

masses, not only at a point on the surface of our earth, where the force of gravity can be considered to be constant, but all through the universe, where it varies with the distances of the moving masses.

22.
Gravitation
not an
ultimate
property of
matter.

The Newtonian formula of gravitation was not at once accepted by philosophers as a correct statement of the facts of nature.¹ It appeared to limit the existence of

¹ The philosophy of Descartes, which then reigned on the Continent, seemed in many ways to hinder the acceptance of Newton's doctrines. Descartes had taken a great step in advance in philosophical teaching; he had placed mathematics at the head of his doctrine; he had opposed the older metaphysical methods, and he had, through his application of algebra to geometry, made great progress towards a mechanical description of phenomena. But he had not separated the description from the interpretation of nature. Philosophy and science remained united, the mathematical formulæ were only a new kind of metaphysics, incapable without observation of making any real advance in the knowledge of nature. The facts of geometry which are required for an application of analysis are the well-known axioms of Euclid. An application of analysis to dynamics requires a knowledge of the laws or fundamental properties of motion. These were not correctly and completely known to Descartes; Newton placed them at the head of his mathematical philosophy of nature. A further application to physical phenomena required a knowledge of some general physical fact: such was supplied by Newton in the gravitation formula. The laws of motion and gravitation once admitted as facts, there was plenty to do for mathematics. Not so with Descartes. In his philoso-

phy the basis of facts was too narrow and indefinite, and had to be supplemented by metaphysical suppositions and deductions. The field for mathematical reasoning not being sufficiently prepared and wide enough, Descartes had speedily got back again into metaphysical reasoning. In fact the doctrines of Newton, in which mathematical and philosophical deductions had for the first time been successfully separated, encountered on the Continent the doctrines of Descartes, in which mathematical and philosophical deductions were hopelessly mixed up. On one point especially the two views seemed to clash. Descartes had by metaphysical considerations tried to define what matter is. Newton had postponed the answer to this question, but had defined mathematically two properties of matter—*viz.*, inertia and gravitation. Descartes' metaphysical considerations had led to the conception that matter and extension were identical, that space therefore could not be empty. Newton, occupying himself not with matter in the abstract, but only with moving observable matter, had established the general law of gravitation, leaving it undecided whether the apparent vacuum existing between visible bodies was really empty or full. For the deductions from the law of gravitation it might in the first instance be considered empty. Thus on this question about space