Final Year Project Showcase Batch-2020
Year 2024

Department: Automotive & Marine Engineering Programme: Automotive Engineering	
1	**Project Title** Condition monitoring of a vehicle using vibration measurement techniques.
2	**Project Idea** Our project aims to develop an advanced vehicle condition monitoring system using vibration measurement techniques. By integrating the ADXL 345 accelerometer on the vehicle's dashboard,the system will capture and analyze vertical vibrations within the passenger compartment across different roads & speeds conditions. This data will be used to enhance vehicle design, optimize ride performance, and improve passenger comfort and safety. The project addresses gaps in traditional monitoring methods by focusing on real-time vibration analysis, setting new standards for vehicle reliability and aligning with sustainability goals.
3	**Process** The project follows a systematic approach, which includes the following: 1. **Literature Review:** detailed literature review on vibration analysis and sensor technologies. 2. **Vehicle Selection:** The Suzuki Alto 2020 VXR (660cc) was selected due to its suitability andcompatibility for sensor integration and availability**.** 3. **Sensor Selection & Procurement:** The ADXL 345 accelerometer was chosen for its high sensitivity, accuracy, compact size, and cost-effectiveness. 4. **Sensor Calibration Procedure:** Calibration was performed using a homemade pendulum toensure accurate readings in all three axes (X, Y, Z). the Arduino code was Developed and implemented for data acquisition from the ADXL 345 accelerometer across X, Y, and Z axes.,ensured proper Working by Code, developed Calibration Code, Calibration Data was collectedin three axes (X,Y,Z) 5. **System Integration with Vehicle:** The measurement system was integrated into the vehicle,with the accelerometer mounted on the dashboard. 6. **Data acquisition:** was achieved via an Arduino microcontroller, and real-time data was transmitted to a laptop for analysis. 7. **Data Collection:** Vibrational data was collected for 3 minutes (180 seconds) across three different road conditions: Road A, which was an excellent road used as a baseline for vibrations; Road B, which had average conditions with visible defects; and Road C, which represented the worst condition with bumpy roads. Data was collected at speeds of 10, 30, and60 km/h for each road condition. 8. **Data Analysis:** The methodologies that were employed in this study included the following: • **Time Domain Analysis:** Evaluated the accelerations over time to understand the impact of road conditions and speeds on passenger comfort. • **Frequency Domain Analysis:** Used frequency spectrograms to identify significant frequencies contributing to vibrations. • **Cumulative Distribution Function (CDF) Analysis:** Assessed the probability of passenger discomfort due to vibrations, particularly those exceeding the 6 Hz

	comfort threshold. • **Data Filtering:** Applied MATLAB functions to remove outliers and ensure data accuracy.
4	**Outcome** Our project successfully developed a vehicle condition monitoring system using the ADXL 345 accelerometer to analyze vibrations in the passenger compartment. The outcomes revealed that different road conditions and vehicle speeds significantly affect passenger comfort. Key achievements include the selection and calibration of sensors, integration of the measurement system with a vehicle, and comprehensive data analysis. The results demonstrated that higher speeds and poor road conditions lead to increased vibrations, impacting passenger comfort and safety. The findings provide valuable insights for vehicle design, road maintenance, and infrastructure improvement, ultimately enhancing overall driving experience and safety.
5	**Evidence (Theoretical Basis)** **Basis)Summary:** This project focused on condition monitoring of vehicles using vibration measurement techniques,particularly examining how road conditions and vehicle speeds affect passenger comfort and safety.We selected and calibrated sensors, integrated them into a vehicle, and analyzed the data. The results showed a clear relationship between road conditions, speeds, and vibration levels, with higher speeds typically resulting in increased vibrations. **Findings and Achievements** We identified how road conditions and vehicle speeds impact passenger comfort. The project successfully implemented an ADXL 345 sensor-based measurement system, conducted calibration procedures, and integrated the system into a vehicle for real-time vibration data collection. **Study Objectives and Significance** The study analyzed vehicle vibrations affecting passenger comfort across various road conditions and speeds, aiming to identify discomfort thresholds and suggest ways to improve ride quality. **Summary of Methodologies used for Analysis:** We used time domain analysis to evaluate acceleration impacts, frequency domain analysis toidentify significant vibration frequencies, CDF analysis to assess discomfort probabilities, andMATLAB for data filtering. **Summary of Findings:** Regarding passenger comfort, it was found that comfort is optimal within the 0-6 Hz range.Frequencies between 4-20 Hz led to discomfort, particularly on Roads B and C. • **Time Domain Analysis:** In the time domain analysis, Road A showed minor discomfort at higher speeds, while Road B exhibited noticeable discomfort, especially at higher speeds due to road defects. Road C caused consistent discomfort across all speeds due to severe road irregularities. • **Frequency Domain Analysis:**

