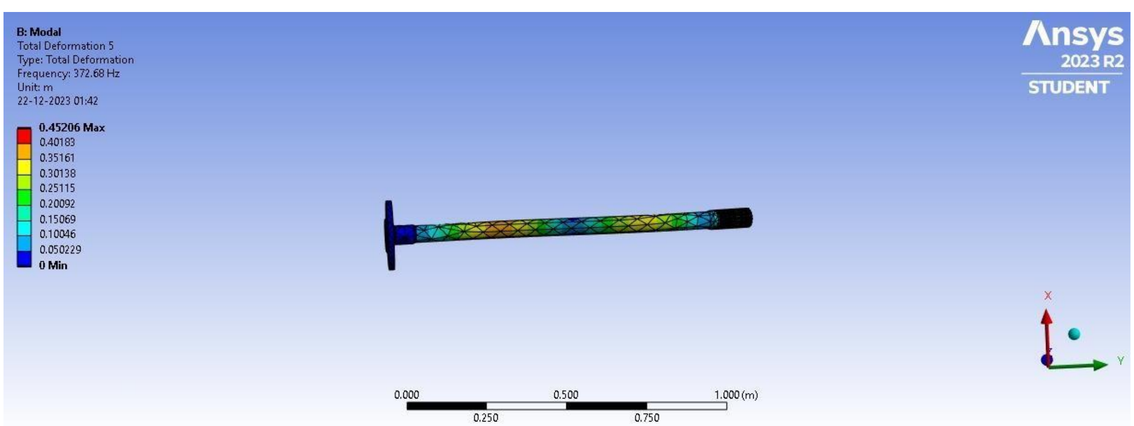
## c) Frequency=133.58Hz



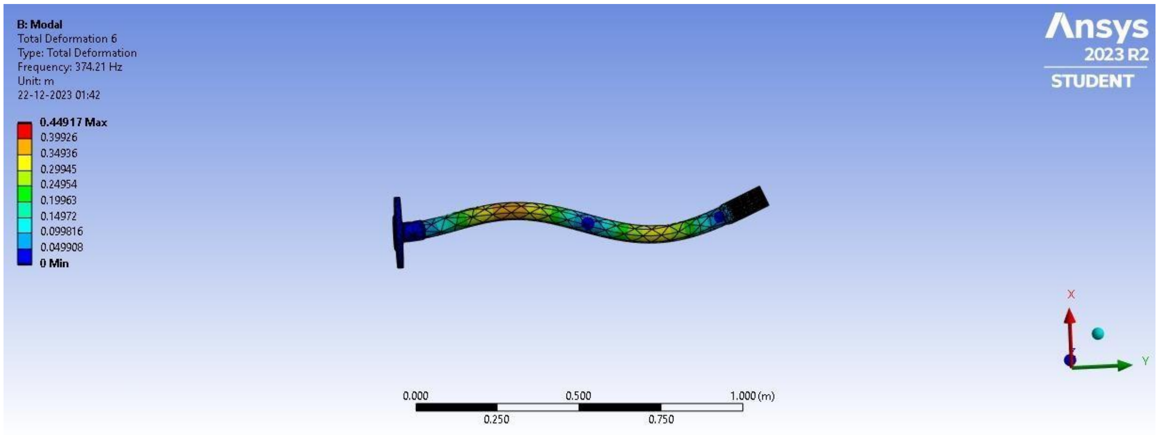

## d) Frequency=134.32Hz



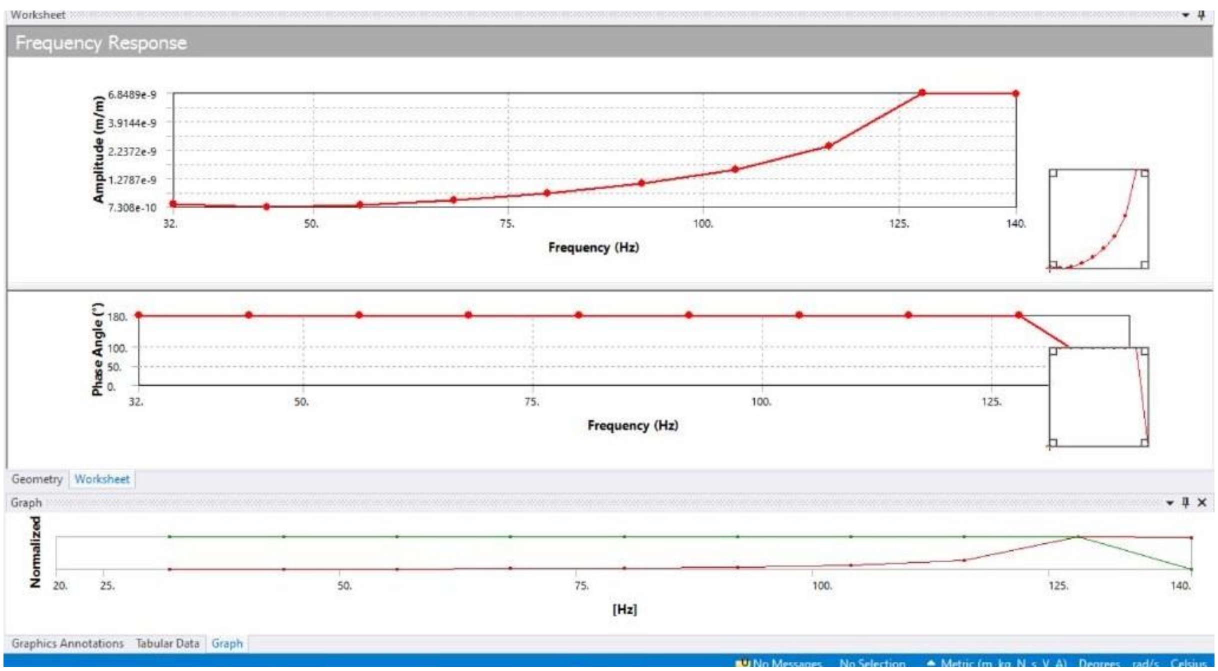

## e) Frequency=372.60Hz



## f) Frequency=374.21Hz

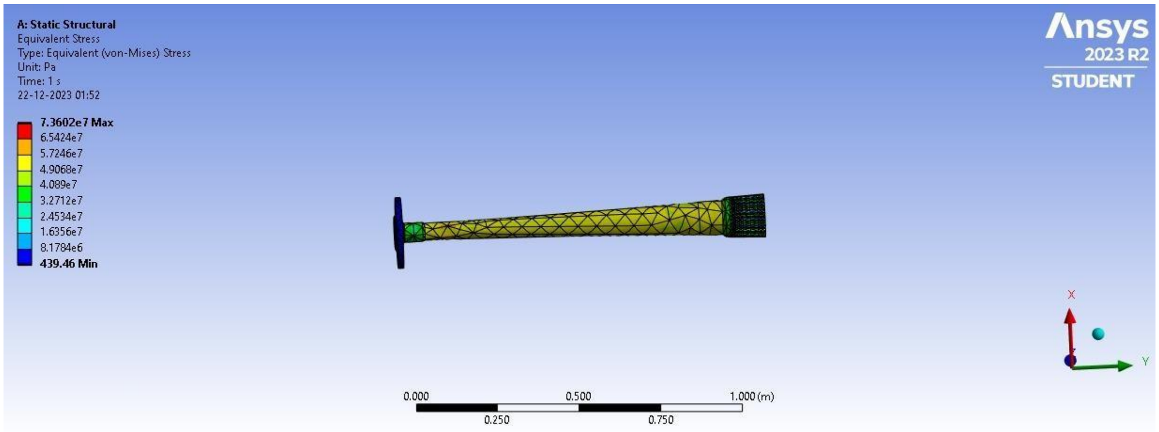



## Amplitude Vs Frequency

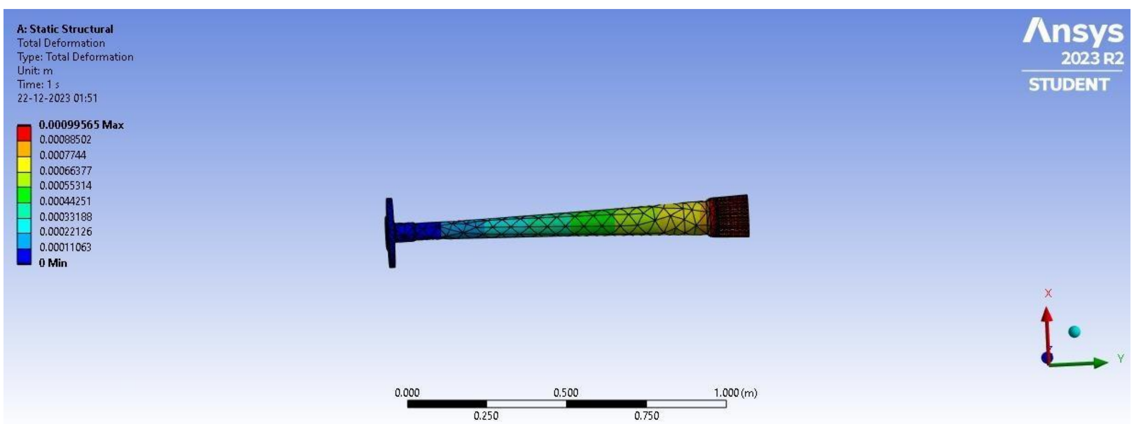


