

plain statement of the truth to add that as a scientific treatise the work cannot be regarded as an authority.

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GRAVITATION AND ABSOLUTE UNITS OF FORCE.

ABSTRACT OF A PAPER READ BEFORE THE NEW YORK MATHEMATICAL SOCIETY AT THE MEETING OF APRIL 7, 1894.

BY PROF. W. WOOLSEY JOHNSON.

THE writer held that the conflict between gravitation and absolute units was irrepressible because of the impossibility of reconciling the practical necessities of the engineer with the scientific needs of the physicist. Accordingly most modern text-books admit both kinds of units. The history of the matter was briefly summarized. Weighing being the inevitable manner of comparing masses, the same terms have always been used to describe masses and the pressures produced by their gravitation. With the rise of mechanical science the conceptions of force and of mass must be differentiated. The older writers were content to write $P \propto mf$; force, mass, and acceleration might be expressed each in its own unit; but the modern method is to write such a relation in the form $P = kmf$, and, first establishing fixed units to be employed, to proceed to determine k . Since no occasion had hitherto arisen for a unit of mass as distinguished from a unit of weight, no difficulty was at first felt in adopting for m such a unit that $k = 1$, and hence $P = mf$, while the pound, the foot, and the second were the units of force, length, and time. In other words, in using $W = mg$ no inconvenience was felt from the fact that in assigning a numerical value to m its unit was not a mass weighing one pound, but a mass weighing g pounds. There would rarely be occasion to employ the numerical value of m , W/g being substituted for it in final results.

But g is found to be variable, and since our standards furnish us with an invariable mass, it is seen that we have been using a variable unit of force. The engineer and practical man, however, while admitting that mass and not force is the third primary unit, still finds it more convenient for his purpose to use this variable, or rather let us say 'local,' unit of force, in spite of the fact that in using the formula $W = mg$ this implies also a variable or 'local' unit of mass.

This variable unit of mass seems intolerable to a certain class of writers who object *in toto* to gravitation units. With these writers "the British unit of mass is the Imperial