Editorial

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Fundamental principles of gyroscope theory based on kinetic energy

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The topic of gyroscopic effects attracts numerous physicists and mathematicians more than two centuries as far as researchers cannot find true mathematical models and cannot explain their physics. The term "gyroscopic effects" was derived due to unexplainable motions and the action of the inertial forces on the spinning objects. The primary and remarkable effect of a spinning object is maintaining its axis in the space that uses mostly in modern gyroscopic devices of aerospace and ship industries.

The first scientist that analytically formulated only one gyroscopic effect was famous mathematician L. Euler. He derived the principle of the change in the angular momentum that is the inertial torque acting on the spinning disc. However, this principle could not explain other gyroscopic effects. Beginning from the Industrial Revolution, researchers of all ranks tried to find the analytic approaches and describe the physics of gyroscopic effects related to the numerous rotating objects in engineering. The solution of gyroscope theory has hanged in mid-air and protracted a couple of centuries. To accuse famous physicists and mathematicians of past times does not have reasons that they did not develop the gyroscope theory. The reason is the physical concepts and properties of the matter that express the gyroscopic effects were developed and published at different times. The concept of the inertial force was developed in 1687, centrifugal force in 1659, Euler's precession torque in 1765, Coriolis force in 1835, potential and kinetic energies in 1842. These chronicle dates of the concepts about the physical properties of the matter are evidenced that scientists and researchers of 17-19 centuries could not solve problems of gyroscopic effects in principle. The scientists of the following centuries could not discover the new inertial torques and combine their action on the spinning objects.

The physics of gyroscopic effects is many times harder than presented in the known simplified theories. Gyroscope theory is based on the kinetic energy of the spinning object that expresses the action of the several inertial torques and interrelated motions around its axes of rotation. The new principles based on causal dependencies of the acting interrelated internal torques and used for formulation of the mathematical models for the gyroscope motions. This statement is founded by the system of physical principles manifested at gyroscopic effects and validated by the practical tests. New investigations and detailed analysis of the inertial forces acting on the rotating objects discovered the action of the system of interrelated inertial torques. This torques are generated by centrifugal T_{ct}, common inertial T_{in}, and Coriolis forces T_{cr} of the rotating mass elements, as well as the change in the angular momentum T_{am}. This inertial torques is interrelated by the ratio of the angular velocities of the spinning disc motions around axes of rotation. This system of inertial torques and interrelated the angular velocities of the spinning disc motions around axes constitutes the fundamental principles of the gyroscope theory.

The system of the interrelated inertial torques produced by the spinning disc inclined on the angle γ and action around two axes is represented in Figure 1 & Table 1.[1] All inertial torques are used for the formulation of the motions of the rotating objects around three axes of the 3D coordinate system Σoxyz.

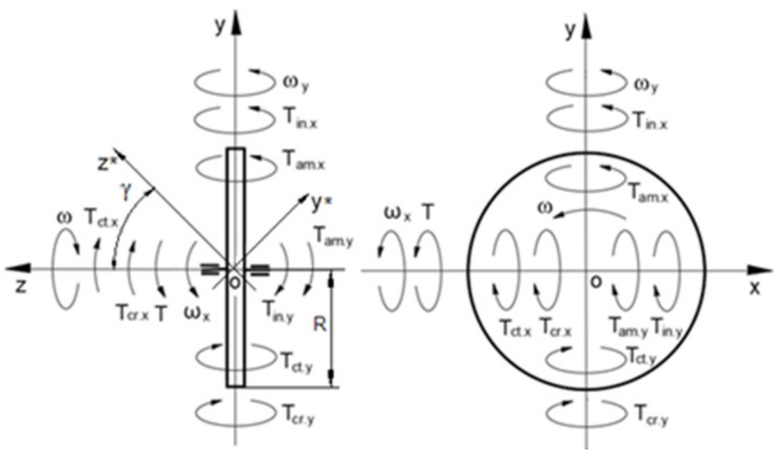

Figure 1 The system of interacted inertial torques of the spinning disc.

Table 1 Fundamental principles of the gyroscope theory

Inertial torques acting around axes generated by	Equation
Centrifugal forces Inertial forces	$T_{ct.i} = T_{in.i} = (2/9)\pi^2 J\omega\omega_i$
Coriolis forces	$T_{cr.i} = (8/9)J\omega\omega_i$
Change in angular momentum	$T_{am.i} = J\omega\omega_i$
The dependency of angular velocities of gyroscope rotation around axes *ox* and oy	
$\omega_y = \left[\frac{2\pi^2 + 8 + (2\pi^2 + 9)\cos\gamma}{2\pi^2 + 9 - (2\pi^2 + 8)\cos\gamma}\right]\omega_x$	

where ω_i is the angular velocity of the spinning disc around axis *i*; ω is the angular velocity of the spinning disc around axis *oz*; J is the mass moment of inertia of the spinning disc; other component are as specified above

The gyroscope theory is presented in the book R Usubamatov, Theory of Gyroscopic Effects for Rotating Objects, Springer, Singapore, 2020. The theory of gyroscopic effects considers the dynamics of the rotating objects in which mathematical models for the inertial forces and motions are presented in the Euler's form. The analytical approaches were treated by the methods of mathematical analysis and enabled for writing the complete theory of gyroscopic effects that is accurate, systematic, and clear in physical processes. The mathematical models for gyroscopic forces and motions are concerned with fundamental principles of physics. This type of presentation enables for easy understanding and avoiding the cumbersome mathematical models that expressed by 3D Lagrange's and Euler's angles method. Formulation of the theory of gyroscopic effects and solutions do not contain analytic approximations and simplifications for mathematical models to fit with practical results.

The gyroscope theory contains mathematical models for the inertial torques that depend on the geometry of the spinning object that can be cone, sphere, paraboloid, propeller, etc. The external torques acting around different gyroscope's axes is resulting in the change in the kinetic energy of the rotating objects that lead to the gyroscope's lift up ("antigravity effect") and oscillation and nutation. The mathematical models tested on the most unsolvable cases of the gyroscope with spinning disc suspended from the flexible cord and with one side pivoted support. The result of the practical tests perfect matches the mathematical models of the gyroscope motions. This fact is the best validation of their correctness.

The fundamental principles of the theory of gyroscopic effects can be used for solving the vast engineering problems generated by the rotating objects. The gyroscope theory for spinning objects opens a new direction in classical mechanics for computing inertial forces and motions of the objects. Science and engineering receive a new powerful analytical tool and method that enable formulating the torque and motion of the spinning objects in engineering. The new fundamental principles of the gyroscope theory can be applied to numerous mechanical gyroscopic devices in engineering and present challenges for practitioners, researchers, engineers, lecturers, and students of universities.

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Conflicts of interest

The author declares that there is no conflict of interest.

References

1. Usubamatov R, Bergander M. The fundamental principles of gyroscope theory. *Journal of Applied & Computational Mathematics*. 2020;9(1):1–2.