# Energy, Momentum, and Force in Classical Electrodynamics: Application to Negative-index Media

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Abstract:
The classical theory of electromagnetism is based on Maxwell's macroscopic equations, an energy postulate, a momentum postulate, and a generalized form of the Lorentz law of force. These seven postulates constitute the foundation of a complete and consistent theory, thus eliminating the need for physical models of polarization P and magnetization M -- these being the distinguishing features of Maxwell's macroscopic equations. In the proposed formulation, P(r, t) and M(r, t) are arbitrary functions of space and time, their physical properties being embedded in the seven postulates of the theory. The postulates are self-consistent, comply with special relativity, and satisfy the laws of conservation of energy, linear momentum, and angular momentum. The Abraham momentum density $p_{EM}(r, t) = E(r, t) \times H(r, t)/c^2$ emerges as the universal electromagnetic momentum that does not depend on whether the field is propagating or evanescent, and whether or not the host media are homogeneous, transparent, isotropic, linear, dispersive, magnetic, hysteretic, negative-index, etc. Any variation with time of the total electromagnetic momentum of a closed system results in a force exerted on the material media within the system in accordance with the generalized Lorentz law.