# 4-COMPOSITE MATERIAL

## 4.1. STRESS

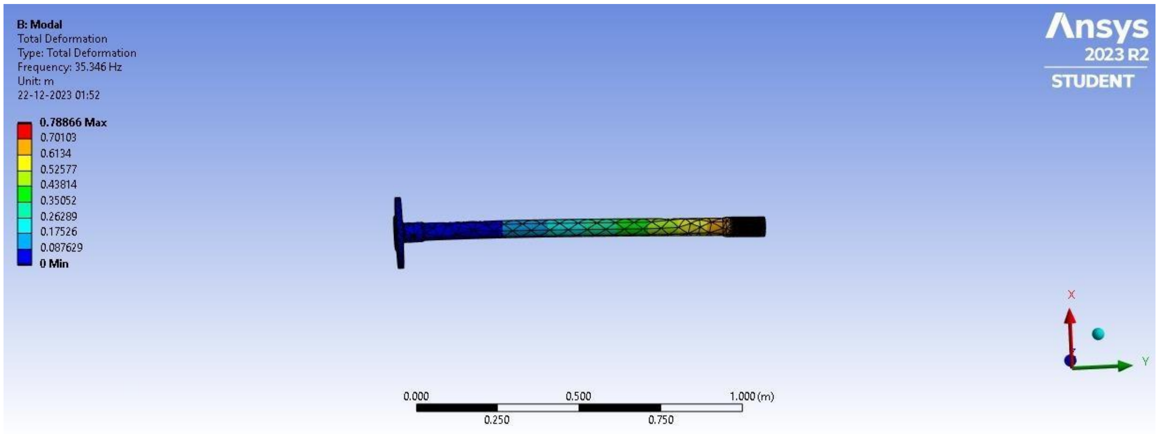



## 4.2. DEFORMATION

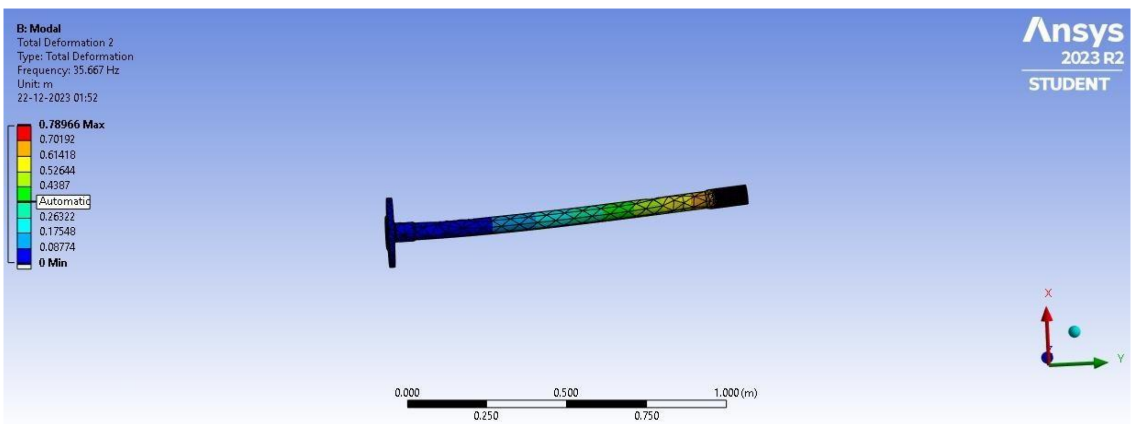


## 4.3. DEFORMATION WITH FREQUENCY

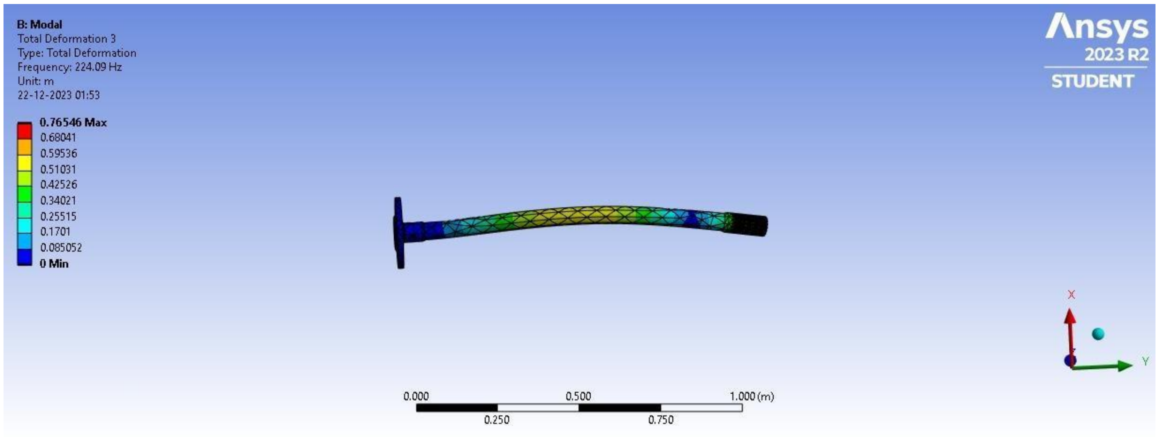
### a) Frequency=35.346Hz



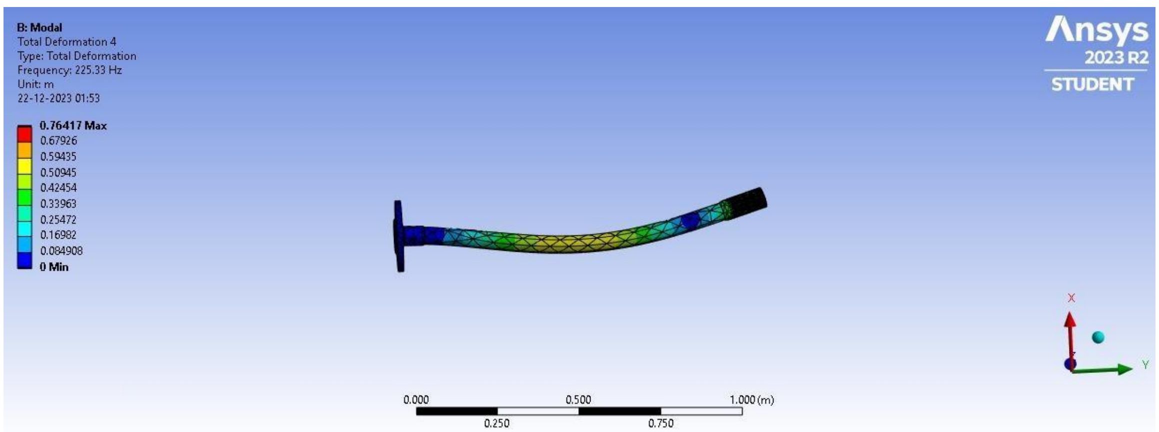

### b) Frequency=35.667Hz



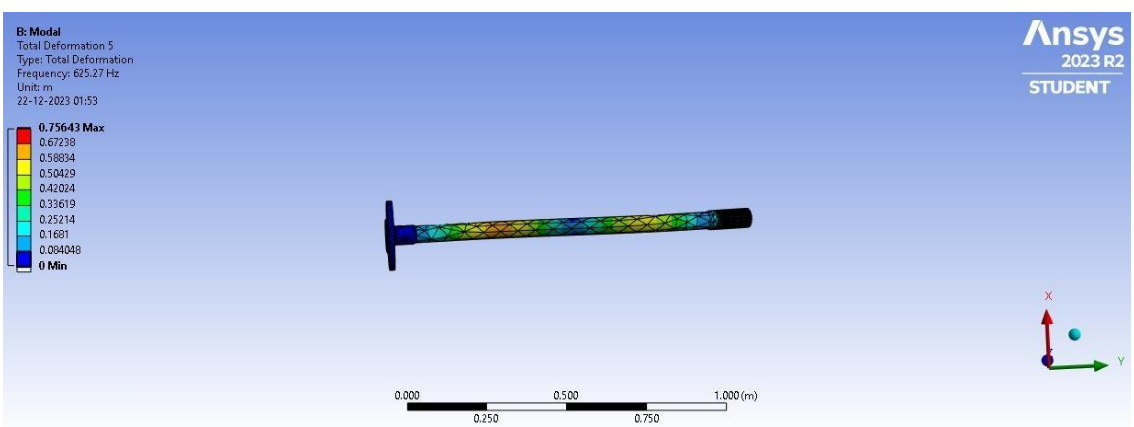
