An Arbitrary Veto

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word "any" might be used instead, thus 2360 would read two three six any.

If the 0 with the horizontal bar is decided on, it may be useful at times to introduce other figures similarly ruled through. For example, in multiplying 30 by 6, if we say six times aught are aught and six times three are eighteen, writing the result 180, we have omitted to allow for carrying on from the multiplication of 0 by 6. On the other hand if we say six times aught are aught carry aught, six times three are eighteen and aught are aught carry two and write the answer 200, we are safe at any rate, but we are not making such a close estimate as if we wrote the answer 180.

The resemblance of θ to the Greek θ is rather useful in connection with the custom of using θ to denote an unknown quantity between 0 and 1 in the remainder in Taylor's Series. With the new notation $f^{(n)}(x + \theta h)$ would become $f^{(n)}(x + (0\cdot\theta +)h)$.

It is impossible to add, subtract, multiply or divide past the unknown digit. The latter acts as an automatic brake which stops the pupil from evaluating a long string of digits with his customary unmathematical inaccuracy.

The notation $1\cdot57 \times 10^6$ certainly gets over the difficulty to a limited extent, but it is difficult to make people use this notation.

There is also the need of a notation for an indeterminate quantity: unfortunately the symbol most suited for the purpose is used to denote "per cent."

The suggestions raised here will doubtless give rise to differences of opinion. Possibly a better notation than either I have suggested can be found. For this reason I would urge the Association to deal with the matter, either by appointing a small committee or by referring the question to the Council.

G. H. BRYAN.

AN ARBITRARY VETO.

HAVING read with more than ordinary interest the Address delivered by Professor Perry on "The Correlation of the Teaching of Mathematics and Science," I should like to lay before the members of the Mathematical Association a few remarks which, I trust, will be found to the point.

I need not further endorse the view that as long as a student does not specialize in mathematics or in science, the teaching of both these subjects will be greatly improved if in the hands of the same teacher. Such an arrangement must benefit both teacher and student. By "science" I mean physics, and those parts of applied mechanics, electricity, and magnetism, generally comprised with certain other practical subjects under the general term of "engineering."

It is inevitable that those who have to teach the working-class element that forms the majority of those who attend Evening Classes should hold this view.

To these students,—wage-earning lads, and thereby somewhat inclined to be more independent and critical, and less amenable to school routine than the ordinary school-boy—the logic of the pure mathematician will scarcely appeal. And further, the practical interest a physicist or an engineer can give to most of the questions that are considered in mathematics is certain to react upon them and to promote that attention and regularity in attendance without which no teaching can have really good and lasting results.

Take the case of $(1+a)^n = 1+na$, when a is small compared to unity. The mathematician will see but an occasion for abstract applications and will accordingly keep his students on such exercises as evaluating $(1.006)^3$ or $\sqrt[3]{0.994}$. But the mathematical physicist or engineer will seize the opportunity of introducing practical examples. He will, for instance—even if this necessitates the definition of “pitch” and of “arc of approach,” which he can easily explain in a few words (and by means of two sectors of gearing cut in cardboard, if he be not taken unawares)—mention that, with the usual proportion of involute gearing, the ratio of the arc of approach to the pitch is found to be

$$\frac{n}{24} \left(\sqrt{1 + \frac{57.6}{n}} - 1 \right)$$

where n is the number of teeth in the follower. He will then ask his students to show that, when the number of teeth is very much greater than 57.6, the ratio is independent of the former. Such examples will teach the students not only what the tool is, but for what purpose it is used, and how it is used, a point which is too often entirely lost sight of in teaching mathematics.

