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Double Wishbone Pushrod Suspension Systems Co-Simulation for Racing Applications

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Abstract : In high-performance automotive engineering, the realistic simulation of suspension systems is crucial for enhancing vehicle dynamics and handling. This study focuses on the double wishbone suspension system, prevalent in racing vehicles due to its superior control and stability characteristics. Utilizing MATLAB and Adams Car simulation software, we conduct a comprehensive analysis of displacement behaviors and damper sizing under various dynamic conditions. The initial phase involves using MATLAB to simulate the entire suspension system, allowing for the preliminary determination of damper size based on the system's response under simulated conditions. Following this, manual calculations of wheel loads are performed to assess the forces acting on the front and rear suspensions during scenarios such as braking, cornering, maximum vertical loads, and acceleration. Further dynamic force analysis is carried out using MATLAB Simulink, focusing on the interactions between suspension components during key movements such as bumps and rebounds. This simulation helps in formulating precise force equations and in calculating the stiffness of the suspension springs. To enhance the accuracy of our findings, we focus on a detailed kinematic and dynamic analysis. This includes the creation of kinematic loops, derivation of relevant equations, and computation of Jacobian matrices to accurately determine damper travel and compression metrics. The calculated spring stiffness is crucial in selecting appropriate springs to ensure optimal suspension performance. To validate and refine our results, we replicate the analyses using the Adams Car software, renowned for its detailed handling of vehicular dynamics. The goal is to achieve a robust, reliable suspension setup that maximizes performance under the extreme conditions encountered in racing scenarios. This study exemplifies the integration of theoretical mechanics with advanced simulation tools to achieve a high-performance suspension setup that can significantly improve race car performance, providing a methodology that can be adapted for different types of racing vehicles.

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