THE

CABINET CYCLOPÆDIA.

LONDON:
Printed by A. & R. Spottiswoode,
New-Street-Square.

THE

CABINET CYCLOPÆDIA.

CONDUCTED BY THE

REV. DIONYSIUS LARDNER, LL.D. F.R.S. L. & E.

M.R.I.A. F.L.S. F.Z.S. Hon. F.C.P.S. M.Ast.S. &c. &c.

ASSISTED BY

EMINENT LITERARY AND SCIENTIFIC MEN.

Natural Philosophy.

MECHANICS.

BY

CAPTAIN HENRY KATER, V.Pres.R.S. &c.

AND THE

REV. DIONYSIUS LARDNER, LL.D. F.R.S. &c.

LONDON:

PRINTED FOR

LONGMAN, REES, ORME, BROWN, AND GREEN,

PATERNOSTER-ROW;

AND JOHN TAYLOR,

UPPER GOWER STREET.

1830.

A

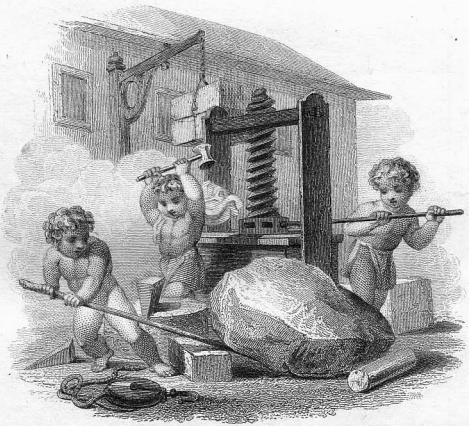
TREATISE ON MECHANICS,

BY

CAPTAIN HENRY KATER, V. PRES: R. S.

and

REV: DIONYSIUS LARDNER, L.L.D. F.R.S. L & E.



H. Corbould del. *E. Finden sc.*

London:

PRINTED FOR LONGMAN, REES, ORME, BROWN & GREEN; PATERNOSTER ROW.
AND JOHN TAYLOR, UPPER GOWER STREET.

1830.

ADVERTISEMENT.

THIS Treatise being the joint production of two persons, it is right to state the portions of it which are the exclusive work of each. The chapter on Balances and Pendulums, the instruments on which the measurement of *weight* and *time* depends, has been written by Captain Kater. For the remainder of the volume, Dr. Lardner is responsible.

CONTENTS.

CHAP. XV.

OF THE PULLEY.

CHAP. XVI.

ON THE INCLINED PLANE, WEDGE, AND SCREW.

CHAP. XVII.

ON THE REGULATION AND ACCUMULATION OF FORCE.

CHAP. XVIII.

MECHANICAL CONTRIVANCES FOR MODIFYING MOTION.

CHAP. XIX.

OF FRICTION AND THE RIGIDITY OF CORDAGE.

CHAP. XX.

ON THE STRENGTH OF MATERIALS.

CHAP. XXI.

ON BALANCES AND PENDULUMS.

THE

ELEMENTS OF MECHANICS.

CHAP. I.

PROPERTIES OF MATTER — MAGNITUDE — IMPENETRABILITY — FIGURE — FORCE.

(1.) PLACED in the material world, Man is continually exposed to the action of an infinite variety of objects by which he is surrounded. The body, to which the thinking and living principles have been united, is an apparatus exquisitely contrived to receive and to transmit these impressions. Its various parts are organised with obvious reference to the several external agents by which it is to be affected. Each organ is designed to convey to the mind immediate notice of some peculiar action, and is accordingly endued with a corresponding susceptibility. This adaptation of the organs of sense to the particular influences of material agents, is rendered still more conspicuous when we consider that, however delicate its structure, each organ is wholly insensible to every influence except that to which it appears to be specially appropriated. The eye, so intensely susceptible of impressions from light, is not at all affected by those of sound; while the fine mechanism of the ear, so sensitively alive to every effect of the latter class, is altogether insensible to the former. The splendour of excessive light may occasion blindness, and deafness may result from the roar of a cannonade; but neither the sight nor the hearing can be injured by the most ex-

treme action of that principle which is designed to affect the other.

Thus the organs of sense are instruments by which the mind is enabled to determine the existence and the qualities of external things. The effects which these objects produce upon the mind through the organs, are called *sensations*, and these sensations are the immediate elements of all human knowledge. MATTER is the general name which has been given to that substance, which, under forms infinitely various, affects the senses. Metaphysicians have differed in defining this principle. Some have even doubted of its existence. But these discussions are beyond the sphere of mechanical philosophy, the conclusions of which are in nowise affected by them. Our investigations here relate, not to matter as an abstract existence, but to those qualities which we discover in it by the senses, and of the existence of which we are sure, however the question as to matter itself may be decided. When we speak of "bodies," we mean those things, whatever they be, which excite in our minds certain sensations; and the powers to excite those sensations are called "properties," or "qualities."

