FORCE (assuming $g=981$). (See p. 48.)

Weight of 1 grain	$=63{\cdot}57$ dynes, nearly.
,, 1 oz. avoir.	$=2{\cdot}78\times10^4$ dynes, nearly.
,, 1 lb. avoir.	$=4{\cdot}45\times10^5$ dynes, nearly.
,, 1 ton	$=9{\cdot}97\times10^8$ dynes, nearly.
,, 1 gramme	$=981$ dynes, nearly.
,, 1 kilogramme	$=9{\cdot}81\times10^5$ dynes, nearly.

WORK (assuming $g=981$). (See p. 48.)

1 foot-pound	$=1{\cdot}356\times10^7$ ergs, nearly.
1 kilogrammetre	$=9{\cdot}81\times10^7$ ergs, nearly.
Work in a second by one theoretical "horse."	$=7{\cdot}46\times10^9$ ergs, nearly.

STRESS (assuming $g=981$).

1 lb. per sq. ft.	$=479$ dynes per sq. cm., nearly.
1 lb. per sq. inch	$=6{\cdot}9\times10^4$ dynes per sq. cm., nearly.
1 kilog. per sq. cm.	$=9{\cdot}81\times10^5$ dynes per sq. cm., nearly.
760 mm. of mercury at 0°C.	$=1{\cdot}014\times10^6$ dynes per sq. cm., nearly.
30 inches of mercury at 0° C.	$=1{\cdot}0163\times10^6$ dynes per sq. cm., nearly.
1 inch of mercury at 0° C.	$=3{\cdot}388\times10^4$ dynes per sq. cm., nearly.

TABLE OF DENSITIES, IN GRAMMES PER CUBIC CENTIMETRE.

LIQUIDS.

Pure water at 4° C.,	1·000
Sea water, ordinary,	1·026
Alcohol, pure,	·791
,, proof spirit,	·916
Ether,	·716
Mercury at 0° C.,	13·596
Naphtha,	·848

SOLIDS.

Brass, cast,	7·8 to 8·4
,, wire,	8·54
Bronze,	8·4
Copper, cast,	8·6
,, sheet,	8·8
,, hammered,	8·9
Gold,	19 to 19·6
Iron, cast,	6·95 to 7·3
,, wrought,	7·6 to 7·8
Lead,	11·4
Platinum,	21 to 22
Silver,	10·5
Steel,	7·8 to 7·9
Tin,	7·3 to 7·5
Zinc,	6·8 to 7·2
Ice,	·92
Basalt,	3·00
Brick,	2 to 2·17
Brickwork,	1·8
Chalk,	1·8 to 2·8
Clay,	1·92
Glass, crown,	2·5
,, flint,	3·0
Quartz (rock-crystal),	2·65
Sand,	1·42
Fir, spruce,	·48 to ·7
Oak, European,	·69 to ·99
Lignum-vitæ,	·65 to 1·33
Sulphur, octahedral,	2·05
,, prismatic,	1·98

GASES, at 0° C. and a pressure of a million dynes per sq. cm. (see p. 142).

Air, dry,	·0012759
Oxygen,	·0014107
Nitrogen,	·0012393
Hydrogen,	·00008837
Carbonic acid,	·0019509

ELEMENTARY TREATISE ON NATURAL PHILOSOPHY.

CHAPTER I.

INTRODUCTORY.

1. Natural Science, in the widest sense of the term, comprises all the phenomena of the material world. In so far as it merely describes and classifies these phenomena, it may be called Natural History; in so far as it furnishes accurate quantitative knowledge of the relations between causes and effects it is called Natural Philosophy. Many subjects of study pass through the natural history stage before they attain the natural philosophy stage; the phenomena being observed and compared for many years before the quantitative laws which govern them are disclosed.

2. There are two extensive groups of phenomena which are conventionally excluded from the domain of Natural Philosophy, and regarded as constituting separate branches of science in themselves; namely:—

First. Those phenomena which depend on vital forces; such phenomena, for example, as the growth of animals and plants. These constitute the domain of Biology.

Secondly. Those which depend on elective attractions between the atoms of particular substances, attractions which are known by the name of chemical affinities. These phenomena are relegated to the special science of Chemistry.

Again, Astronomy, which treats of the nature and movements of the heavenly bodies, is, like Chemistry, so vast a subject, that it forms a special science of itself; though certain general laws, which its phenomena exemplify, are still included in the study of Natural Philosophy.

3. Those phenomena which specially belong to the domain of Natural Philosophy are called *physical;* and Natural Philosophy itself is called *Physics.* It may be divided into the following branches.

I. DYNAMICS, or the general laws of force and of the relations which exist between force, mass, and velocity. These laws may be applied to solids, liquids, or gases. Thus we have the three divisions, *Mechanics, Hydrostatics,* and *Pneumatics.*

II. THERMICS; the science of Heat.

III. The science of ELECTRICITY, with the closely related subject of MAGNETISM.

IV. ACOUSTICS; the science of Sound.

V. OPTICS; the science of Light.

The branches here numbered I. II. III. are treated in Parts I. II. III. respectively, of the present Work. The two branches numbered IV. V. are treated in Part IV.

CHAPTER II.

FIRST PRINCIPLES OF DYNAMICS. STATICS.

4. **Force.**—Force may be defined as that which tends to produce motion in a body at rest, or to produce change of motion in a body which is moving. A particle is said to have uniform or unchanged motion when it moves in a straight line with constant velocity; and every deviation of material particles from uniform motion is due to forces acting upon them.

5. **Translation and Rotation.**—When a body moves so that all lines in it remain constantly parallel to their original positions (or, to use the ordinary technical phrase, *move parallel to themselves*), its movement is called a *pure translation.* Since the lines joining the extremities of equal and parallel straight lines are themselves equal and parallel, it can easily be shown that, in such motion, all points of the body have equal and parallel velocities, so that the movement of the whole body is completely represented by the movement of any one of its points.

On the other hand, if one point of a rigid body be fixed, the only movement possible for the body is *pure rotation,* the axis of the rotation at any moment being some straight line passing through this point.

Every movement of a rigid body can be specified by specifying the movement of one of its points (any point will do) together with the rotation of the body about this point.

6. Force which acts uniformly on all the particles of a body, as gravity does sensibly in the case of bodies of moderate size on the earth's surface (equal particles being urged with equal forces and in parallel directions), tends to give the body a movement of pure translation.

In elementary statements of the laws of force, it is necessary, for