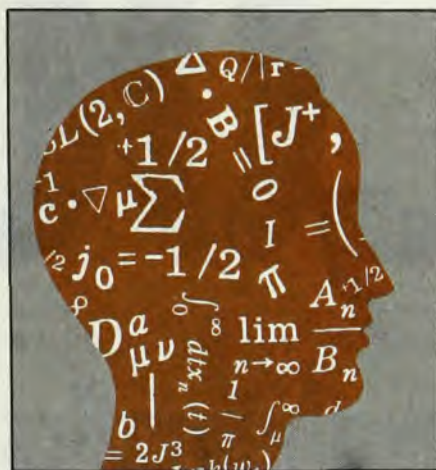


More mathematics

Despite all the discussion in PHYSICS TODAY over the last few years, I have seen no authoritative and/or candid presentation of the precise reasons why physics has been hit hardest by the cutback in support of science, and why physicists are unemployed or underemployed in numbers that would have seemed unimaginable only a few years ago. One must conclude that the precise reasons are buried in the murky depths of Washington, and are too embarrassing to the leaders of physics for them to be discussed openly and honestly.

Without this more precise information, one can only make general conjectures. My suggestion is that there is something wrong in the education of physicists that prevents them from being as versatile as the official rhetoric about such matters would have it. I would place a certain amount of blame for this on their education in mathematics, which is strictly oriented towards the pragmatic goal of learning the minimal amount needed to do physics, and even that in a usually archaic form, not at all correlated with the sort of mathematics that other scientists are learning and using. I have found (for example, in my term as associate editor of the *Journal of Mathematical Physics*) many physicists to be magnificently learned and ingenious about obscure areas of 19th-century mathematics and proudly ignorant about anything that has been done recently, even that which is most relevant to their own work.

To support this conjecture I can point to the example of the electrical engineers, who are often in competition for jobs with physicists (and who usually win the competition). In my experience the talent and training of undergraduate electrical engineers and physicists seem to be roughly equivalent. However, some influential electrical engineers decided, in the period since World War II, to modernize and broaden their graduate curriculum, and to teach their students mathematical tools that go beyond those that were strictly necessary for the job at hand. As a result, many electrical en-



gineers now receive an excellent working education in such areas of mathematics as differential equations, functional analysis, the algebra of linear vector spaces and combinatorial systems, statistics and stochastic processes. Using these tools, they have developed such general topics as systems, information and optimal-control artificial-intelligence theory that have enabled them to move successfully into such developing fields as biology, computer science and operations research.

I am suggesting then that a broader and more systematic training in selected parts of modern mathematics would be a relatively easy step towards making physicists more versatile. (I believe that it would also help in solving physics problems, too, but most physicists seem to be under the romantic spell of a tradition of amateur dilettantism in mathematics that has been passed on from the previous generation, who developed atomic and nuclear physics very successfully with minimal mathematics.) There is even a class of people—called “mathematical physicists”—who presumably could, if they were given the opportunity, help carry out this modernization. However, in this country at least, they are very few in number—and those numbers are not likely to increase, given the fact that, paradoxically, many are unemployed or underemployed, because neither mathematics nor physics departments will

give them jobs, and government agencies will not give them research contracts.

I have no concrete suggestions on how to break this vicious circle, but perhaps these observations are worth the attention of the physics community.

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Register for references?

I wish to suggest the creation by the American Physical Society or a similar organization of a Central References Register, particularly for current research in theoretical physics.

At present, the system of references followed in theoretical physics is chaotic. References are given to papers that one has recently become aware of, or has access to, without special consideration being given to completeness. Unfortunately, the omissions, inadvertent though they usually are, quite often raise problems.

Now, imagine there was a Central Register of References, prepared creatively, not by a computer but by competent physicists in the subdisciplines concerned. This register could be made available to the members of APS and the physics community in general. The APS (and other) journals could adopt the system of giving references, not to individual papers but to the numbered Standard References—something like this: Yang-Mills Theory; “Standard Reference No. 79—see in particular papers Nos. 7,8,10,27.” Anyone whose paper was not included in the Standard Reference could write in and have the omission rectified. In order that the Register remain useful, it would, of course, be essential to subdivide a topic—for example the topic of “Yang-Mills Theory”—into separate sub-references: “Yang-Mills Theory”: “Renormalization Problem,” “Gauge Problems,” “The Relevant Ward-Takahashi Identities” and so on.

The task of preparing the Standard References should not be arduous.