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BEYOND $F=ma$: EMPIRICAL CHALLENGES TO NEWTON'S SECOND LAW IN REAL-WORLD PHYSICS EDUCATION

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This study examines the practical application of Newton's second law ($F=ma$) by systematically analyzing the effects of resistance forces in real-world systems. Through controlled experiments using calibrated weighing scales, we measure frictional variations (1.44-1.80N across surfaces with $\mu=0.1$ -0.7) and air resistance (0.24-0.37N) to develop an enhanced force equation ($F=ma+r$) that incorporates cumulative resistances. Our celestial mechanics models demonstrate how a 10N force on a 5kg mass produces environment-dependent accelerations (1.876 m/s² on Pluto vs. 0.0408 m/s² on Earth), highlighting the importance of contextual factors in force calculations. These findings provide physics educators with empirically validated teaching tools, including practical measurement techniques using standard laboratory equipment and ready-to-implement celestial mechanics examples that bridge theoretical principles with experimental observations.

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