

letters

Teaching physics scientifically

Although I have never sat in a classroom with Frederick Reif teaching, I would imagine on the basis of his dazzlingly lucid textbook on statistical mechanics and thermodynamics that he is an awesome teacher. So it was with a certain amount of respect and interest that I read his stimulating article in the November 1986 *PHYSICS TODAY* (page 48), "Scientific approaches to science education." The article raised in my mind a number of semi-philosophical issues that may be of interest.

Let us suppose that sometime in the future, research such as Reif proposes leads to much more efficient ways of teaching than the (admittedly haphazard) methods currently in use. Perhaps these will take the form of infinitely patient computers, whose software will guide the student back and forth through the subject until he or she emerges with a thorough knowledge of the material (as shown by, say, the ability to achieve 90% or above on a standardized exam). Then presumably there would be no need for grades; to learn, say, differential calculus would just be a matter of spending a certain amount of time with the computer. One wouldn't be as patient as one might be now with the sort of person who says, "I just never could understand math!"

Ah, brave new world! How wonderful (at least, if you are me) to get rid of the onerous other side of teaching, grading—the constant need, throughout a course, and especially at the end, to judge students and their work: this one an "A," that one an "F." Wonderful future, where everyone enters a course of study, and everyone emerges at the other end with the requisite skills and knowledge.

On the other hand, anyone who teaches is aware that there are definitely some people who are better at most things than others, that there exists some factor, maybe as simple to define as IQ, or perhaps more complex. Some people understand an idea at the first explanation of it, while others are still

confused after the idea is presented a number of times, from different angles.

So it would seem that in this better, future time, if a student came to you as a freshman and said, "Do you think I should pursue theoretical physics [or soil mechanics, or whatever]?" there would be no need to hesitate. Sure, go ahead; after a certain amount of time with the computer, the knowledge would be imparted, regardless of field. But as a practical point, it would appear that for certain (lower IQ?) people this would take an enormously long time—the more "difficult" the subject (whatever that now meant), the more time—maybe more than could be fit into a lifetime (unless that were extended then also). So maybe one would have to come up with rules: Unless a student could get through Physics 101–102 in such and such a number of hours, he or she should not be encouraged to become a physicist; and the fewer hours required, the more the encouragement might be.

Ulp, back to grading! One can imagine a committee deciding that so many hours to master the subject equals an "A," so many hours a "B" and so on. And perhaps somewhere on the fringes of that academia there lurks a Karl Marx, analyzing the dark satanic mills of piecemeal education?

My point, getting back to the current real world and present methods, is that no matter what techniques one uses, however much audiovisual material is incorporated, however many highlighted examples in the textbook, extra problem sessions and so on, some people never seem to "get it," and it does not seem realistic to expect that methods will be found to solve this.

One final note, going back to the infinitely patient computers: Someone will write the software with a certain point of view on, say, ballistic motion. A student with Feynman-like ability might be in total conflict with this point of view, and be unable to proceed. Our current methods of teaching, patchy though they are, have a great strength in that they allow a student to

CHARGE SENSITIVE PREAMPLIFIERS



FEATURES

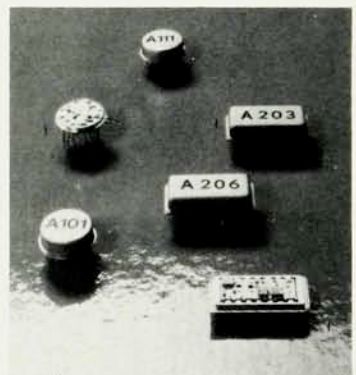
- Thin film hybrid technology
- Small size (TO-8, DIP)
- Low power (5–18 milliwatts)
- Low noise
- Single supply voltage
- 168 hours of burn-in time
- MIL-STD-883/B
- One year warranty

APPLICATIONS

- Aerospace instrumentation
- Mass spectrometers
- Particle detection
- Imaging
- Research experiments
- Medical and nuclear electronics
- Electro-optical systems

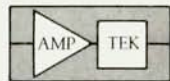
ULTRA LOW NOISE < 280 electrons r.m.s.!

Model A-225 Charge Sensitive Preamplifier and Shaping Amplifier is an FET input preamp designed for high resolution systems employing solid state detectors, proportional counters etc. It represents the state of the art in our industry!



Models A-101 and A-111 are Charge Sensitive Preamplifier-Discriminators developed especially for instrumentation employing photomultiplier tubes, channel electron multipliers (CEM), microchannel plates (MCP), channel electron multiplier arrays (CEMA) and other charge producing detectors in the pulse counting mode.

