

from this theoretical result. For it may be observed, that the curvilinear paths ascribed to military projectiles by Rivius and Tartalea, and by other writers who followed them, as Digges and Norton in our own country, though utterly different from the theoretical form, the parabola, do, in fact, approach nearer the true paths of a cannon or musket ball than a parabola would do; and this approximation more especially exists in that which at first sight appears most absurd in the old theory; namely, the assertion that the ball, which ascends in a sloping direction, finally descends vertically. In consequence of the resistance of the air, this is really the path of a projectile; and when the velocity is very great, as in military projectiles, the deviation from the parabolic form is very manifest. This cause of discrepancy between the theory, which does not take resistance into the account, and the fact, Galileo perceived; and accordingly he says,<sup>12</sup> that the velocities of the projectiles, in such cases, may be considered as excessive and supernatural. With the due allowance to such causes, he maintained that his theory was verified, and might be applied in practice. Such practical applications of the doctrine of projectiles no doubt had a share in establishing the truth of Galileo's views. We must not forget, however, that the full establishment of this second law of motion was the result of the theoretical and experimental discussions concerning the motion of the earth: its fortunes were involved in those of the Copernican system; and it shared the triumph of that doctrine. This triumph was already decisive, indeed, in the time of Galileo, but not complete till the time of Newton.

*Sect. 4.—Generalization of the Laws of Equilibrium.—Principle of Virtual Velocities.*

It was known, even as early as Aristotle, that the two weights which balance each other on the lever, if they move at all, move with velocities which are in the inverse proportions of the weights. The peculiar resources of the Greek language, which could state this relation of inverse proportionality in a single word (*ἀντιπέπουθεν*), fixed it in men's minds, and prompted them to generalize from this property. Such attempts were at first made with indistinct ideas, and on conjecture only, and had, therefore, no scientific value. This is the judgment which we must pass on the book of Jordanus Nemorarius, which

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<sup>12</sup> *Op.* vol. iii. p. 147.