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# THE INFLUENCE OF THE MASSES' VALUE AND OF THE MOMENTS OF INERTIA'S VALUE REGARDING THE MONOWHEEL VEHICLE' STABILITY

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***Abstract:*** Monowheel vehicles present a number of challenges to the designer and several compromises have to be made to get everything come together into a functional machine. The first problem is stability; because monowheel depends on gyroscopic effect to keep it upright.
***Keywords:*** monowheel, vehicle simulation, stability

## 1. INTRODUCTION

The monowheel [1] consists of an inner frame (1) and a wheel (2). The inner frame (1) has three small wheels (4) that make contact with the wheel (2).
The wheel (2) is the actual rotating wheel and has a solid rubber tire.
The rider sits inside the inner frame that also contains the driving roller (3), the engine, the clutch, the propulsion mechanism and the petrol tank.
Let us consider the following representation:

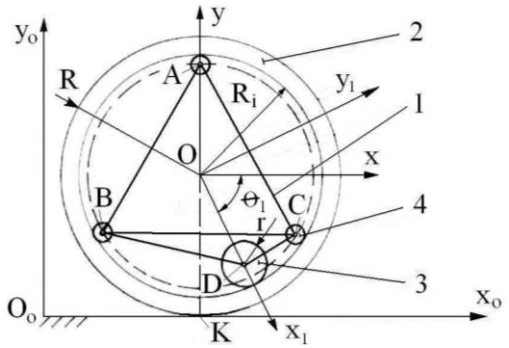


**Figure 1**. Simplified model

## 2. ADAMS SIMULATION

Vehicle handling and stability are significantly affected by inertial properties including moments of inertia and center of gravity location. Therefore let's generally analyze how vehicle inertial properties (i.e., weight, moment of inertia and center of gravity location) relate to typical dimensions (length, width and height) and how these properties affect vehicle dynamics.

The first contribution of this study is the creation of a realistic physical model which includes diverse kinematic and dynamic effects that are often difficult to foresee. The monowheel dynamic model was developed using the Lagrangian approach. In the first step the free Lagrangian is computed from the total kinetic energy.

After having implemented it, the dynamics model must be validated before being used for control analysis. To this purpose, several tests have been made, encompassing different situations. Namely, the spectrum of simulation comprehends diverse torques applied by the driver, starting conditions and external forces.

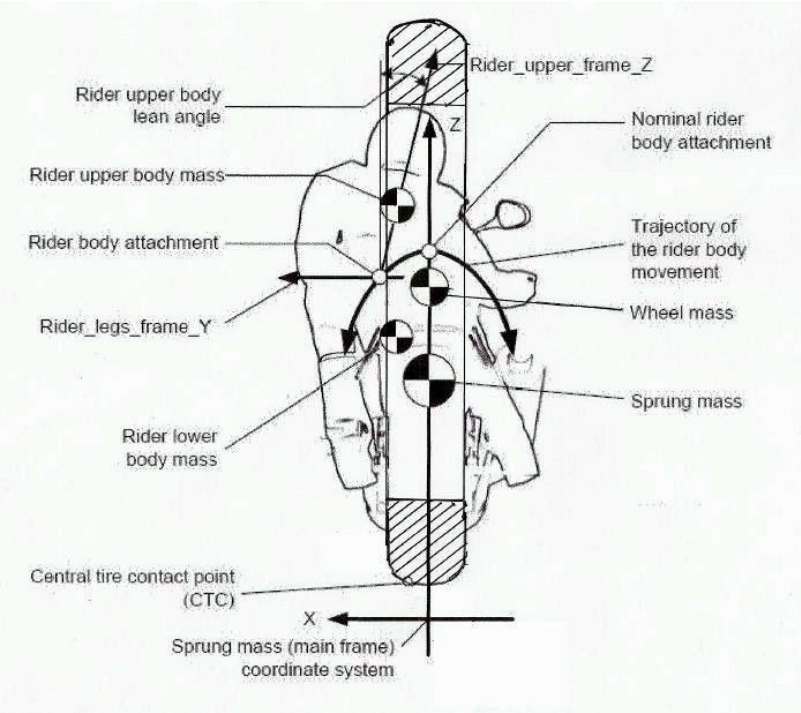


**Figure 2:** Monowheel cross-section

Usually it is useful to have a general appreciation of the effects of vehicle properties on stability and handling. This information is helpful in the preliminary phases of vehicle design. In the same time useful relationships between typical dimensions and inertial properties are provide through the use of regression analysis.

