Speaker: : Professor Reza N. Jazar

Professor Reza N. Jazar received the master's degree in robotics in 1990, and the Ph.D. degree in nonlinear dynamics and applied mathematics in 1997. He is also a Specialist in classical and nonlinear dynamic systems and has extensive experience in the field of vehicle dynamics and mathematical modeling. He has worked in several universities worldwide, and through his years of work experience, he has formulated many theorems, innovative ideas, and discoveries in classical dynamics, robotics, control, and nonlinear vibrations. Razi acceleration, theory of time derivative, order-free transformations, caster theory, autodriver algorithm, floating-time method, energy-rate method, and RMS Optimization method are some of his discoveries and innovative ideas. He has authored 20 books, all among the most prestigious publications in their fields.

Topic : **Smart Flat Ride Tuning**

Abstract : Pitch mode of vibration after roll is the most uncomfortable vibration of vehicles. Due to wheelbase distance between front and rear axles of a passenger car, any laterally extended disturbance of the road will put the vehicle into pitch and bounce modes of vibrations. A smart design of the front and rear suspensions will eliminate pitch and transform it into less uncomfortable hop vibrations. Employing a bicycle model, it has been suggested (Olley, 1934) that if the radius of gyration, r, in pitch is equal to the multiplication of the distance from the center of gravity of the front, a_1, and rear, a_2, wheels of the car ($r^2=a_1 . a_2$), the bounce center of the vehicle will be located at one spring and the pitch center on the other spring of a bicycle car model. Employing the flat ride condition, $r^2=a_1 . a_2$, the system of the sprung masses of a vehicle can be considered as two separate mass-spring systems. Therefore, front and rear suspensions may be modelled as two separate one degree of freedom spring-mass system.

This presentation mathematically derives the flat ride condition and clarifies analytically how exact is the suggested condition and how a smart strategy can make flat ride requirements fulfilled. Street and road bumps make a car to have e time lag between the front and rear wheels excitation producing a pitch mode of vibration in addition to the bounce mode of vibrations. A proper design of front and rear suspensions to eliminate and transfer the pitch into hop motion is called "Flat Ride Optimization." A general recommendation was to set the natural frequency of the front suspension to be lower than the rear natural frequency (Olley, 1938) to minimize the not favorite pitch vibrations. Following this correct recommendation makes the rear part of the car oscillate faster and catch up with the front to eliminate pitch and put the car in bounce mode before the vibrations die out by damping. Based on this recommendation, scientists tried to find a relation between the front and rear spring ratios to transfer the pitch motions of a car into bounce motion. This search end up with a series of experiments by Olley that has been caster as "Olley's Flat Ride." This result, not considering the other prerequisites can be casted as:

"The front suspension should have around 30% lower ride rate then the rear"

Although measurement of ride has been subjective, Olley's guideline is still considered valid rules of thumb. A prerequisite for flat ride was the uncoupling condition (Milliken, Milliken & Olley 2002) that put s the bounce and pitch centers of the model to locate on the front and rear springs. Employing this condition, the front and rear spring systems of the vehicle can be regarded as two separate one degree of freedom systems.

In this talk, we use analytical methods and proofs to investigate the flat ride conditions which has been recommended and being used by car manufacturers' designers. This study will prove and provide a mathematical approach for what have been the criteria of design in vehicle dynamic studies.