	In the frequency domain analysis, Road A's frequencies generally remained within the comfort range. However, Road B presented significant discomfort at frequencies associated with road roughness, and Road C caused severe discomfort due to high-frequency vibrations. • **CDF Analysis:** The CDF analysis indicated that Road A had a low probability of exceeding comfort thresholds, while Road B showed a higher likelihood of discomfort, and Road C had thehighest probability of discomfort. **Practical Applications and Benefits:** Our findings have practical applications in enhancing vehicle diagnostics, safety, and passenger comfort. The data can inform better vehicle design, particularly regarding dashboard vibrations and overall vehicle interior comfort. Additionally, this data can be used for pavement irregularitymeasurement and designing safer road conditions. **Concluding Remarks** The study underscores the importance of analyzing vehicle vibrations to improve passenger comfort and vehicle interior design. The insights gained from this research contribute to both vehicle performance and road maintenance, providing a holistic approach to reducing vibrationsin passenger vehicles.
6	**Impact on Sustainability of Urban Regions or SDG-11 "Sustainable Cities andCommunities"** Our research and analysis of vehicle vibrations and road conditions helps in designing better infrastructure and improving urban mobility, whichis crucial for sustainable urban development.
7	**Competitive Advantage or Unique Selling Proposition** Our project offers a unique blend of cost reduction, process improvement, and alignment with Sustainable Development Goals (SDGs), making it highly appealing for industry investment. **1. Cost Reduction:** By utilizing advanced data analysis techniques to optimize vehicle dynamics and passenger comfort, our project significantly reduces the need for costly trial-and-error methods in vehicle design. This efficiency can translate into substantial cost savings for automotive manufacturers. **2. Process Improvement:** The implementation of MEMS accelerometers and advanced signal processing techniques allows for more accurate and real-time analysis of vehicle vibrations. This improves the diagnosticprocess, leading to faster identification and resolution of issues related to passenger comfort and vehicle safety. **3. Attainment of SDG:** Our project contributes to SDG 11: Sustainable Cities and Communities. By enhancing vehicledesign for better passenger comfort and safety, we promote sustainable transport systems, reduce road-related fatalities, and contribute to healthier living environments. **4. Superior Performance:**

	The use of high-precision data from our experiments enables a more refined analysis of vehicle interior vibrations, setting a new standard in the industry for vehicle comfort analysis. This superior performance over traditional methods provides a strong competitive edge. Our project stands out in the market due to its potential to not only enhance vehicle design andsafety but also contribute to global sustainability efforts, making it a compelling investment opportunity for the automotive industry.
a	**Attainment of any SDG** (e.g. How it is achieved and why it is necessary for the region) **SDG#4, Quality Education:** The project provided practical engineering experience, enhancingeducation by bridging theory and real-world application. **SDG#3, Good Health and Well-Being:** By analyzing vehicle vibrations and their impact on comfort,the project contributes to safer vehicle designs, promoting passenger well-being. **SDG#9, Industry, Innovation, and Infrastructure**: The project involves advanced vibration measurement techniques and sensor technology, contributing to innovation and improved infrastructure in the automotive industry.
b	**Any Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.) **Reduction of Material Waste**: By identifying and mitigating excessive vibrations, our project helps to minimize wear and tear on vehicle components. This prolongs the lifespan of parts, reducingthe frequency of replacements and, consequently, the production and disposal of automotive materials. This contributes to a reduction in overall material waste and supports circular economy principles. **Improved Road Infrastructure Planning**: The data and insights generated from our vibration analysis can inform better road construction and maintenance practices. By identifying areas where road conditions contribute to increased vehicle emissions, city planners can prioritize repairs or redesigns that promote smoother, more efficient driving. This results in less fuel consumption and lower emissions, contributing to a cleaner environment.
c	**Cost Reduction of Existing Product** Our project focuses on reducing the cost of existing automotive products, which are used for measurements of vibration levels in an automobile, by employing improved vibration analysis techniques. By accurately identifying and mitigating sources of excessive vibrations, we can enhance passenger comfort without the need for expensive design overhauls. This streamlined approach leads to lower manufacturing costs, reduced material usage, and minimized need for costly post-production modifications, resulting in a more cost-effective product that maintains highstandards of performance and comfort.
d	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests) Our project introduces a refined vibration analysis process, addressing inefficiencies in the currentmethods. By utilizing advanced filtering techniques and precise data analysis, we can more accurately identify problematic vibrations early in the design process. This leads to a

	superior product by reducing the need for costly redesigns, enhancing overall manufacturing efficiency, andlowering production costs. The improvement streamlines the development process, ensuring a smoother transition from design to production while maintaining high-quality standards.	
e	**Expanding of Market share** (e.g. how it expand and what is the problem with the current market Our project has the potential to expand market share by addressing a key gap in the current market— accurate and cost-effective vibration analysis for passenger comfort. Existing solutions are often expensive and complex, limiting accessibility to smaller manufacturers. By offering a more affordable and user-friendly system, we can attract new clients, particularly in emerging markets, and increase adoption rates, thereby expanding the market share and creating new opportunities forgrowth	
f	**Capture New Market** (e.g. Niche market or unaddressed segment) Our project targets a niche market within the automotive industry—focused on enhancing passengercomfort through advanced vibration analysis. This segment has been largely unaddressed, particularly for mid-range vehicles where cost constraints often limit the adoption of sophisticatedcomfort-enhancing technologies. By offering a tailored solution that balances performance with affordability, our project has the potential to capture this untapped market, offering manufacturers a unique value proposition and opening up new revenue streams.	
g	**Any Other Aspect** **Safety Enhancement:** Our project significantly improves vehicle safety by providing real-time analysis of vibration patterns, allowing for early detection of potential mechanical failures, thereby preventing accidents and enhancing overall passenger safety. **Compliance with Regulations:** The project ensures vehicles meet stringent vibration and comfort regulations, helping manufacturers avoid penalties and maintain their market reputation. **Sustainability Compliance**: By optimizing vehicle dynamics and reducing the wear and tear caused by road vibrations, the project contributes to longer vehicle life cycles and supports sustainable practices in the automotive industry	
8	**Target Market** (Industries, Groups, Individuals, Families, Students, etc) Please provide some detail about the end-user of the product, process, or service The primary target market for this project includes **automobile manufacturers** and **automotive component suppliers** who are focused on enhancing vehicle safety, comfort, and performance. Additionally, **road construction companies** and **transportation authorities** can benefit from theinsights provided for designing safer and smoother road surfaces. The end-users also extend to **families** and **individuals** who prioritize comfort and safety in their vehicles, as well as **student researchers** and **academics** studying vehicle dynamics and passenger comfort.	
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