# Vehicle Motion Model with Wheel Lock

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**ABSTRACT**
This article examines the braking process of cars. Based on the work of researchers V. G. Wilke and I. L. Shapovalov, we considered the model of car movement with locked wheels. In this article, we compared the results of scientists' research on wheel blacking.

**Keywords:** Car, brake, wheel, mass, braking, opposing forces, a moment of inertia

**Introduction**

In this article, we will compare the braking of the wheels, and the research results of scientists, for example, the car and the forces are expressed in the process of braking, which is shown in Figure 1

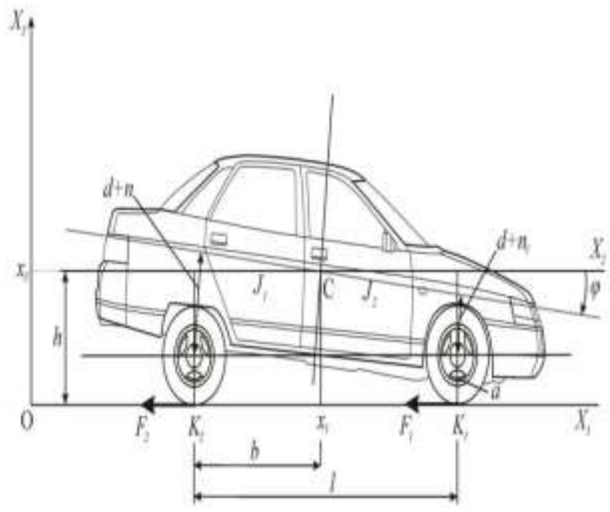

**Figure 1. A model of the forces acting on vehicle braking**

Center of mass Shock absorbers (shock absorbers, springs and shock absorbers) are connected to the wheels from the car body [1-7].

In practice, we consider the movement of the car in Figure 1. We assume that the car body is in the process of braking. rotates at an angle around the axis.$X_2$ $\varphi$

At the beginning of the braking of the car, the braking force F appears, where $F_1$- the braking force of the front wheels and $F_2$- the braking force of the rear wheels, that is, the total braking force acting on the passenger car is applied front and rear g expressed as 'wheels and $F_1$ [8-14].

The braking force creates a torque directed against the inclined plane, the passenger car rotates around the centre of gravity (C) and the rear part of the car body rises. In this case, part of the load (T) from the total load (mg, where m is the mass of the passenger car, kg; g – acceleration free fall m/s$^2$) is transmitted from the rear wheels to the front wheels, which occurs during braking. Creates opposite forces from the edge of the road, corresponding changes that lead to the appearance of a moment, the axle attached to the car body, working in the clockwise direction, completely balances the first moment [15-23]. Based on this, we get the moments acting on the car body to determine:

$$F_1h + F_2h = Fh = \theta b \quad (1)$$

At the beginning of the braking process, at the point of initiation of sliding, the resulting total braking force F is expressed by the following expression:

$$F = \mu mg$$

$$\Theta = \mu mgh / b$$

here:

$\mu$- coefficient of adhesion of car wheels to the base surface;

*m*- a mass of the car, kg;

*g*- acceleration of free fall, m/s$^2$;

*h*- height to the centre of gravity, m;

*b*- the distance from the centre of mass to the rear axle, m.

As a result, the load is redistributed due to the difference between the front and the impact forces during the braking of the car, the rear wheels and other factors can only lead to blocking, which can lead to an accident depending on the rear wheels [24-31]. To prevent this, it is unlikely that the machines are equipped with special equipment, and there is intensive braking of the shafts that limit the pressure in the hydraulic system [32-41].

In further theoretical studies based on the works, we assume that the movement of the front wheel of Shapovalova IL 2 is the same and we replace them with one wheel in the model. We take as an initial expression: twice the mass 2m and twice the moment of inertia. By analogy, let's first expressions and for the rear wheels Car is considered together with the coordinate system $SS_1\ X_2\ X_3$ For further study, the model of car motion when blocked wheels take $X_1$, $X_3$ is the weight of the car body the coordinates of the centre of mass will be available [42-49].

