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Vehicle Dynamics In Accident Reconstruction

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Engineers and accident reconstructionists examine physical evidence for clues into the motions of the vehicles and thus the actions of the drivers involved in a collision. A clear understanding of the vehicle dynamics that occurred pre- and post-impact can be crucial in determining the cause of a collision event.

What is Vehicle Dynamics?

Vehicle dynamics is the relationship of a vehicle's motion to the forces acting upon it. In automobiles and heavy trucks such forces include tire forces, collision forces and aerodynamic forces. Driver inputs such as steering, brake application and throttle application affect vehicle motion, making the driver an important component in understanding the overall system. Vehicle dynamic responses include, but are not limited to cornering, decelerating, accelerating, yaw rotation (spin), flips, vaults, rollovers, and the relative dynamics of combination vehicles including tractors, trailers, and semitrailers.

Vehicle Dynamics' Analysis

The dynamics involved in a vehicle crash may range from the relatively simple instance of an automobile skid-to-a-stop, to a complex case such as a tractor-trailer rollover involving questionable load securement. Expertise in how a variety of vehicles respond to various forces under varying conditions is essential for an accurate analysis.

An ability to comprehend the dynamic behavior of vehicles allows an expert to accurately assess the widest range of accident scenarios. Many techniques used in accident reconstruction rely on basic physics principles. These methods are theoretically valid when used in the appropriate circumstances and produce accurate results when correct assignable values are selected.

For example, a simple equation will often suffice to calculate the speed of a vehicle that has slid to a stop under locked-wheel braking. Additionally, using conservation of momentum may often be sufficient to accurately determine the collision speeds of two automobiles. However, in some cases the use of simple equations to analyze vehicle movement is an oversimplification and can lead to highly erroneous results.

For instance, if tire forces cause one or more of the vehicles to travel in a significantly curved pre- or post-impact path (yaw) rather than in a straight line, the results from a simple critical speed analysis may be highly inaccurate. Likewise, accidents that produce high post-impact spin and are solved by simple conservation of linear momentum analysis may also be highly inaccurate.

A tractor/semi-trailer rollover in a turn is another example. A simple equation for rollover threshold that assumes a certain radius path for the combination vehicle may not accurately estimate the vehicle's rollover speed. Heavy trucks vary widely in configuration, resulting in a wide variance of rollover thresholds. The dynamic behavior of these vehicles often varies significantly from the assumptions inherent in simple equations, necessitating the use of more complicated analytic methods.

For example, it is usually assumed that a tractor/semi-trailer rollover is initiated by the trailer dynamics. Load shifts, high center of gravity, and speeds excessive for the trailer configuration are looked at as causes. Occasionally,

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however, tractor loss of stability occurs before trailer rollover leading to jack knife and the subsequent tractor/semi-trailer rollover. This is an explanation that is often overlooked but becomes evident with a competent vehicle dynamics assessment.

The necessary evidence for a vehicle dynamics analysis may be obscure. In one case, a tractor-trailer and a pickup were involved in a collision. One of the photographs taken at the scene showed a readable "80" on the pickup's quarter panel that corresponded to the "08" on the tractor tire's sidewall. The location of the transfer mark on the pickup truck was the crucial piece of evidence that proved the pickup truck was going faster than the tractor. Providing a clear explanation of how the motion of the tractor tire related to the motion of both the tractor itself and the pickup served as a key issue in resolving this case.

Vehicle Dynamics Simulation Software

Vehicle dynamics simulation software packages allow analysis of collisions and motion that are too complicated to calculate by simple equations. These software packages adhere to mathematical and physical laws, and model vehicles to varying degrees of fidelity or complexity. Available simulation packages can simulate single vehicles, vehicles with trailers, as well as collisions between automobiles and trucks.

Simulation packages can model vehicles in two dimensions, or so-called 'yaw-plane' analyses, or in three dimensions, allowing for rollover analysis. The ability to accurately recreate a vehicle's dynamics using these programs is ultimately determined by the accuracy of the parameters inputted by the user.

An understanding of the modeling techniques combined with a thorough understanding of vehicle parameters allows the reconstructionist to more fully utilize the simulation software and critique the results. Many of the simulation software packages can produce video output that allows the vehicle motion to be clearly demonstrated and understood. The video output should obey the physical laws of visual perspective.

Summation

Through investigation of physical evidence, accident reconstructionists and engineers reach conclusions regarding the motions that vehicles have undergone and thus determine how a collision occurred. Techniques including and beyond basic physics principles are needed to accurately analyze a broad array of collisions, due to the variance in their complexity. Knowledge and understanding of vehicle dynamics is a fundamental component to accurate analysis of complex collision events.

Contact Information

Ruhl Forensic has staff members trained in vehicle dynamics and in simulation packages. For additional information, please contact our Champaign office at (800) 355-7800 or the Scottsdale office at (800) 235-2808. Our e-mail address is ruhl@ruhl.com.