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前言

Purpose and Emphasis. Mechanics not only is the oldest branch of physics but was and still is the basis for all of theoretical physics. Quantum mechanics can hardly be understood, perhaps cannot even be formulated, without a good knowl- edge of general mechanics. Field theories such as electrodynamics borrow their formal framework and many of their building principles from mechanics. In short, throughout the many modern developments of physics where one frequently turns back to the principles of classical mechanics its model character is felt. For this reason it is not surprising that the presentation of mechanics reflects to some ex- tent the development of modern physics and that today this classical branch of theoretical physics is taught rather differently than at the time of Arnold Som- merfeld, in the 1920s, or even in the 1950s, when more emphasis was put on the theory and the applications of partial-differential equations. Today, symmetries and invariance principles, the structure of the space-time continuum, and the geomet- rical structure of mechanics play an important role. The beginner should realize that mechanics is not primarily the art of describing block-and-tackles, collisions of billiard balls, constrained motions of the cylinder in a washing machine, or bi- cycle riding. However fascinating such systems may be, mechanics is primarily the field where one learns to develop general principles from which equations of motion may be derived, to understand the importance of symmetries for the dy- namics, and, last but not least, to get some practice in using theoretical tools and concepts that are essential for all branches of physics.　　Besides its role as a basis for much of theoretical physics and as a training ground for physical concepts, mechanics is a fascinating field in itself. It is not easy to master, for the beginner, because it has many different facets and its structure is less homogeneous than, say, that of electrodynamics. On a first assault one usually does not fully realize both its charm and its difficulty. Indeed, on returning to various aspects of mechanics, in the course of one's studies, one will be surprised to discover again and again that it has new facets and new secrets. And finally, one should be aware of the fact that mechanics is not a closed subject, lost forever in the archives of the nineteenth century. As the reader will realize in Chap. 6, if he or she has not realized it already, mechanics is an exciting field of research with many important questions of qualitative dynamics remaining unanswered.

内容概要

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章节摘录

By assumption the transformation matrix is not singular; cf. （2.34）. This proves the proposition. Another way of stating this result is this: the variational derivatives are covariant under diffeomorphic transformations of the generalized coordinates. It is not correct, therefore, to state that the Lagrangian function is "T - U". Although this is a natural form, in those cases where kinetic and potential energies are defined it is certainly not the only one that describes a given problem. In gen- eral, L is a function of q and q', as well as of time t, and no more. How to construct a Lagrangian function is more a question of the symmetries and invariances of the physical system one wishes to describe. There may well be cases where there is no kinetic energy or no potential energy, in the usual sense, but where a Lagrangian can be found, up to gauge transformations （2.33）, which gives the correct equa- tions of motion. This is true, in particular, in applying the variational principle of Hamilton to theories in which fields take over the role of dynamical variables. For such theories, the notion of kinetic and potential parts in the Lagrangian must be generalized anyway, if they are defined at all. The proposition proved above tells us that with any set of generalized coordi- nates there is an infinity of other, equivalent sets of variables. Which set is chosen in practice depends on the peculiarities of the system under consideration. For ex- ample, a clever choice will be one where as many integrals of the motion as possi- ble will be manifest. We shall say more about this as well as about the geometric meaning of this multiplicity later. For the moment we note that the transforma- tions must be diffeomorphisms. In transforming to new coordinates we wish to conserve the number of degrees of freedom as well as the differential structure of the system. Only then can the physics be independent of the special choice of variables. ……