Models A-203 and A-206 are a Charge Sensitive Preamplifier/Shaping Amplifier and a matching Voltage Amplifier/Low Level Discriminator developed especially for instrumentation employing solid state detectors, proportional counters, photomultipliers or any charge producing detectors in the pulse height analysis or pulse counting mode of operation.



AMPTEK INC.

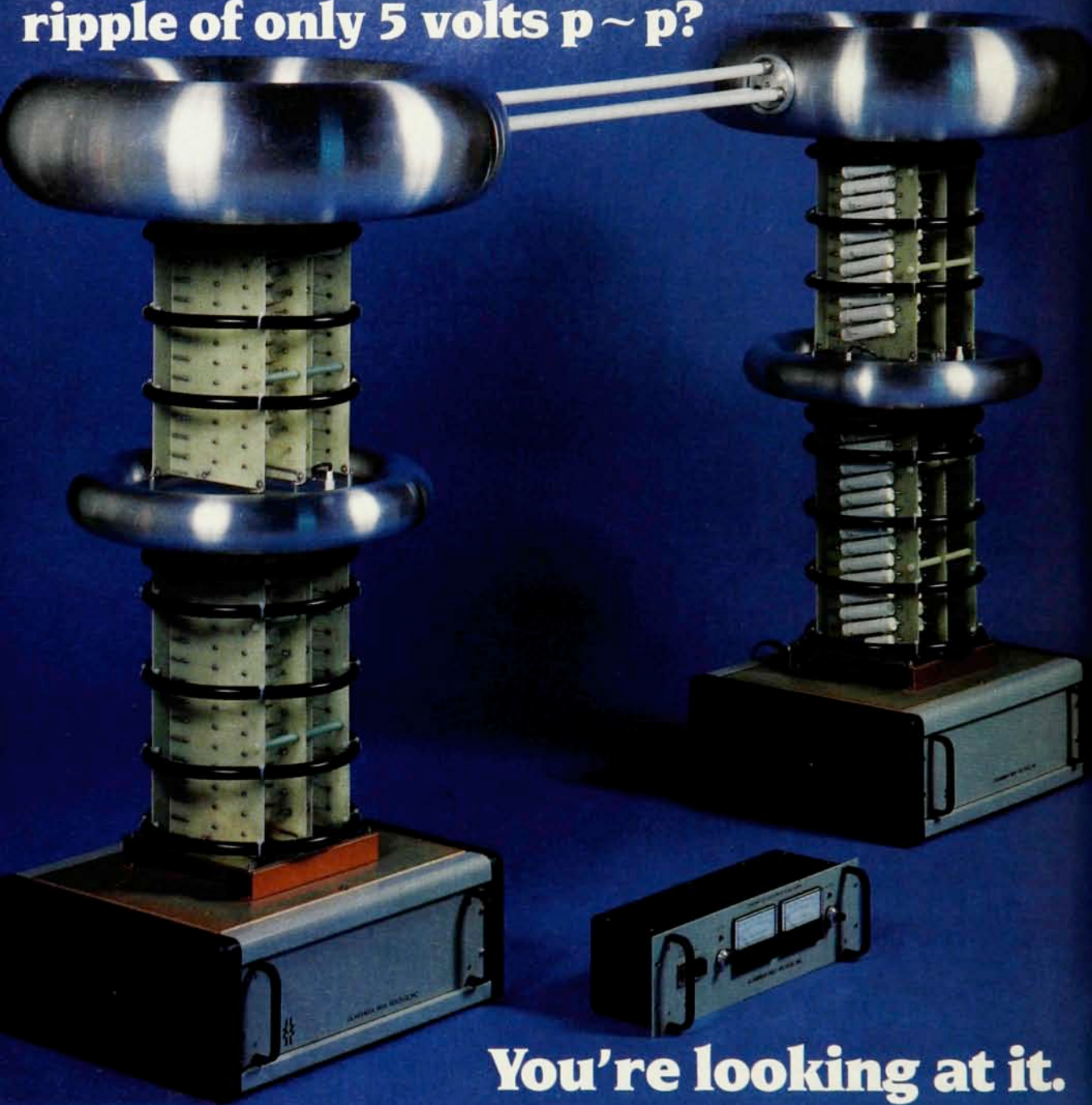
6 DE ANGELO DRIVE, BEDFORD, MA 01730

U.S.A. TEL: (617) 275-2242

With representatives around the world.

Circle number 8 on Reader Service Card

**Is it possible to build a 300kV/1 mA
switching power supply with output
ripple of only 5 volts p ~ p?**



You're looking at it.

Not only is it possible—it's a standard option we offer for any PG series open stack model (100kV and higher). Of course, before we built this one, a lot of people thought it couldn't be done with an air insulated switching design—at least not at a reasonable cost.

But we gave it our best shot and even surprised ourselves. This unit actually exceeded the required specifications by a substantial margin.

