Ilin, K. I.; Moffatt, H. K.; Vladimirov, V. A. 
Dynamics of a rolling robot. (English) [Zbl 1404.70023] 

Summary: Equations describing the rolling of a spherical ball on a horizontal surface are obtained, the motion being activated by an internal rotor driven by a battery mechanism. The rotor is modeled as a point mass mounted inside a spherical shell and caused to move in a prescribed circular orbit relative to the shell. The system is described in terms of four independent dimensionless parameters. The equations governing the angular momentum of the ball relative to the point of contact with the plane constitute a six-dimensional, nonholonomic, nonautonomous dynamical system with cubic nonlinearity. This system is decoupled from a subsidiary system that describes the trajectories of the center of the ball. Numerical integration of these equations for prescribed values of the parameters and initial conditions reveals a tendency toward chaotic behavior as the radius of the circular orbit of the point mass increases (other parameters being held constant). It is further shown that there is a range of values of the initial angular velocity of the shell for which chaotic trajectories are realized while contact between the shell and the plane is maintained. The predicted behavior has been observed in our experiments.

MSC:
70E60 Robot dynamics and control of rigid bodies
70E18 Motion of a rigid body in contact with a solid surface
37N05 Dynamical systems in classical and celestial mechanics
70-05 Experimental work for problems pertaining to mechanics of particles and systems

Full Text: DOI