California State University, Sacramento
Department of Physics & Astronomy Fall 2004

Physics Colloquium Series

Electromagnetics of a Magnet Moving Through a Metallic Pipe

The popular demonstration involving a permanent magnet falling through a metallic pipe is treated as a cylindrically symmetric boundary value problem. Specifically, Maxwell's equations are solved for a uniformly magnetized, cylindrical bar magnet moving coaxially inside an infinitely long, conducting cylindrical shell of finite thickness at nonrelativistic speeds. Analytic solutions for the fields are developed and used to derive the resulting drag force acting on the magnet in integral form. This treatment provides a significant improvement over the existing ones, and can be made the basis of a quantitative laboratory experiment. A detailed analytical and numerical study of the properties of the drag force is presented. While the analysis is rigorous and the results are new, the presentation is primarily pedagogical and emphasizes clarity, completeness, and accessibility. Accordingly, extended discussions of the importance of neglected contributions, electrodynamics of moving magnets, and energy conservation are presented.

Eliza J. Morris

CSUS Physics Major

(recipient of an SPS Undergraduate Research Award)

Thursday, December 2, 2004

4:00-5:20 PM MND 1015

OPEN & FREE TO ALL STUDENTS & FACULTY