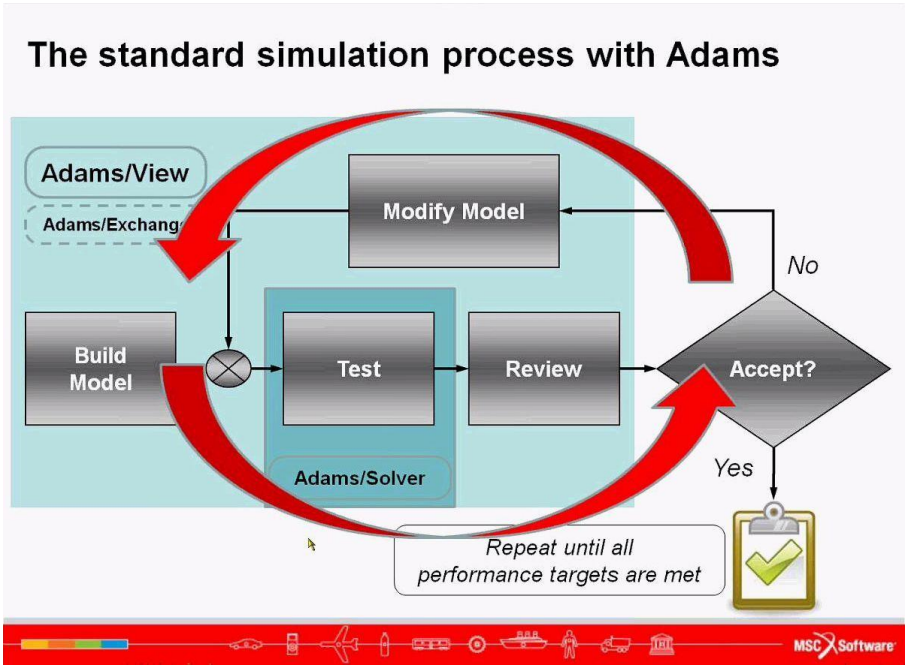


**Figure 3:** Simulation steps

Inertial properties have known effects on vehicle dynamic response, and key inertial variables relate to directional and roll mode stability issues. A validated nonlinear simulation is used to demonstrate stability problems related to inertial properties. Then we will use regression analysis to reveal the relationships between

vehicle inertial properties and basic size dimensions. Finally, we carry out some nonlinear computer simulation analysis with detailed vehicle models to show how size and speed interact to create stability problems.

## 3. LATERAL/DIRECTIONAL STABILITY

Lateral/directional vehicle dynamics models give a general feeling for the effect of vehicle inertial properties on vehicle handling and stability. The following matrix expresses vehicle lateral velocity (v) and yaw rate (r) as a function.

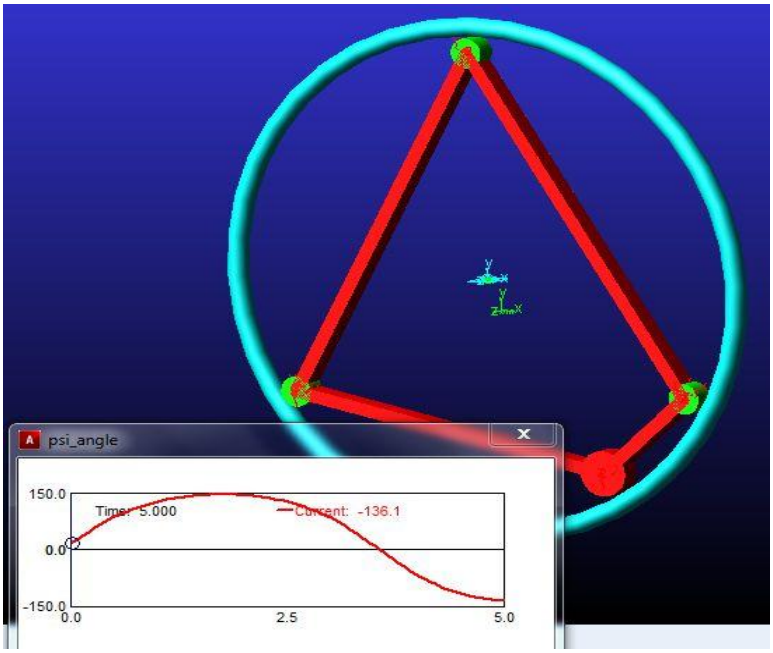


**Figure 4:** Yaw angle caption

Basic vehicle dynamics have been traditionally subdivided into lateral/directional dynamic modes including yawing and rolling motions. The basic input for these dynamics is steering, and speed is a key operating point. Lateral/directional dynamics are affected significantly by inertial properties including mass, moments of inertia and the location of center of gravity as will be analyzed subsequently. Inertial properties affect the time constants of various response modes, and also the influence of control inputs.

## 4. CONCLUSION

The analysis in this paper shows that vehicle inertial properties are strongly correlated with standard measures of length, width and height. It has also been shown that these inertial properties are related to lateral/directional handling and stability. In particular, specific inertial parameters are related to specific dynamic response properties.

The challenging factor of this stage was connected to the minimal influence of the effect of sustaining vertical position of the monowheel resulting from the gyroscopic effect (low angular velocity of the wheel) or its lack.

## REFERENCES

[1] Deliu, G. (2002) *Mechanics for Engineering Students.* Editura Albastră, ISBN 973-650-082-9, Cluj-Napoca, 2002

[2] http://web.mscsoftware.com/Academia/Student-Center

[3] https://github.com/hazelnusse/OBD

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