THE New York Academy of Sciences has announced prize contests for 1941. The A. Cressy Morrison Prizes in Natural Science of $200 each will be awarded to a member of the academy or one of the affiliated societies, for the two most acceptable papers in a field of science covered by the academy or an affiliated society. In accordance with the terms of a bequest made by the late George Frederick Kunz, the accumulated annual income of the sum of $1,000 is offered at intervals by the council of the academy for a paper by a member of the academy in the field of geology and mineralogy. The prize, amounting to $200, is now offered for the first time. These prizes will be presented at the annual dinner in December.

ACCORDING to the *British Medical Journal* the Rockefeller Foundation has agreed to continue until the end of 1941 its grant of £1,200 a year for research in cellular physiology at the Molteno Institute under the direction of Professor David Keilin, Quick professor of biology at the University of Cambridge.

DISCUSSION

PHYSICISTS NEEDED FOR NATIONAL DEFENSE WORK

MATHEMATICS, THE BOTTLENECK FOR PHYSICISTS

THE U. S. Civil Service Commission[1] recently called attention to the fact that we haven't in this country a sufficient number of trained physicists to carry on with our defense program and at the same time keep our educational institutions and industrial research laboratories going with proper personnel.

We are asking ourselves why more men are not going on into advanced work in physics after completing their college course. Many of our graduates are capable of doing advanced work if they cared to do so.

After 35 years of teaching I am personally convinced that the outstanding restraint to a larger election of physics as a life work is due to the fact that for the average undergraduate no practical and fruitful results follow from a study of mathematics and physics. Mathematics (the sine qua non for physics) and physics too are exacting beyond all compromise. "They involve a degree of coercion and constraint which is beyond the power of any teacher to fully mitigate," unless the student feels that he is getting something practical and worth while. If in the technique of mathematics and physics a student sees the tools wherewith he can tackle unknown problems (the research method[2]) he will go to any length to master the same. The subjects will then become challenging to an individual with red corpuscles and the intestinal stamina to work.

Let us examine this common ground between mathematics and physics and which will be presently true of chemistry and eventually of biology. In the teaching of first-year college physics I am confronted year after year with the inability of my students to do the simplest kinds of ordinary algebraic transformations. Ordinary proportions appear to them to have nothing to do with chemistry and physics. If shown the expression:

$$a : b = c : d$$

they would say it was a proportion and would say with a little prodding that

$$\frac{a}{a+b} = \frac{c}{c+d}$$

was a case of proportion transformed by composition. Suppose, however, we give these students the following problem:

Two spheres are charged with a combined charge of 15 esu. If the radii of the two spheres are 10 and 20 centimeters, respectively, what is the charge on each sphere when put to a common potential by touching one sphere to the other? If they have studied the basic equation for static electricity, $C = Q/V$, they would go so far as to say that at the common potential, V, the two spheres would have the relation:

$$V = \frac{Q_1}{C_1} = \frac{Q_2}{C_2}$$

and

$$\frac{Q_1}{Q_2} = \frac{C_1}{C_2}$$

or since the capacitance of a sphere is numerically equal to the radius of the sphere we may write

$$\frac{Q_1}{Q_2} = \frac{r_1}{r_2}.$$

There they would stick. They might suggest that they had two simultaneous equations:

$$\frac{Q_1}{Q_2} = \frac{1}{2}$$

and

$$Q_1 + Q_2 = 15$$

It would seldom occur to the average student of physics that

$$\frac{Q_1}{Q_1 + Q_2} = \frac{r_1}{r_1 + r_2} = \frac{10}{30} = \frac{Q_1}{15}$$

and, therefore, $Q_1 = 5$ esu, while $Q_2 = 10$ esu.

Students will tell you that

$$y = mx$$

is the equation for a straight line, but seldom can they tell you what sort of a curve the velocity of a falling body would give when plotted against time of falling, as in the equation, $v = at$.

[1] *Jour. Applied Physics*, 12: 127, 1941.

[2] S. R. Williams, *School Science and Mathematics*, 29: October, 1929.

