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Danilo Capecchi

The Problem of the Motion of Bodies

A Historical View of the Development of Classical Mechanics

Springer

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Preface

It is clear that describing the problem of motion of bodies means somehow writing the history of the whole mechanics. My idea is not however to remake a traditional history, although this would be a useful undertaking, as current histories of mechanics are based on historiographical standards that are no longer acceptable. But this would be too hard a task and not feasible for one person alone. My idea is rather to try to fully understand what were the deeper ideas that inspired, first the attempt to understand mechanics, and then to formulate theories that in addition to being explanatory also had predictive value. With this objective in mind, it seemed to me possible to neglect most of the history of fluid mechanics, statics and modern astronomy, while I decided to include part of the history of thermodynamics, which is its own peculiar point of view on motion and is the basis of motion through thermal machines. The subject to be covered still remains too large and it is possible that it would have been more useful to enlist contributions from many scholars, each specialized in a given period. On the other hand, the unitary treatment provided by a single writer would be lost.

Inspired in part by the historical epistemology, I will put aside the various views and theories of a given historical period (synchronic analysis) and then make a comparison between different periods (diachronic analysis). In each period I have chosen one or two meaningful contributions and concentrate on them rather than considering a long inventory of scientist achievements. I think this is the only way to present an intelligible framework of the history of mechanics in a single book.

In order to do that, I consider a number of historical periods, internally quite homogeneous, altogether following a fairly shared use. I consider two periods of antiquity, Classicism-Hellenism (fifth century BC, second century AD) and Middle Ages (1200–1400) in which the authors with documented works are separated by large time intervals. The early Renaissance (1400–1550) follows, from Leonardo to Niccolò Tartaglia with a mildly intense production of texts. There is then Galileo Galilei's and René Descartes's age (1600–1650) with an intense production of texts. The golden age of the second half of 1600 and Isaac Newton's *Philosophiae naturalis principia mathematica* follow. Finally, the mechanics of the eighteenth century, which sees its culmination with Joseph Louis Lagrange's *Méchanique analitique*, is presented and adjustments and refinements of 1800 with the contributions of William Rowan Hamilton and Carl Jacobi. In the latter two phases publications and exchanges of information are very intense.

Within each period there is a certain uniformity of background knowledge, including the type of prevalent mathematics, that define the epistemological conditions. This makes it possible for many scientists to compare their ideas with those of others and criticize them in order to establish a discussion (internal controversy) in some public way, which leads to a clarification and a synthesis of the various positions. The diachronic comparison serves to correlate positions derived from different epistemic conditions and highlight the various incommensurabilities (Kuhn meaning) and the resulting conflicts (external controversy).

As a limit case of the diachronic analysis I will also make a comparison of concepts and problems of selected historical periods with the modern ones. I am indeed convinced that a comparison of the conceptions which we have a good knowledge of and conceptions of the past will highlight the differences, and help to better understand ancient science. In essence, comparison with the modern conceptions, instead of introducing elements of anachronism and finalism, serves precisely for a better contextualization. For example, the comparison between Aristotle's and modern laws of motion—if the positivist intransigent conclusion on the falsity of the former, is avoided—allows us to highlight the differences between our conception of force and that of Aristotle and an incentive to speculate on the reasons for this difference.

Personally, I am convinced of a substantial cumulative growth of science. For I believe that although the problems the scientist are facing vary from period to period and the answers to them depend on the standards of the period, one can identify some problems that have remained unchanged in the core, in the long run, and, over time, have been made precise and provided with more complete responses. Using the historical perspective that focuses on the evolution of the laws of motion, the idea of cumulative development of knowledge and problems appears quite natural. For example, the so-called scientific revolution of the Renaissance, which plausibly seems to have occurred when considered in the broader context of the whole scientific thought, is reduced to a few things, though basic with respect to the evolution of mechanics.

