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The mathematical principles of mechanical philosophy, and their application to the theory of universal gravitation

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Cambridge, M.DCCC.XXXVI. [1836]

ETH-Bibliothek Zürich

Shelf Mark: Rar 32687

Persistent Link: <https://doi.org/10.3931/e-rara-72776>

Introduction and definitions.

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INTRODUCTION AND DEFINITIONS.

1. THE uniformity which characterises the operations of nature leads us to conjecture that the phenomena of the material world are regulated by certain fixed laws. The never-ceasing alternation of light and darkness, the unvarying succession of the Seasons, the periodical flux and reflux of the Ocean, the constant tendency of bodies downwards, and numberless such like appearances, mutually strengthen the suspicion that they are the necessary consequences of some universal principles with which matter has been endued by the Creator of the World. It is the object of Mechanical Philosophy to search out these Principles.

But at the very outset we are overwhelmed with such a variety of causes, all in simultaneous action, that it becomes no easy task to disentangle the simple laws from the maze in which they are involved.

The whole universe is in perpetual fluctuation, changes are incessantly taking place, and while we are occupying ourselves with the investigation of present appearances, the appearances themselves are in the act of transition from one state to another, and new phenomena press themselves upon our notice.

It is only by a careful and attentive examination of the phenomena perpetually presenting themselves to our view, arranging them in groups, selecting, re-examining and re-arranging, that we are able to rise, by a process of induction and generalisation from the mass of facts accumulated by observation, to the laws from which they flow. Having once reached this summit, we descend, making these laws our guides, and follow out, by a deductive process, the phenomena which must naturally result from their operation. A comparison of

the calculated results with the phenomena observed determines, by their agreement or disagreement, whether the laws, to which our investigations have conducted us, are laws of nature or not. It is by a process of this nature that we are convinced of the truth of the Law of Universal Gravitation: and the chief object which we have in view in the present undertaking is to lead the student step by step up to this great Principle, and then shew him the real foundation on which we rest our belief of its truth by displaying its power of explaining accurately every astronomical phenomenon with which we are acquainted.

2. We give the name *Matter* to everything that affects our senses in any manner whatever. *Bodies* are portions of matter limited in every direction, and are consequently of a determinate *form* and *volume*. The *Mass* of a body is the quantity of matter of which it is composed. A *material particle* is a body infinitely small in every dimension.

3. We may consider a body of finite dimensions to be an assemblage of an infinite number of material particles, and its mass to be the sum of all their infinitely small masses.

The mass of a body is said to be *homogeneous* when the same quantity of matter is contained in equal volumes of the body. When this is not the case, the mass is said to be *heterogeneous*.

Bodies of different material have different quantities of matter comprised in the same volume. The term *density* is used to indicate the quantity of matter contained in a given volume of a mass, and serves to measure the quantities of matter in different bodies. The density of a homogeneous mass is measured by the quantity of matter in a unit of a volume: when the mass is heterogeneous, the density at any point is measured by the quantity of matter of the same nature as that at the given point that would occupy a unit of volume.

4. A body is *in motion* when the body or its parts occupy successively different positions in space. But since space is infinite in extent and in every part identical, we cannot judge of the state of rest or motion of a body without comparing it with other bodies: and, for this reason, all mo-

tions which come under our observation are necessarily *relative* motions.

All bodies are capable of motion; but experience shews us that matter will not move spontaneously. Also it is a matter of experiment, as it is indeed of ordinary experience, that when a body is passing from a state of rest to a state of motion, we can always attribute the change to the action of a foreign cause.

5. Any cause which produces or tends to produce motion in a body or to change its motion is termed *Force*.

6. **MECHANICS** is the Science which treats of the Laws of Rest and Motion of Bodies, whether Solid or Fluid.

We divide this science into four branches.

(1) **STATICS**, which treats of the laws of the equilibrium of solid bodies.

(2) **DYNAMICS**, of the laws of motion of solid bodies.

(3) **HYDROSTATICS**, of the laws of the equilibrium of fluid bodies, and

(4) **HYDRODYNAMICS**, which treats of the laws of motion of fluid bodies.

7. In Statics force is estimated by the *pressure* it causes a body when at rest to exert against another with which it is in contact and is said to be estimated *statically*. In Dynamics, however, the estimate used is *the space through* which the force causes a body to move in a given time, and the measure is said to be *dynamical*. We shall endeavour to make this more intelligible.

8. Let us begin with the consideration of the ordinary phenomenon of a falling body. Experience teaches us that if a body be let free from the hand, it will fall downwards in a certain determinate direction: however frequently the experiment be made, the result is the same, the body strikes the same spot on the ground in each trial, provided the place from which it is dropped remain the same. Now this un-deviating effect must be the result of some cause equally un-deviating. The cause is assumed to be an affinity which

all bodies have for the earth, and is termed the force of *Attraction*. It is found to prevail in all parts of the globe.

The direction in which the body falls is called the *vertical line* of the place where the experiment is made: and a plane perpendicular to this is called the *horizontal plane* of the place. If the motion be prevented by interposing the hand, the body exerts a *pressure*, and it requires a muscular effort to keep the body from falling.

In one case then the attraction of the Earth produces a pressure, in the other motion: now of these, *viz.*, the pressure exerted by the body when at rest, and the space through which the body falls when in motion, either may be taken as a means of estimating the intensity of the force of attraction at different places on the Earth, at different elevations above or depressions below its surface.

9. And the same may be said of any force: as another instance let us consider the force exerted by a constrained spring. If the force of the spring be estimated by the pressure it produces on a body holding it in its constrained position, the estimate is said to be statical. But if the force be estimated by the magnitude of the motion generated in a body which it causes to move, the estimate is dynamical.

10. *Weight* is the name given to the pressure which the attraction of the Earth causes a body to exert on another with which it is in contact. Since the gravitation of bodies downwards is unceasing, weight becomes a very useful means of estimating all statical forces. Thus the force of a constrained spring, may be measured by the weight which will just hold the spring in its constrained position. The force of attraction of a magnet may be measured by the weight it will sustain; and so of other forces.