Symbols of Applied Algebra.

UNFORTUNATELY Mr. C. S. Jackson (p. 293) does not appear to believe that I mean what I say, nor does he definitely apprehend what I mean. It is possible, however, that he represents some other teachers, and, therefore, I must regretfully occupy your space with the elementary statements: (1) that absolute measure has nothing to do with "standard substances"; directly a standard substance is introduced the "measure" becomes relative; (2) that specific gravities are expressible in tons per cubic yard (weight or mass being understood in accordance with context and subject-matter), or in grammes per cubic inch, or even in dynes or poundals per cubic metre; and (3) that to consider a density as a mere number is erroneous.

January 31. OLIVER J. LODGE.

On Mass.

DESPITE the extraordinary letter of Mr. C. S. Jackson, which appears in your issue of December 31, 1896, I must say that if there is a term which teachers of rational mechanics should retain and emphasise, it is the term *mass*. Mass denotes the quantity of matter, or the amount of stuff, in a given body. It is a definite and invariable quantity, whether you have the body at latitude 0° or at latitude 90°; whether you conceive it transferred to the surface of Jupiter, or to the outermost ring of Saturn.

On the other hand, the weight of the said body is a variable quantity, being measurably greater in a high than in a low latitude. At the earth's centre, it vanishes; on the moon, it would be less than here in New York; whilst on Jupiter, it would be considerably greater.

The inevitable conclusion is that scientifically the *mass* of a given body is of more importance than such a variable quantity as its *weight*.

This holds even commercially, for when we buy a pound of sugar we are more concerned with the quantity of the saccharine material that we get than with its weight. The weight is taken, in any given place, as a convenient measure of the mass.

Mr. Jackson's equation

$$P/Q = f/\alpha$$

is misleading; it is true only when the forces P and Q act on *equal masses*. To write such an equation without the above statement, is merely begging the whole question at issue.

It is to be hoped that teachers of rational mechanics will ever insist on the different ideas connoted by the terms *Mass* and *Weight*. M. F. O'REILLY.

Manhattan College, New York City, January 13.

Dynamical Units.

IF Prof. Perry's reply to my letter (on p. 126) is summed up in the charge that I think of "stuff" when I ought to be thinking of inertia, then the issue between us should reduce to very minute dimensions. It is, perhaps, unfortunate that in English the term mass may signify either "quantity of matter" or the inertia of that matter, but hardly so unfortunate as the fact that weight may denote either a quantity of matter or a force, an ambiguity to which we are all prone, though Prof. Perry makes light of it; for a definite amount of matter implies, at least, a definite amount of inertia, but not a definite weight, in the sense of force If Prof. Perry thinks that with himself the word mass means simply inertia, then, substituting at the bottom of p. 49 in the current volume, I find that he says: "My unit of inertia is the *inertia* [the italics are mine] to which unit force gives an acceleration of 1 foot per second per second." I am free to confess that I cannot dissociate the conception of inertia from the idea of matter; but here we have abstraction indeed.

The main points to which I confined my remarks were the observation that with British standards the poundal is unique among units of force, and the showing that the alternative system of units advocated by Prof. Perry is artificial and inconvenient. Even if he makes such verbal alterations in my letter as may suit his craving for rigorous expression, the objections to his proposals will still hold. But I do not know for certain what alterations he demands. In the case of a student who is commencing the study of dynamics by observing the effect of forces applied to bodies moving smoothly on the flat, would he tell him at the outset that it is not a number of pounds of iron or other stuff that he is moving about, though he may think so, but an amount m of inertia? Surely he would not. Or is it that he objects to my statement that his system involves the conception of one piece of matter (the standard pound) whose weight (under conditions) is the unit of force, and also of another lump of matter of 32·18 lbs. whose inertia is the unit of inertia? Well, if he says that no such conception presents itself to him I will not insist. I am not familiar with his psychological processes, but such images arose in my mind on reading his exposition of the system, and I think the same would (and ought to) occur in the case of a student on first trying to understand it. And it is for the beginner that Prof. Perry is so solicitous: an advanced student may be left to choose his own system, and will get on in spite of all systems.

In seeking to justify his preference, Prof. Perry, dexterously using the figure paraleipsis, extracts such support as he can get from existing legal definitions of the pound. We have had our law-abiding instincts appealed to in this connection before; but the law is a broken reed to rely on. The legal standard pound was originally established almost entirely with a view to facilitate the accurate weighing of Prof. Perry's conventional or metaphysical ideas—in other words, quantities of stuff of various kinds. Its environment did not signify, as its weight, in the sense for which modern physicists try to reserve the term, was quite a secondary matter. The standard pound was adopted for the sake of something which it and all its true copies, of whatever material they may be made, possess, or appear to possess, in themselves; and this thing they possess, or are associated with to the same extent wherever they may exist in the known universe: and it is not their weight, in the modern sense. It is their mass, in the sense of, or as measured by, their quantity of inertia. Prof. Perry is welcome to whatever comfort he can obtain from the wording of Weights and Measures Acts.

However, we have the thing—the standard pound. No one denies that its weight, when it is placed in vacuo near London, furnishes us with an excellent practical unit of force. But this is not good enough to secure the banishment of the poundal and the dynamical system associated with it. I do not quite gather where Prof. Perry himself considers the "huggermugger" comes in with regard to this unit; but if I understand his letter aright, something perilously near to this appears to have crept in among his observations on the subject.

In his letter (NATURE, vol. lv. p. 176) he affects to ignore the fact that the standard pound really furnishes us with a standard *something* that is constant—its inertia. He uses such phrases as "Assuming . . . that the weight and inertia of a certain body measured under the same circumstances at the same place are always the same"; and again: "Now here are your standards" (*i.e.* of weight and inertia) "in one piece of metal and its environment, and in your instruments." How ingenious is the suggestion that its inertia suffers from the same incurable disease that afflicts its weight, viz. that it is a function not of the body only, but also of its more or less unknown and uncontrollable environment. If it should ever be shown, as he seems to think may occur, that for a given body its inertia—the ratio of force to acceleration produced—is not to be regarded as an absolute constant, then not only the poundal, but a good many more of our dynamical ideas will have to be thoroughly overhauled.

Furthermore, he cannot mean what he appears to say, that he really considers the weight of a body, its attraction by and for the earth, to be the most fundamental property of matter, though from the stress he lays on the importance of his system one might almost suppose that it is so, and, moreover, that it is the weight at London which possesses this distinction. If he means that he regards the gravitational field of force associated with every particle of matter (ether-stress, if you will) as the most fundamental property of matter, I understand him, while not quite agreeing with him. Still, he can found a mechanical system on that basis, free from the objections applying to his present system; but it will have no 32·18, and I am afraid practical men will not receive it with gratitude.

As emphatically pointed out by Prof. Lodge, the interest of the question is pre-eminently educational. Prof. Perry agrees that to an expert, so far as his own personal work is concerned, the units he works in are generally of no great consequence. Such a one can use, say, the Birmingham wire-gauge or the Baumé hydrometer with much more facility than an ordinary person could use more rational devices. And so far as actual