At the initial stage, before locking the wheels, the following situation occurred:

$$X_1(-0) = \varphi(-0) = \varphi(-0) = 0 \quad (2)$$

$$X_1(-0) = v_0 \quad (3)$$

$$\varepsilon_i(-0) = \varepsilon_i(-0) = 0, \quad i = 1.2 \quad (4)$$

For further development of the model, we assume the following conditions:

1. the wheels of the car were spinning fast.

$$\Omega = \frac{v_0}{a} \quad (5)$$

2. the centre of mass of the mechanical system about point C (car body and
four wheels)

3. The speed of a car is equal to 0.

At the time of deceleration, there is no internal shock moment [50-56]. The change in the magnitude of the angular momentum of the mechanical system relative to its centre of mass (point S, relative to the axes of K$_e$) is expressed by the following equation:

$$4J_1\Omega = a\varphi(+0) = 0 \quad (6)$$

$$A = J_0 + 4J_1 + 4ml^2 + 4m_r d^2 \qquad \varphi(+0) = \frac{4J_1v_0}{Aa} \Rightarrow \quad (7)$$

Here, A is the moment of inertia relative to the centre of mass of the car and the weight of the car decreases.

Based on this, the initial condition is established.

Braking a passenger car due to the absence of shock pulses during wheel locking, we accept the initial conditions for the rest:

$$X_1(+0) = \varphi(+0) = 0 \quad (8)$$

$$X_1(+0) = v_0 \quad (9)$$

$$\mathrm{E}_i = \mathrm{E}_i(+0) = 0 \quad I = 1.2 \quad (10)$$

The mechanical system under consideration then accepts solutions.

As can be seen from the relations, the situation is observed if the fifth equation of the system is subtraction. For this type, the following equation applies: $\mathcal{E}_1(\mathrm{t}) = (\mathrm{t}) = \mathcal{E}_2(\mathrm{t}) = \mathcal{E}_\mathrm{i}(\mathrm{t})$

$$M_oX_1 - 4md + 4m\mathrm{E} = 4F \quad (11)$$

$$l_o + 4md(X_1 + \mathrm{E}) + 4c_2l^2 = -4Fd_1 - 4N \quad (12)$$

To further simplify the calculations, we introduce the following symbols:

$$V = X_1,$$
$$u = \varphi,$$
$$U = \varphi, \qquad (13)$$
$$\omega = E_i,$$
$$W = E_i$$

$$J_{01} = \frac{J_0}{4} + J_1 - mdd_1 \quad (14)$$

We describe the modified system of equations (13) as follows:

$$V = 4c_1 MM^{(-1)}\omega \qquad (15)$$
$$u = U,$$
$$\omega = W,$$
$$J_0 3U + ma(V + W) + Nl^2 U + c_2 l^2 u + dc\,\omega = 0$$
(16)

Expressed as the initial speed of the car, taking into account self-oscillations during braking, we get:$V + W - dU$

$$V = U + kNm^2 U + c_2 l^2 u + dc\,\omega \qquad (17)$$

Under the assumption that the coefficient is one and the wheel radius from the circumference k, the vibrations of the car body itself are separated from other variables, which eventually leads to their decay $d_1 = 0 a = 0$. Accepting these conditions shows that the body is the centre of mass, and the passenger car (point C) is located in the middle of the segment, connecting points $K_1$ and $K_2$, i.e. The points of contact of the wheels (contact patches) of the passenger car with the road, and the radius of the wheels is equal to zero.

## Conclusion

With these conditions, it is almost impossible to constructively implement the proposed approach in crash investigation, but it is necessary to try to reduce the height of the centre of mass of the car body to reduce the vibrations of the car body around the corner. Ph is formed during its braking. The conditions of the accident can only be recreated with the help of simulation. In order to determine the coefficient of adhesion along the base surface of a car wheel, a theoretical experimental stand is made for modelling.

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