	No.	log.
$\dfrac{523{\cdot}7 \times 3{\cdot}872}{96{\cdot}01}$	523·7	2·7191 +
	3·872	0·5879 +
	96·01	1·9823 −
$\simeq$21 1	21 12	1·3247

To achieve reform would require some effort for the teacher to change fixed habits, and the pupils would have to be persuaded that the method in the text-book is old-fashioned and that the new way is better.

Yours, N. DE Q. DODDS

The Haberdashers' Aske's School,
Elstree, Herts.

To the Editor of the *Mathematical Gazette*

DEAR SIR,—Dr. Buckley (*Math. Gaz.*, XLV, p. 186) asks for other views regarding the teaching of the method of virtual work.

In my opinion, it is best to commence by defining a virtual displacement of a mechanical system as *a purely imaginary displacement of the particles of the system during which the forces (both internal and external) acting upon them remain unchanged in magnitude and direction.* The displacement is then accepted as hypothetical from the outset since, for an actual displacement, the forces of the system will not generally remain constant. The method of virtual work is then seen clearly for what it is: a device to facilitate the writing down of the equation of equilibrium $\sum \mathbf{F} \cdot \delta\mathbf{r} = 0$ (which is true for quite arbitrary $\delta\mathbf{r}$, since $\mathbf{F} = 0$ for each particle) by interpreting this equation physically as an equation of work. This form of definition permits the use of displacements inconsistent with the constraints and displacements leading to deformation of components of the system, for the purposes of calculating constraining or internal forces respectively. If the virtual displacement is taken to be always consistent with the constraints, the calculation of a reaction at a constraint has to be carried through indirectly by imagining the constraint removed and replaced by a force. One effort of the imagination at the outset eliminates the necessity for this pretence.

Thus, in the case of the particle on the rough inclined plane, I have no objection to the particle being pushed into the plane or lifted off it in a virtual displacement. The normal reaction R remains steady during either displacement, no matter how it would vary in practice and the work it does is Rd, where d is the displacement (positive for motion off the plane). I also have no objection to the particle being displaced up the plane, though the frictional force would then reverse for an actual displacement.

It must, of course, be explained to students why a displacement consistent with the constraints is often the most convenient, but if this feature is incorporated in the definition of a virtual displacement, I think there is a loss of flexibility in the application of this idea which

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can only be overcome by the employment of special devices later. When setting up Lagrange's equations, the virtual displacement will be chosen to be consistent with the constraints, but more general displacements are often convenient for the solution of statical problems and there seems no reason to exclude them from the start.

Yours truly, DEREK F. LAWDEN

University of Canterbury,
*Christchurch, C.*1
New Zealand

To the Editor of the *Mathematical Gazette*

DEAR SIR,—I have read Professor Sondheimer's inaugural lecture with great interest, nevertheless I remain unconvinced that applied mathematics is a science.

I find it easy to agree that " pure mathematics is essentially pure logic "; I find it much more difficult to accept the suggestion that " applied mathematics uses mathematical methods to study and describe and formulate theories of observable phenomena in the external world ". If one can accept this definition then it is reasonable to conclude that applied mathematics can be physics. But surely this is true only during the process of research and development. As Professor Sondheimer explains, " Once a branch of the subject has been fully established, we do try to bring out its logical coherence in just this way, by developing it like a branch of pure mathematics from a fundamental set of axioms which are chosen so as to summarise some particular aspect of our experience of the external world."

By the time an applied mathematics has been incorporated in the text-books it will be more or less indistinguishable from pure mathematics. The student of this subject will not necessarily be concerned with the relevance of the axioms to the external world, and in many cases will not know enough of physics to judge their relevance for himself. Also the applied mathematics of one generation may become the pure mathematics of another, when its axioms are shown to be no longer consistent with physical theory.

Perhaps the most satisfactory conclusion is that applied mathematics can be regarded either as mathematics or science. For the research worker it can be a science: for many students it is simply mathematics, but it should be possible for teachers to make use of both aspects of the subject in their teaching.

Professor Sondheimer's definition of applied mathematics raises another important question. Physics is not the only science which uses mathematical methods to formulate theories concerning the external world. Should these other sciences be used as the basis for other applied mathematics? Should there be, for example, an applied mathematics to correspond to Mathematical Economics?

Yours sincerely, FREDA CONWAY

University Road,
Leicester.

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