In Boyle's law,

$$PV = \text{a constant},$$

at constant temperature. They hardly ever see that this equation has anything to do with

$$xy = \text{a constant},$$

an equation, about which they have learned a little in analytical geometry. One could go far afield in this branch of mathematics showing how little association there is between the mathematics a student has learned and the applications he wishes to make in studying physics, such as the plotting of curves and what they mean in the particular problem under consideration. Why does a physicist (at least one) prefer to plot pressures against the reciprocals of volumes in Boyle's law and not get an hyperbola, when students having been told that $PV = $ a constant is the equation of an hyperbola will insist that P plotted against $\frac{1}{V}$ will give an hyperbola? Examples are legions in which the physics student seems unable to apply his mathematics intelligently to physical problems.

What is the trouble? Here is a problem in which physicists and mathematicians should be greatly interested. So far as the usefulness of the mathematics is concerned one wonders if mathematics teachers do not take too much the attitude of the author of a book on quaternions who is reported to have said when finishing the manuscript—"There, thank God, that has no practical value."

Calculus was developed by a physicist (Newton) because he needed such a tool wherewith to describe the motion of a body whose velocity was continuously and uniformly changing. Vector analysis was developed in a similar fashion. It combines within itself most of the advantages of both quaternions and of Cartesian analysis. Both calculus and vector analysis are necessary (practical) tools and when mathematics is taught from the standpoint from which most of it was developed, mathematics will have come into its rightful heritage and serve once more its true worshippers.

If this be a tirade against mathematicians it applies equally well in principle to physicists. What's food for the goose is also food for the gander. Physicists have been teaching an emasculated subject, because they are not willing to make the subject-matter useful. We have tried to teach a parlor physics devoid of mathematics and practical applications, and the student has rightfully felt he was receiving only husks. As W. S. Franklin once wrote: "There are too many people who fancy they have an interest in the 'results' of science and who, poor fools, invest in Keeley Motors and Sea Gold Companies because, forsooth, the desired result is so clearly evident."[3]

Teachers of physics spend too much time in the classroom expanding, let us say, on the wonders of television and its sociological connotations. They wish to sugar-coat it also by its historical setting and its philosophical implications. The really important and fundamental things which lie back in a vacuum tube have been quite forgotten; a knowledge of which was won by the sweat of other men.

When an individual, whose chief research is with a microscope, wonders why he can't get the same magnifying power for his instrument which the makers have given to it, and can't understand why the tube length has anything to do with the question, the thoughtful reader must realize that some physics teacher failed in making a simple mathematical equation,

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f},$$

and its consequences clear in first-year physics. The physics of lenses was not taught so as to be useful to any one. A carpenter may possess a set of tools, but if he can't build a house, of what use are the tools?

A potential physiologist or chemist ought to know the simple equation for a Wheatstone bridge or a potentiometer and how to use both the equation and instrument conjointly.

Metrology, the science of measurement, whether in the biological or in the physical sciences, rests upon the fundamental units of length, mass and time, whose standards have been established and maintained by physicists.

When one brings together in one student a supposed knowledge of both mathematics and physics and that student finds in the end that he has not been taught how to apply that knowledge, the student has a just cause for not liking physics which rests so fundamentally on mathematics.

A few years ago I had occasion to observe American and German students working together in the laboratory. The first thing a German student did was to see how the experiment would look set up in mathematical form. If it looked hopeful he progressed to the experimental set-up.

This is a proper procedure. American students couldn't even set up the equations for the problem, much less solve them, and yet these students were supposed to be at the same stage in their educational program. There is something to be said for Prussian drill master procedure in teaching mathematics. Mathematics must become an integral part of those who use the subject as the multiplication table is for most of us. There should be constant drill in mathematical technique when it is taught and particularly in its applications. Look over the average mathemati-

[3] W. S. Franklin, "The Elements of Mechanics," p. 17, 1907. The Macmillan Company, New York.

cal text-book and note page after page of problems, all of which are to be worked out by a common formula; why not introduce a lot of simple problems to be found in both the biological and the physical sciences for a practical application as one drills in the mathematical technique?

