

# CONCEPTS OF REVERSE FUNCTION APPLYING TO RACE MOTORBIKES REAR SUSPENSION SYSTEMS

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## Abstract

This paper concerns the study of motorbikes rear variable-stiffness suspension system using a purpose software. The rear suspension system is composed by a shock-absorber located between two elements of a quadrangle; this kind of linkage is drawn in a way that the spring compression law is suitable to vehicle ride control. In this document is shown how, applying the Reverse Function method, is possible to find the same leverage ratio from suspension layouts also totally different. In this article there are several application examples of many recent motorcycles layouts with the discussion of results.

The wobble, instead, is typical of medium speed and it involves the steering vibrations with a frequency of 6-10 Hz: it is a dangerous phenomenon especially on rambling roads. Finally the capsize is not an oscillatory phenomenon, but it represents the motorcycle trend to fall down from one side. The off-road sector gave a very important impulse to the suspensions because of the own utilization exasperation, all the present motorcycles suspensions were born from motocross.

During the earlier '70, the twin shock absorber systems have been substituted by the mono-shock systems with the spring placed in central position regards the swinging arm.

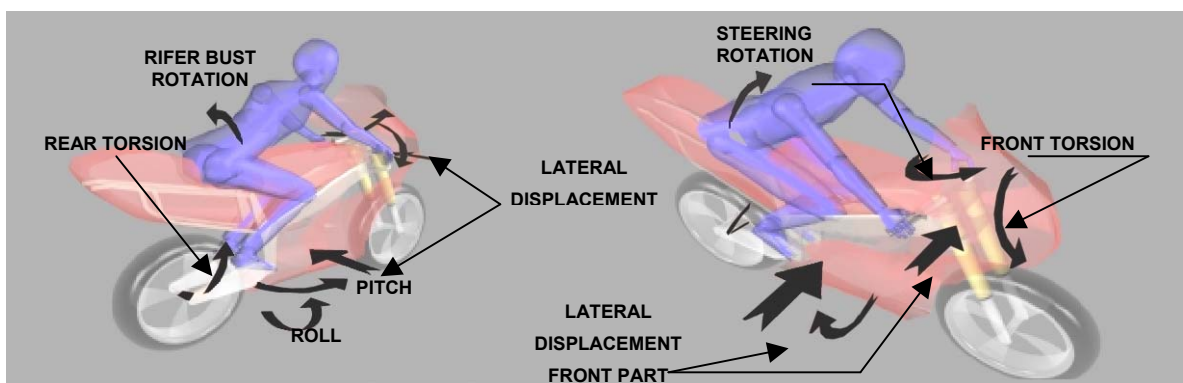


Fig.1 System motorcycle-driver degrees of freedom

## Introduction

The target of a suspension system is to keep, in every road conditions, the contact between the wheels and the road, and to minimize all motions and vibrations that bikes transmit to the frame; so we speak about "comfort" referred to not racing motorcycles, and about "handling" and "stability" for racing ones. The contact is an indispensable condition for a good ride control because only through it all forces exchange themselves to the road (moving forces and braking forces) and only controlling these forces is possible to control all the vehicle. It is still important to reduce all motions and vibrations transmitted to the frame, both for comfort and driving: this second aspect is very important especially for high speed motorbikes. A motorcycle, in fact, it is a typically unstable vehicle because it is supported by two wheels; a very used and realistic mathematical model, splits the system, composed by bike and rider into three subsystems constituted by the tyres, the motorcycle and the rider; this method generates eight degrees of freedom (Fig.1) which cause eight possible vibration modes. Combining some of these possible vibration modes we obtain the principal instability phenomena that are called weave, wobble and capsize. The weave is the ensemble of a yaw and a roll and it can show itself both at low speed (if the driver is very inexperienced) and at high speed (for example in cornering where driver's contribute is fundamental to stabilize the vehicle) with low oscillation frequency (about 3 Hz).

Yamaha adopted monoshock system for the first time in a cross model of 1973: it was the "Monocross", constituted by a single shock absorber, placed under the tank in almost horizontal position, which was moved directly by the swing arm. This type of suspension makes worse the shock cooling, but ensure an equal answer on both side of the swinging arm, allows a greater mass concentration around the centre of gravity and a lowering of itself, with the consequent advantages in term of aerodynamic and stability and it also allows an easier regulation. All the other constructors followed Yamaha so that in 1980 everybody has obtained a wheel travel of 300 mm. After, concerned to motocross it became clear that a very hard suspension is right when we have to do high jumps but it is not the ideal solution in the fast parts of track because on lightly rambling roads a very hard suspension produces continuous wheel jumping which make difficult the driving and make worse the traction. We have a similar situation in the racing motorcycles: along the straight line you can meet small obstacles such as the road undulations and in these cases the suspension might be soft to avoid wheel jumping, but when accelerating, when cornering and especially when braking (chattering) the motorcycle suffers the very strong load variations which can be tolerate only if the suspension is very hard. To solve the problem it is necessary that the suspension behaves in a different way for different wheel travel: the suspension should be soft for low wheel travel and hard for high wheel travel, in a word it should be progressive.