(2.) To ascertain by observation the properties of bodies, is the first step towards obtaining a knowledge of nature. Hence man becomes a natural philosopher the moment he begins to feel and to perceive. The first stage of life is a state of constant and curious excitement. Observation and attention, ever awake, are engaged upon a succession of objects new and wonderful. The large repository of the memory is opened, and every hour pours into it unbounded stores of natural facts and appearances, the rich materials of future knowledge. The keen appetite for discovery implanted in the mind for the highest ends, continually stimulated by the presence of what is novel, renders torpid every other faculty, and the powers of reflection and comparison are lost in the incessant activity and unexhausted vigour of observation. After a season, however, the

more ordinary classes of phenomena cease to excite by their novelty. Attention is drawn from the discovery of what is new, to the examination of what is familiar. From the external world the mind turns in upon itself, and the feverish astonishment of childhood gives place to the more calm contemplation of incipient maturity. The vast and heterogeneous mass of phenomena collected by past experience is brought under review. The great work of comparison begins. Memory produces her stores, and reason arranges them. Then succeed those first attempts at generalisation which mark the dawn of science in the mind.

To compare, to classify, to generalise, seem to be instinctive propensities peculiar to man. They separate him from inferior animals by a wide chasm. It is to these powers that all the higher mental attributes may be traced, and it is from their right application that all progress in science must arise. Without these powers, the phenomena of nature would continue a confused heap of crude facts, with which the memory might be loaded, but from which the intellect would derive no advantage. Comparison and generalisation are the great digestive organs of the mind, by which only nutrition can be extracted from this mass of intellectual food, and without which, observation the most extensive, and attention the most unremitting, can be productive of no real or useful advancement in knowledge.

(3.) Upon reviewing those properties of bodies which the senses most frequently present to us, we observe that very few of them are essential to, and inseparable from, matter. The greater number may be called *particular* or *peculiar qualities*, being found in some bodies but not in others. Thus the property of attracting iron is peculiar to the loadstone, and not observable in other substances. One body excites the sensation of green, another of red, and a third is deprived of all colour. A few characteristic and essential qualities are, however, inseparable from matter in whatever state, or

under whatever form it exist. Such properties alone can be considered as tests of materiality. Where their presence is neither manifest to sense, nor demonstrable by reason, *there* matter is not. The principal of these qualities are *magnitude* and *impenetrability*.

(4.) *Magnitude.*— Every body occupies space, that is, it has magnitude. This is a property observable by the senses in all bodies which are not so minute as to elude them, and which the understanding can trace to the smallest particle of matter. It is impossible, by any stretch of imagination, even to conceive a portion of matter so minute as to have no magnitude.

The *quantity* of space which a body occupies is sometimes called its *magnitude*. In colloquial phraseology, the word *size* is used to express this notion; but the most correct term, and that which we shall generally adopt is *volume*. Thus we say, the volume of the earth is so many cubic miles, the volume of this room is so many cubic feet.

The external limits of the magnitude of a body are *lines* and *surfaces*, lines being the limits which separate the several surfaces of the same body. The linear limits of a body are also called *edges*. Thus the line which separates the top of a chest from one of its sides is called an edge.

The *quantity* of a surface is called its *area*, and the *quantity* of a line is called its *length*. Thus we say, the *area* of a field is so many acres, the *length* of a rope is so many yards. The word "magnitude" is, however, often used indifferently for volume, area, and length. If the objects of investigation were of a more complex and subtle character, as in metaphysics, this unsteady application of terms might be productive of confusion, and even of error; but in this science the meaning of the term is evident, from the way in which it is applied, and no inconvenience is found to arise.

(5.) *Impenetrability.* — This property will be most clearly explained by defining the positive quality from which it takes its name, and of which it merely signifies

the absence. A substance would be *penetrable* if it were such as to allow another to pass through the space which it occupies, without disturbing its component parts. Thus, if a comet striking the earth could enter it at one side, and, passing through it, emerge from the other without separating or deranging any bodies on or within the earth, then the earth would be penetrable by the comet. When bodies are said to be impenetrable, it is therefore meant that one cannot pass through another without displacing some or all of the component parts of that other. There are many instances of apparent penetration; but in all these, the parts of the body which seem to be penetrated are displaced. Thus, if the point of a needle be plunged in a vessel of water, all the water which previously filled the space into which the needle enters will be displaced, and the level of the water will rise in the vessel to the same height as it would by pouring in so much more water as would fill the space occupied by the needle.

(6.) *Figure.* — If the hand be placed upon a solid body, we become sensible of its impenetrability, by the obstruction which it opposes to the entrance of the hand within its dimensions. We are also sensible that this obstruction commences at certain places; that it has certain determinate limits; that these limitations are placed in certain directions relatively to each other. The mutual relation which is found to subsist between these boundaries of a body, gives us the notion of its *figure.* The *figure* and *volume* of a body should be carefully distinguished. Each is entirely independent of the other. Bodies having very different *volumes* may have the same *figure;* and in like manner bodies differing in *figure* may have the same *volume.* The figure of a body is what in popular language is called its *shape* or *form.* The volume of a body is that which is commonly called its *size.* It will hence be easily understood, that one body (a globe, for example) may have ten times the volume of another (globe), and yet have the same figure; and that two bodies (as a die and a globe) may have *figures* altogether