THE ELEMENTS OF MECHANICAL PHYSICS

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OF

MECHANICAL PHYSICS

BY

J. C. BUCKMASTER,

LATE STUDENT IN THE GOVERNMENT SCHOOL OF MINES;
CERTIFICATED TEACHER OF SCIENCE BY THE DEPARTMENT OF SCIENCE AND ART;
EXAMINER IN CHEMISTRY AND PHYSICS
IN THE ROYAL COLLEGE OF PRECEPTORS; AND
LATE LECTURER IN CHEMISTRY AND PHYSICS TO THE EVENING CLASSES
OF THE ROYAL POLYTECHNIC INSTITUTION,
ETC. ETC.

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PREFACE.

INDUSTRY, sobriety, and quick perception, are not sufficient to make a thoughtful and intelligent workman. Without some knowledge of mathematics and mechanics he will never advance beyond the mere practical application of a few rules and principles, and he will often be driven to very circuitous methods, at a great waste of material, in arriving at results which could be obtained more easily and more readily by scientific methods. Most persons now engaged in the mechanical arts can read and write; they understand the use of tools, but they have never received that special instruction which enables a man to understand the reason of things; their muscles have been strengthened by labour, but their minds have never been disciplined by knowledge. Many mechanics possess considerable inventive talent, which frequently leads to speculations, which terminate not only in their disappointment, but in the ruin of others. If this ability (which exists to a large extent) in many of our workshops were only directed by some mathematical and mechanical knowledge, it would frequently lead to very important results. In our elementary schools we cannot expect to find much of this knowledge, and in our middle schools it is disregarded.

Within the last few years there has grown up during the winter months a very extensive system of evening classes in connexion with Mechanics' Institutions and similar bodies. Instruction in elementary science may be conveniently carried on in these classes. I have endeavoured to adapt the work for this purpose; it is popular, and at the same time demonstrative, and differs but little from other works on this subject, except in the large number of examples, most of which may be worked out by any person who understands proportion.

The principles of a science appear to me the last things understood. How many examples in arithmetic are worked before the boy can reason out the rule, and just as this power of reasoning begins to develop itself the boy leaves school, and the rule is seldom understood.

I shall be glad if teachers and others could give me any hints for the improvement of the work, or any additional examples. I must express my obligations to Mr. Aarons, of St. Mark's College, and Mr. Adkins, of Leicester, for many valuable suggestions.

St. John's Hill, Wandsworth, S.W.,
January, 1864.

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ELEMENTS OF MECHANICAL PHYSICS.

CHAPTER I.

THE Science of Mechanics may be conveniently studied under two divisions, *viz.*:—

STATICS, *which treats of Bodies in a State of Rest, and*

DYNAMICS, *which investigates the Laws of Bodies in Motion.*

If a person were to ask himself this question,—Why does that stone which I see on the ground remain year after year in the same position? By the consideration of this question, and others which would arise out of it, a person has commenced the study of that branch of mechanics known as Statics, or the laws which govern bodies in a state of rest.

But if that stone be thrown into the air, and the question asked why does it not continue moving for ever in a uniform straight line, or why, after a few seconds, it falls to the earth, and is again brought to a state of rest? By the consideration of these and *similar questions*, a person has commenced the study

of Dynamics, or the laws which govern a body in motion.

Bodies of themselves cannot change from a state of rest to a state of motion, or from a state of motion to a state of rest.

There must be some cause to put a body at rest in motion, or to bring a body in motion to a state of rest.

FORCE.

Let us suppose a ball resting on a smooth table. If it be struck in any direction parallel to the surface of the table, it will move in the direction in which the blow was given. While in motion it may be struck again at an angle to the line in which it is moving, it will now move in a different direction.

If a blow of sufficient *magnitude* be given to the ball in a direction exactly opposite to that in which it is moving, the ball will be brought to a state of rest. In this illustration the ball was first moved from a state of rest to a state of motion; it was then struck so as to change the direction of its motion, and then brought to a state of rest. That which caused all these changes is called *force*. From this we learn that force tends to change bodies from a state of rest to a state of motion. To change the motion of bodies into different motions. To change bodies from a state of motion to a state of rest.

Definition.—Force is any cause which changes or tends to change the state of rest or motion in a body.

The direction of a force may be represented by a line, and its magnitude by a number. But when we represent magnitude by a number, we must have some *fixed* standard of the same kind as that we represent *by the number*: inches, feet, yards, &c., are the

units commonly used for comparing lengths. Ounces, pounds, tons, &c., are the units for comparing pressures or forces.

A pound pressure means that amount of force which is exerted towards the centre of the earth, by the quantity of matter called a pound.

A pound of matter is a quantity equal to 27·727 cubic inches of pure water at a temperature of 60° Fahrenheit.

A line has a great advantage over a number in representing force.

The direction of the force is shown, and the extremity or commencement of the line shows the point at which the force acts. Forces may also be represented in magnitude by lines of different lengths: a unit of length being taken to represent a unit of force. The point at which the force acts, the direction of the force, and its magnitude, may all be defined by a line, while a number can only represent its magnitude.

GRAVITATION AND WEIGHT.

If we take a stone and hold it on the hand, we feel a downward pressure which is called *weight*. The stone seems drawn towards the earth, and upon turning the hand over the stone falls to the ground. There must be some unseen force which causes the stone first to press the hand, and then to fall to the ground when the hand is withdrawn.

If a stone be thrown upwards it will rise only for a few seconds; it will then fall faster and faster until it is stopped and brought to a state of rest by the surface of the earth.

This unseen force not only caused the stone to fall when the support of the hand was withdrawn, but it

has neutralised and overcome the upward force which was given to the stone when it was thrown into the air. That such a force exists is proved by experiment, and it is also proved that it consists of a force in the centre of the earth, which is called attraction, and all bodies are attracted or drawn in straight lines towards the earth's centre. The resistance of the ground prevents bodies moving below the surface of the earth.

This property of bodies, falling towards the earth's centre, is called *gravity*, and the effect it produces on a body, the *gravitation* of that body.

The attraction of gravitation is always operating, and will operate through all time, although its effects are not always visible; for the attraction may be neutralised by some other force. If a globe be suspended from the ceiling by a string, it does not move towards the centre of the earth, but it is, nevertheless, attracted towards it. The string is stretched; this stretching of the string is called its tension; and if the string were cut the globe would fall, because the counteracting force would no longer operate.

Every body is continually attracted towards the centre of the earth, even though it may be prevented by some obstacle from actually moving in that direction.

From this it will be understood what is meant by the term—weight.

Weight, then, is the force with which a body presses downwards towards the centre of the earth; it is, in fact, the measure of the earth's attraction.

When we say a body weighs five pounds, we mean that its pressure towards the centre of the earth is the same as that of five other bodies, each of whose pressures had been called by common consent a pound.