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## THE MECHANICS OF FLUIDS.

*Hydrostatics and Elementary Hydrokinetics.* By George M. Minchin, M.A., Professor of Applied Mathematics in the Royal Indian Engineering College, Coopers Hill. (Oxford: at the Clarendon Press, 1892.)

A WORK on this subject which should incorporate the latest developments has long been wanted; and Prof. Minchin has performed a very useful service in providing a treatise of a convenient size for purposes of instruction.

The first chapter starts with some general theorems on the distribution of strain and stress in the interior of a body, which to our way of thinking had better have been relegated to Chapters iii. or iv., by which time the student would be able to appreciate their importance. Mr. Minchin, however, justifies his method in eloquent language, but his simile of the danger of leaving uncaptured fortresses in the rear partakes of ante-Napoleonic ideas; as Napoleon proved it makes all the difference whether the foe is stationary or mobile.

We are pleased to see the author's practical protest against the banishment of the notation (we cannot dispense with the idea) of the Differential Calculus, traditional in our elementary treatises. A French schoolboy acquires a working knowledge of the Differential Calculus episodically, in the course of his studies of elementary algebra and trigonometry.

Mr. Minchin postulates at the outset a *perfect* fluid, that is a fluid devoid of viscosity. This is necessary when we come to the Motion of Fluids; but the theorems of Hydrostatics are true of all fluids, however viscous, such as tar, or even pitch; a fluid from its general definition is not capable of coming to rest till the *normality* of the stress has been attained.

The word *intensity* is prefixed by the author when it is wished to indicate that a stress is estimated per unit area; thus, for instance, 150 pounds on the square inch he calls the "intensity of the pressure." But this is contrary to our ordinary language, where "intensity" is never employed. Mr. Minchin had better have adopted another word, "thrust," to express total pressure or push against a given area, leaving the words stress and pressure, as in common usage, to imply that they are estimated per unit area, square foot or inch, metre or centimetre.

This would not be the work of a modern college professor if the author did not explain at some length that the world has been calling things by their wrong names; thus it is maintained that the expression above "a pressure of 150 pounds on the square inch" is inaccurate, and should always be replaced by "an intensity of pressure of 150 pounds' *weight* on the square inch."

This is a counsel of perfection which a careful search would probably show is not always observed by the author himself; and it is invariably ignored and rejected by practical men, including his own engineering colleagues.

Thus Prof. Hearson, R.N., in a recent examination paper at the Naval College, Greenwich, asks for the calculation of the resistance of a train in "pounds per ton weight"; but his M.A. colleague would edit this into "pounds' weight per ton mass."

The Coopers Hill student will have to be as careful to recollect the expression appropriate for the class-room he is attending, as the Chairman of the House of Representatives in America, according to the story, in addressing the rival members of Illi*noi* and Illi*noise.*

The use of the word "weight" to designate only the accidental quality of a body due to its position on the surface of the Earth is much insisted upon by a certain school of our writers; but this temporary fad will soon pass away, we hope, as it seems to be tainted with the ancient heresy of the existence of bodies possessing positive levitation, such as the fire or inflammable air said to have been employed in Archytas's pigeon, or the rarefied dew with which Bishop Wilkins proposed to fill a number of egg-shells, and thereby fly in the air.

For instance, what is the weight of a ton (mass) of hydrogen; must we say that it is about—13 tons?

Prof. Oliver Lodge would banish the word "hundredweight" from our language; but what has he to offer the architect in exchange?

Pressures on foundations in architecture are most conveniently measured in cwt. per square foot, from the simple fact that the average weight of a cubic foot of brickwork is one hundredweight.

If the architect of the Tower of Pisa had made a calculation in accordance with the modern formula for the resistance of foundations in earth,

$$p = w\,h\left(\frac{1 + \sin\phi}{1 - \sin\phi}\right)^2,$$

in cwt. per sq. foot, at a depth of $h$ feet in earth of density $w$ cwt. per cubic foot, $\phi$ denoting the angle of repose of the earth, he would have found that his depth of 22 feet, with $w = 0{\cdot}8$ and $\phi = 22°$, would bear only 84 cwt. per square foot; while the pressure due to the weight of the tower mounted up to 145 cwt. per square foot.

Students owe a debt of gratitude to Prof. Minchin for having almost entirely banished the old-fashioned mystifications concerning

$$W = sV \text{ and } W = g\rho V;$$

and he very clearly points out that the pressure at a depth $z$ in liquid of density $\rho$ is not given by $\rho z$ gravitation units, but by $g\rho z$ absolute units.

But the introduction of the new term "*specific weight*" to designate what has hitherto been called the *heaviness* (or *density*) of a substance is to be deprecated, especially as the author is careful to explain that he does not mean *specific gravity* by *specific weight.*

But the German for specific gravity is *spezifische gewicht,* so that confusion is sure to arise; much the same as with the word *masseinheit,* which means unit *of measure,* and not *unit of mass,* as it has been incorrectly translated.

It is doubtful whether any advantage is gained by the introduction of absolute units into a statical subject; they are never used in experimental and practical work; but if the experimenter wishes to express his numerical results in a cosmopolitan form, he can multiply his gravitation results by the local value of $g$, as the last operation of all.

Unfortunately, in the C.G.S. system selected by scientific men, the units are so minute that they are only suitable for the most delicate phenomena of the physical laboratory, such as Capillarity; and numbers run very high in ordinary dynamical problems.