In the cumulative development there are certainly periods of apparent step backwards. Knowledge acquired, perhaps inconspicuously, may disappear into oblivion. It is difficult, however, that there is a total loss; some trace always remains somewhere to offer a new starting point. Hellenistic mathematics, for example, had long been forgotten in the West. However, of it did remain at least the myth, and some manuscripts deposited somewhere; it was a sleeping knowledge, a well-known phenomenon by historians of ideas. When Hellenistic mathematics was recovered it was embedded into a new reality and produced fruit that had not been able to produce at its time. Referring to smaller time intervals, limited to a few centuries, consider for example the discovery of the correct law of the inclined plane. This was known in the thirteenth century, or rather it had been stated and supported with good arguments in some scientific communities. But it had not been adequately disseminated, in part because not everyone accepted the arguments of its probation. The knowledge has been so dormant for a long period, confined to texts that although circulating at least in the universities, were not studied by people who would have been able to appreciate them. The proper law of the inclined plane was found again with completely different criteria in the sixteenth century by Simon Stevin and Galileo Galilei. But in the seventeenth century the formulation of the thirteenth century was recovered, for example in the text of Pierre Herigone and, shortly after, it was invested with new meanings by René Descartes. A similar argument holds for the theorem of mean velocity. It was proved by both Oxford *calculatores* and philosophers from the terminist school of Paris. But the result did not receive adequate attention and, mostly, was not discussed by scientists interested in studying the motion. The result was found again after more than two centuries by Galileo Galilei and others, probably independently.

The historical sources used in my study mainly come from printed works and scientists official correspondence, but relevance has also been given to unpublished works and private correspondence. In some cases, especially for biographical information and socioeconomic framework I referred to the secondary literature. If the objective had been to understand in-depth the ideas and motivation of the individual scientist and the way the scientific knowledge grows, then it is evident that the analysis of unprinted works would have been an overriding need. Both because the scientist does not publish all the results obtained, and, with few exceptions, scientists are reluctant to publicly present those of their ideas which are not sufficiently precise and documented. My objective is instead to make a collective history of science, so the question is different and the knowledge of the relevant information which the scientists may draw in their time is sufficient. This derives from the cultural background, the experiences of everyday life, and published witness of the several scholars who report both theories and experiment. It is clear that the analysis of unpublished works is still important but to a lesser extent. It mainly serves to clarify the background conceptions of the period.

I want to acknowledge my daughter Giulia, Flavia Marcacci and Francesco Dell'Isola for their comments on some parts of my book. But in particular I want to thank Salvatore Esposito for his accurate reading of the whole text, whose comments allowed me to avoid many inconsistencies and to fill some gaps.

Editorial Considerations

Figures related to quotations are nearly all redrawn to allow a better comprehension. They are however as much as possible close to the original ones. Symbols of formulas are always those of the authors, except cases easily identifiable. Translations of texts from French, Latin, German and Italian are as much as possible close to the original texts. For the Latin, Italian of the fifteenth and sixteenth centuries and French of the seventeenth century a critical transcription has been preferred. In the critical Latin transcription some shortenings are resolved, ‘v’ is modified in ‘u’ and vice versa where necessary, ij in ii, following the modern rule; moreover, the use of accents is avoided. In the Italian critical transcription some shortenings are resolved, ‘v’ is modified in ‘u’ and vice versa, and a unitary way of writing words is adopted. In the French critical transcription of the seventeenth century (Descartes’s in particular), in most cases the modern spelling is adopted, so for instance *mesme* becomes *même*. Books and papers are always reproduced in the original spelling. For the name of the different characters the spelling of their native language is used, except for the ancient Greeks, for which the English spelling is assumed, and some medieval people, for which the Latin spelling is assumed, following the common use. However, in many cases when the spelling is not fixed, a modern form is assumed. For instance, Gian Battista, Giovan Battista, all become Giovanni Battista, Lodovico becomes Ludovico and so on.

Through the text I searched to avoid modern terms and expressions as much as possible while referring to ancient theories. In some cases, however, I transgressed this resolution for the sake of simplicity. This concerns the use for instance of terms like *mass* and *work* even in the period they were not known. From the context it is however clear that they are used with not technical meaning. The same holds good for expressions like *principle of inertia* and *principle of virtual work*, that were established for sure only after the eighteenth century.

Rome, May 2014 Danilo Capecchi

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