17.9: Implications of Relativistic Theory to Classical Mechanics

Einstein's theories of relativity have had an enormous impact on twentieth century physics and the philosophy of science. Relativistic mechanics is crucial to an understanding of the physics of the atom, nucleus and the substructure of the nucleons, but the impacts are minimal in everyday experience. As a consequence the enormous philosophical implications of Einstein's theories of relativity may not be as readily apparent as other major developments during the 20^{th} century. In spite of this, it is important to be cognizant of the consequences of these theories of nature. The Special Theory of Relativity replaces Newton's Laws of motion; i.e. Newton's law is only an approximation applicable for low velocities. The General Theory of Relativity replaces Newton's Law of Gravitation and provides a natural explanation of the equivalence principle. Einstein's theories of relativity imply a profound and fundamental change in the view of the separation of space, time, and mass, that contradicts the basic tenets that are the foundation of Newtonian mechanics. The Newtonian concepts of absolute frame of reference, plus the separation of space, time, and mass, are invalid at high velocities. Lagrangian and Hamiltonian variational approaches to classical mechanics provide the formalism necessary for handling relativistic mechanics. The present chapter has shown that logical extensions of Lagrangian and Hamiltonian mechanics lead to the relativistically-invariant extended Lagrangian and Hamiltonian formulations of mechanics which is adequate for handling one-body systems within the Special Theory of Relativity. However, major unsolved problems remain applying these formulations to systems having more than one body.