## c) Frequency=224.09Hz



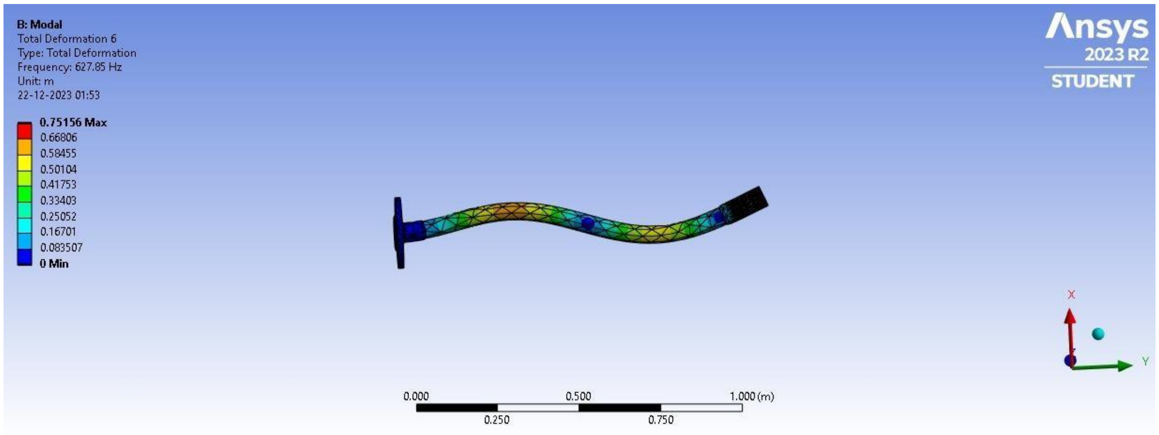

## d) Frequency=225.33Hz



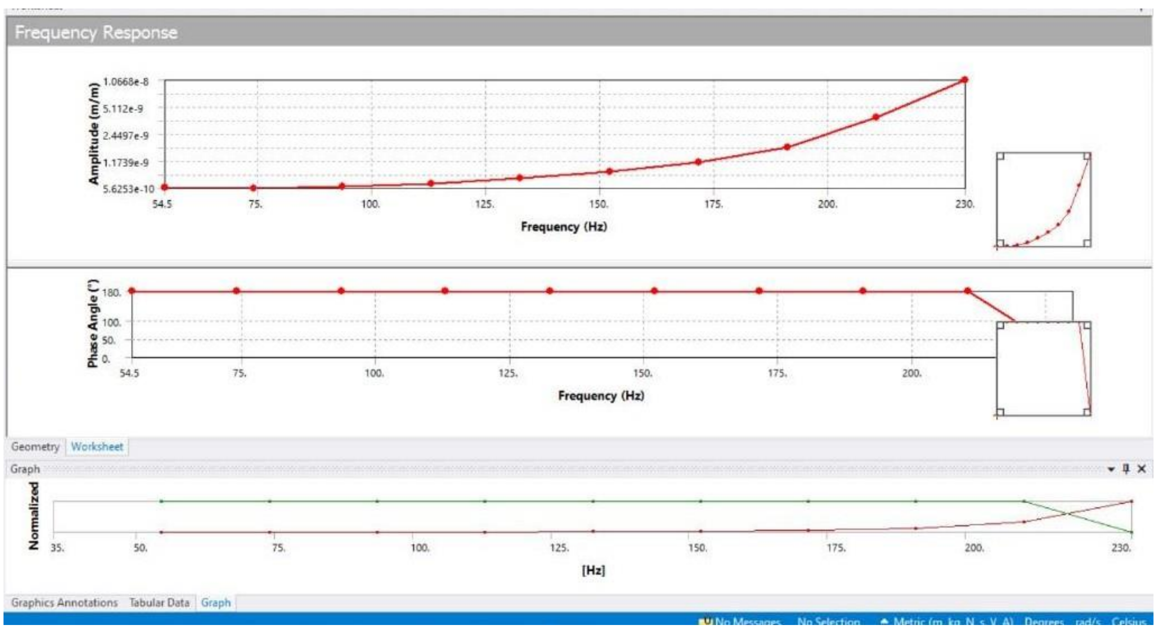

## e) Frequency=625.27Hz



## f) Frequency=627.85Hz




## Amplitude Vs Frequency



# CALCULATION

## Engine Torque Calculation

Maximum speed of a tractor = 80 km/h

Length of the propeller shaft = 0.8m

Rotational Speed n = 2300 rpm

