A General Vector Theory of the Dynamics of a Rapidly Rotating Top

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Previously, the motion of tops has been studied on flat surfaces with either pointed or rounded bases. These models, though intuitive, have limited applications and cannot describe the motion of tops in varying contexts and their real-world applications. For example, Beyblades are a form of toy top which begin spinning at the lowest point inside a spherical shell (stadium), then over time gain speed and height (i.e., kinetic energy and gravitational potential). However, current models of spinning tops do not provide explanations for either of these phenomena. This research investigates the behavior of a top with a flat base on a spherical surface for the purposes of developing a generalizable model for the forces and torques on a top. The model is based on five forces (gravity, the normal force, friction, rolling resistance, air resistance) and their associated torques. A simulation algorithm was developed in Visual C# which computed the resulting motion, assuming the equations presented to be correct. The simulations show that the model presented is far more accurate than existing ones and predicts the same style of motion as occurs in real-world testing (increase in kinetic energy and gravitational potential). Despite this, there was a significant discrepancy between the simulated results and experimental data. Upon investigation, the discrepancies were likely due to an incomplete description of the physics, most probably that of rolling resistance, demanding more work be done to fully develop models of contact forces such as rolling resistance in the case of a spinning top.

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