Millions of *boles* of impulse would be required to flick a sixpence across the counter; and the answer "millions," which Albert Smith said he received from the stoker when he asked how many degrees of temperature there were in the stoke-hold, would not be wrong if he had asked what pressure the boilers carried; "fifteen millions" might be the answer of the scientific stoker of to-day, trained in the use of the C.G.S. system.

Another banishment from this treatise to be grateful for, is that of "the whole pressure of a fluid on a curved surface."

If, however, this whole pressure is divided by the surface, we obtain the *average* pressure over the surface, a distinct mechanical motion, sometimes useful; with this resetting the "visionary problems of pure mathematics" on whole pressure might be allowed to survive, as some of them embody elegant geometrical applications.

Generally throughout the work Mr. Minchin has secured the assistance of his colleague Mr. Stocker, the Professor of Physics, for the experimental illustrations and diagrams, and we meet with many novel and ingenious experiments, for instance in the illustration of Boyle's Law in Fig. 57.

This gives a flavour of the Physical Laboratory to the book, and not that of the Engineering Theatre, except for the elegant geometrical treatment of the Line of Thrust in a Reservoir Dam. The Hydraulic Press of Fig. 7 could hardly serve to lift a girder of the Britannia Bridge, or squeeze a steel forging with a thrust of thousands of tons.

The equilibrium and stability of a floating body is illustrated in Fig. 49 by what looks like a champagne cork, and not by the cross-section of an ironclad or Atlantic steamer, with compartments bilged and full of water to illustrate the effect of petroleum or liquid cargo, or the unfortunate capsizing of the *Victoria*.

The diagram of a floating body in the ordinary mathematical treatise, where it is not like a cinder or a potato, but a vague idea of the cross-section of a ship, has the metacentre placed somewhere up the mast.

Prof. Minchin reduces this metacentric height to more reasonable figures, 5 or 6 feet; but even this is excessive, as H.M.S. *Prince Consort*, with a metacentric height of 6 feet, was a notorious bad roller; vessels of the greatest size are plying successfully with a metacentric height of under 1 foot; and we read a day or two ago of one of the largest modern steamers becoming unstable when being undocked.

The question of the stability of a ship involves the two antagonistic qualities of "stiffness" and "steadiness."

A "steady" vessel has a small initial metacentric height, and "stiffness" under sail is secured by making the metacentre rise rapidly as the ship heels.

The whole theory of the geometry of the ship is one of great mathematical interest; and the valuable compilation of all the best recent work on this subject, made by Sir E. J. Reed in his "Stability of Ships," deserves to be better known among mathematicians.

Chapter vi., on Gases, is one which will excite great admiration, from the way in which the leading parts of Thermodynamics are introduced; the most recent theories have been incorporated and illustrated numerically and experimentally; here the valuable assistance of Prof. Stocker is acknowledged. In this part of the subject we think that a simplification would be effected by pointing out that with the gravitation units employed in § 48, the quantity $k$ in the equation $p = kp$ is the "height of the homogeneous atmosphere."

Hydraulic and Pneumatic Machines are carefully described and illustrated in Chapter vii. Fig. 71 of the Fire Engine is curious as illustrating the continuity of mathematical diagrams, as it might have been copied from the one given in Hero's Pneumatics B.C. 120, as invented by Ctesibius.

The hydraulic ram (*bélier hydraulique*), Fig. 73, is here attributed to Whitehurst, of Derby (1772). This will raise a protest in France, where Montgolfier is considered the inventor; but, on the other hand, Mr. Minchin gives Mariotte a half share in the discovery of Boyle's law.

Chapter viii., on "Molecular Forces and Capillarity," is very complete but rather formidable, as it does not shirk the difficult theories of Laplace on Molecular Pressure. The author must utilise in the next edition the scale invented by Mr. C. V. Boys, for drawing with accuracy the various capillary curves.

In the two hydrodynamical Chapters, ix. and x., there may appear some need for the use of the absolute units; but considering that the motion discussed is due to gravity, the only effect of a change from gravitation to absolute units is to remove $g$ from the denominator of certain terms to the numerator of the remainder in the equations.

The use of hyperbolic functions would simplify the expressions on the last page of the book, in the discussion of Kelland's state of wave motion.

Judiciously selected examples are introduced in small sets, to illustrate the principles at easy stages; these are printed in smaller type, and the book is thereby kept within a handy size; at the expense, however, of the eyesight of some readers.

A. G. GREENHILL.

## LETTERS TO THE EDITOR.

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### Palæozoic Glaciation in the Southern Hemisphere.

THE interest evinced in the above subject in so many quarters, and the evident ignorance of what has been done in the matter, is my excuse for asking space for some notes on my personal researches.

*South Africa.*—In July, 1872, while journeying through Bushmanland, at Mr. Niekerk's farm "Welgevonden," near Prieska, on the Orange River, I observed extensive accumulations of pebbles and boulders loosely piled, many of them striated, scored, and facetted—in fact, unmistakably ice-marked. One of the boulders I took to Cape Town, and deposited it in the South African Museum. This was the first discovery of glaciation in Cape Colony, and it attracted some attention at the time (*vide Cape Monthly Magazine*, &c.). While crossing Bushmanland, the boundaries of this conglomerate were jotted down, and they were delineated on my Sketch