The mathematician will set his class to plot such functions as,

say, $y = \sqrt{5 - \frac{1}{10\sqrt{x}}}$. The scientist will not lose such a chance

of interesting his audience. He will give a short exposition of the principle discovered by Torricelli, so beautiful in its simplicity, and leading to the expression for the discharge of water through a drowned orifice:— $Q = cw \sqrt{2gh}$; (which lends itself admirably to the purpose of physical interpretation). He will then explain in what consists the Spanish module and will then easily deduce for the annular orifice of the module the

formula $r = \sqrt{R^2 - \frac{Q}{a\sqrt{h}}}$, where R , Q , a will be numerical

constants, while r and h are the correlated variables. Each student will then set to work and plot the outline of the plug,

and will have learned ten times more than a bare graph in x, y would have conveyed to him. In addition, this (so precious) conviction that mathematics are not a thing "which they will have to do only in hell" will be profoundly strengthened. (If the opportunity allows, this should at once be followed by the graphical determination of the volume and therefore of the weight of the plug.) To exercise their knowledge as to the graphic solution of equations, instead of keeping students on such work as: "Solve $x^3 - 5x^2 + 2 = 0$," a physicist will tell them: "I want to make an anchor ring, the weight must be 9.68 lbs., the outer diameter being 10 inches; the metal weighs .245 lbs. per cubic inch; how thick must it be?" Mathematics will veil her face, but what a gain for the boys! They will first find out that they are led to a cubic, and be puzzled; one single word, "graph," will launch them excitedly on the pursuit of the required radius of cross-section by plotting $y = x^3 - 5x^2 + 2$. Some will find for answer 4.92 in., others 0.68 in. Thus will they learn the never-to-be-forgotten lesson that one must put a pennyworth of salt with results, obtained by mathematical methods, which are to be put to a practical use.

I could multiply examples, but the cases selected show the greatly increased power of a teacher to impart instruction of the right sort when he can call to the rescue work done or touched upon in other (science) classes taken by himself.

I was greatly surprised that while most speakers approved of the correlated teaching of mathematics and science by the same teacher, none alluded to the arbitrary veto of the University of London. For a teacher to be recognized by the University (and many posts are granted but on this condition) the teacher must not deal with any subject other than the one in which he wishes to be recognized. Before anything can be done this regulation must be abolished. It is responsible for a great deal of the rigour that is keeping strictly apart the various departments of a College or a Polytechnic.

My own experience is bad enough, but as it is a very good example of the case under discussion I may be excused for stating it at length.

One of my duties is to teach apprentices who, after passing a preliminary easy examination, enter a large factory. They come from various schools, have been taught in various ways (some very badly indeed), and to all, without exception, the word "accuracy" is Hebrew. This heterogeneous material is given to me to turn in one year into as homogeneous a body of students as possible, so as to enable a more advanced course to be successfully followed in the second year. As it may be inferred, the task is highly interesting.

Four years ago, I took them in pure mathematics, practical

mathematics (lectures and exercise classes) and general elementary science (lectures and laboratory work). Having these three subjects in hand, I found the work fascinating, the classes being so related that each was a part of a whole, one giving the practical illustrations required in the apparently quite independent theoretical work of another. The results, as may be expected under such a system, were most gratifying, the more so that, being practically their only teacher, I got to be "in touch" with the boys, and this means much when, because they earn a small salary, they consider themselves as beyond the school-boy stage. It was very pleasant work indeed, and I was taking steps to obtain a free pass to visit weekly the shops in which the boys were employed, in order to bring into the evening work something directly connected with their own daily experiences, and thus to make the general educational scheme as efficient as could be. But, owing to difficulties presented by the above-mentioned University regulation, the classes were split up, and I was left with the teaching of mathematics alone.

My experience cannot be unique. If such promising conditions are to be sacrificed on the altar of the god Classification, no improvement in this line can be hoped for as long as the University of London adheres to the present rule concerning recognized teachers.

MAURICE E. J. GHEURY.

ANHARMONIC COORDINATES.

HAMILTON, in his *Elements of Quaternions* (Book I. Chapter II.), developed this system of coordinates, by means of his vectorial algebra, in connection with his theory of geometrical nets.

In the following paper I have re-proved the fundamental theorems, by other methods, and have sketched out the natural lines of development of the system.