Maximum Horsepower P = 280HP i.e., 210 kW

Torque T = P / 2 π n = (210 kW) (1000 W/kW) / 2 π (2300 rev/min) / (60 sec/min)

=871.8 Nm

MAX Force on Differential Unit is

Force= Torque / Length = 871.8/ 0.8 = 1.089 KN

## Stress Calculations For Circular Shaft

Weight on each Rear Tyre (F) : 5000N

Length of Axle shaft : 0.800m

Diameter of the Shaft:0.05m

Stress: =F/A

Area of the Shaft (A) = 2rh + 2Rh =2*3.14*(0.05)*0.8 + 2*3.14*(0.19) *0.025

=0.28103 Sq m

Therefore,

Stress =5000/ 0.28103 =0.17791*10^5 Pa.

# REFERENCES


[1] Piyush. C. Chaudhari, Vimal. D. Sonara, and Dr.Pravin. P. Rathod. “Analysis And Design Of Tractor Rear Axle Using Finite Element Method”.

[2] A.K. Acharya et al. “Failure Analysis For Rear Axle Of Tractor With Loaded Trolley”.

[3] Guruprasad. B, Arun. L, and Mohan. K. “Evaluating For Rear Axle Housing Using Aluminium Composites”.

[4] R. Oyyarvelu , K. Annamalai et al. “Design And Analysis Of Front Axle For Two wheel Drive Tractor”.

[5] Shantanu Ramesh Shinde et al. “Advancement In Simulation Of Front Axle Of Tractor”.