In an article "Science is Mobilised for War," Sir William Bragg[4] says, "The rate at which some scientific war problems are being solved is almost incredible; more advance is being made in a year than in ten years of peace, I suppose because everybody is keyed up and throwing all his energy into the job in hand. One can not help thinking, 'Why not do the same in peace time?' If the same team work could be put into tackling disease, smoky and ugly cities, better use of the land, improvement of our industries, and so on, there is no doubt that problems which have been bogeys for generations would disappear in a few years."

This seems to the writer to be a clear statement that science progresses most rapidly when it is put to practical and definite ends. Unfortunate it is that science must be put to practical uses of war, for Sir William closes with this high aspiration; "Scientists are doing their best to help the country in wartime. You may imagine with what enthusiasm they would join in a similar nationwide effort in times of peace, and how much more congenial to them their share in it would be."

Long ago Bacon wrote, "We advise all men to think of the true ends of knowledge, and that they endeavor not after it for curiosity, contention, or the sake of despising others, nor yet for reputation or power or any other such inferior consideration, but solely for the occasion and uses of life." Can any one imagine any other basis upon which the study of physics can be justified than for the occasions and uses of life?

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PETROGLYPHS AS CRITERIA FOR SLOPE STABILITY

NEAR the western end of the Finlay Mountains, in Hudspeth County, Texas, is a large Indian campsite remarkable for its petroglyphs. This site extends for 850 feet along the scarp-slope and base of a cuesta made of strata belonging to the Cox (Cretaceous) formation.

The slope on which the site is situated has an average inclination of 20°. It is developed across layers of shale and thin-bedded limestone. At the top is a cliff 30 feet high upheld by a massive stratum of sandstone. Joint blocks fallen from the cliff bestrew the slope below, covering perhaps 80 per cent. of its surface. The slope distance from the base of the cliff to the base of the slope is 450 feet.

Many of the joint blocks on the slope exceed 20 feet in length and 10 feet in width. They lie at all angles, forming natural shelters under their projecting margins. It is evident that retreat of the cliff has proceeded largely by the detachment of sandstone joint blocks, which have slid or rolled down the slope below. Looking at the boulder-covered slope, one gets the impression that this retreat must be proceeding rapidly at the present. That this is not true is indicated by the archeology of the site.

Petroglyphs are pecked into the face of the sandstone cliff, and, judging by the continuity of pictures, no part of the cliff has broken away since the drawings were made. Petroglyphs also occur on approximately 60 of the joint blocks on the slope. Many of the pictures on the joint blocks are of animals. These remain in upright positions to-day, showing that none of the blocks on which they occur has toppled or rotated perceptibly since the petroglyphs were made. Middens are found in shelters on the down-slope sides of many blocks bearing petroglyphs. Nowhere was a block found resting on top of one of these deposits; evidently the blocks have not shifted downslope by a measurable quantity since the middens were formed.

Pottery collected from middens adjacent to petroglyph-bearing blocks has been identified as El Paso Polychrome, Chupadero Black-on-white and Three Rivers Red-on-terracotta, a ceramic complex which is typical for the Pueblo sites in the area. The time range of these three wares has been determined on the basis of their presence as intrusives in Pueblo sites of northern New Mexico that have been dated by dendrochronology. The pottery complex at this site has been dated at 1200 to 1300 A.D. by H. P. Mera,[1] of the Laboratory of Anthropology, Santa Fe. The pottery and petroglyphs seem, for the most part, to be contemporaneous; the same types of pottery are associated with similar petroglyphs elsewhere in the area. This indicates that the joint blocks in the cliff and at least 60 large blocks on the twenty-degree slope have been in essentially their present positions for the past 600 or 700 years.

Study of petroglyphs in situations similar to those here described may lead to quantitative data on the stability of cliffs and boulder-protected slopes.

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[4] Sir William Bragg, *Overseas Journal of the B. B. C.*, No. 67, January 12–18, 1941.

[1] H. P. Mera, letter to T. N. Campbell, September 3, 1940.