Best of all, its cost was only about one third, and the size and weight (less than 200 pounds) are just a tiny fraction of existing line frequency designs with comparable specifications.

Today the supply pictured here is a part of the injection deck of a particle accelerator in the nuclear physics lab of a major university. We have since built a number of other PG-LR units, which also meet similar specifications.

The next time you are faced with a high voltage requirement with no reasonable solution, call us. One of our "best shots" could give you exactly what you need, without consuming your entire budget.

Innovations in high voltage power supply technology.

GLASSMAN HIGH VOLTAGE INC.

Route #22 (East), Salem Industrial Park, P.O. Box 551, Whitehouse Station, N.J. 08889
(201) 534-9007 • TWX 710 480 2839



Circle number 9 on Reader Service Card

letters

look at a problem however he or she wishes, as long as the right answers are consistently obtained.

ROBERT LYNCH
King Fahd University
of Petroleum & Minerals
Dhahran, Saudi Arabia

12/86

Researchers concerned with physics education and cognitive psychology often lack the proper feeling for physics, and vice versa. Therefore Frederick Reif's article encompassing both ingredients is to be highly appreciated. Notwithstanding this, let me raise a minor point that may be of some relevance with respect to the complexity of the field.

Students' conceptions are revealed when they are questioned in a qualitative, not completely and quantitatively defined, way. Are misconceptions not sometimes, at least partially, artefacts of the type of questioning? Figure 2 in the article, showing the bob of a swinging simple pendulum at various positions, may represent a typical example. The arrows representing the vector of acceleration at the maximum, half-maximum and zero displacement angles are drawn in the right directions but not to the right lengths.

I am not trying pedantically to expose a flaw, but rather to call attention to an issue of principle. Can students draw the arrows if they do not write down or at least reflect on the equations? Or more explicitly: Wouldn't more students answer a quantitatively formulated question than a question intended only to test whether they understand that both the tangential and centripetal components of acceleration are involved? (In the second case, the wording of the question would appear to be important.) In the first case, students can, using the laws of mechanics, test the consistency of the answer and correct it, whereas in the second case they must to some extent guess. Doesn't a qualitative question force the student to adopt a loose procedure involving vague concepts? Doesn't a well-defined and quantitative question force the student to use sharper procedures and well-defined concepts? One is reminded of the two levels of sophistication of colloquial language: a chat and the more precise professional language of a lecture. Would one connect the first level with misconceptions?

JANEZ STRNAD
University of Ljubljana
Ljubljana, Yugoslavia

1/87

REIF REPLIES: There is no reason to expect that computers used for teach-

ing will eliminate individual differences between students. However, they should make it somewhat easier to adapt instruction to individual differences by addressing more students on a one-to-one basis than is possible in traditional large classes.

Robert Lynch seems to assume that computers necessarily impose more rigid constraints on students than human teachers. But traditional homework assignments and examination questions often impose more rigidity than the exploratory environments made possible by well-designed computer software. Human teachers, computers, textbooks and other media can all be used as instructional means—and each of them has distinctive advantages and disadvantages. Good educational design should aim at a judicious combination of instructional means, one that best exploits their particular strengths and minimizes their weaknesses.

Qualitative and quantitative modes of thinking are *both* important, in complementary ways, even in a highly precise and quantitative science such as physics. Some physicists, among them perhaps Janez Strnad, underestimate the crucial role of qualitative thinking in formulating useful questions, in designing experiments, in suggesting explanations for observed phenomena and in planning solutions to problems before attacking them mathematically. The usefulness of qualitative thinking and back-of-the-envelope calculations is quite apparent in the work of Michael Faraday, Niels Bohr, Enrico Fermi and others. And many physics graduate students come to research poorly prepared because their prior classes have emphasized only quantitative precision and mathematical formalism.

FREDERICK REIF
4/87 University of California, Berkeley

Uniting the fusion community

The 1960s proved that early fusion enthusiasts were hasty in their assessment of the magnitude of plasma heating and confinement problems, and it was realized that a lot needed to be done. In an inspired performance, American plasma physicists rose to the challenge. By 1980 they had chalked up impressive gains in tokamaks, reversed-field pinches and mirrors, and compact toroids looked to be full of promise. Then came the slide.

Based on the success so far, each group wanted a larger machine of its own to prove the usefulness of its concept as a reactor candidate. Dissension between the various groups set in, with the result that each group focused

Highly Rated at High Rates

The 2024 with Gated Integrator



- Shaping Modes:
Gaussian Unipolar
Gaussian Bipolar
Gated Integrator
- Pile-up Rejection
- Live time Correction



Canberra Industries, Inc.
One State Street
Meriden, Connecticut 06450
(203) 238-2351