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Revisiting Newton's 340-year-old Third Law: A Generalized or Extended Form within Newtonian Mechanics.

Revisiting Newton's 340-year-old Third Law: A Generalized or Extended Form within Newtonian Mechanics.

Ajay Sharma
    Department of Physics. Career Point University. Hamirpur, HP 176041 India
        Email: ajoy.plus@gmail.com   Mobile   0091 94184-50899

Abstract

Newton's law asserts the equality and simultaneity of action–reaction force pairs. The law is examined within the Newtonian framework under realistic interaction conditions, extending its applicability to real-world systems relevant to contemporary theoretical and experimental investigations. Newton primarily applied the law qualitatively in Principia, illustrating it through three examples involving macroscopic interactions. Simple rebound experiments show that spherical bodies can retrace their original line of fall and rebound to comparable heights under suitable conditions, whereas asymmetrical or flat bodies exhibit reduced rebound heights and oblique rebound trajectories. The original formulation neglects several interaction-dependent factors, including material properties of bodies, rotation, spin, orientation, contact geometry, and deformation during interaction. Consequently, the law is treated as independent of these factors and is therefore held universally. In horizontal motion the characteristics of the surface are also significant. The prevailing descriptions based on impact force and the coefficient of restitution are inadequate for quantitatively explaining the rebound heights of bodies with varying shapes and material compositions. Motivated by the above qualitative experimental trends and supported by historical and conceptual analysis, a generalized form of Newton's third law is proposed in which the reaction force is modified or extended by dimensionless coefficients accounting for shape, composition, target surface, and other interaction parameters, and expressed as

Reaction (FBA) = − [Kshape × Kcomposition × Ktarget × Kother] Action (FAB)

The generalized form reduces to the original form under suitable conditions of parameters and provides an experimentally testable framework for quantitative confirmation at the macroscopic level. Over time, applications of Newton's third law have been extended to diverse systems, including aerodynamics and aerospace propulsion, each of which requires separate quantitative analysis.

Key Words. Third law, falling and rebounding bodies, shape, composition, and rocket.

Author: SHARMA, Ajay

Presenter: SHARMA, Ajay