letters

Math anxiety and physics

As a representative of the female graduate students and faculty members involved in Cornell University's organization Women in Physics and Related Fields, I was dismayed to read James F. Blake's letter (September, page 108), in which he suggests that women, by nature, are simply not as capable as men of doing math and physics. Using his own experience as a high-school teacher, plus several vague and unreferenced biological and anthropological studies, Blake makes his case that to encourage young women in the sciences is a waste of time because they have no predisposition for such disciplines. His logic and citations of "proof" are so off-base that the letter at first does not seem to warrant a reply. Unfortunately silence is often taken as implicit agreement, and I thus feel compelled to respond.

Blake's most objectionable statements involve his claims that women dislike rigorous thinking due to differences in their brain development, as well as to their genetic evolution into playing nurturing sex roles. Published evidence has not shown females to be biologically inferior to males in analytical and mathematical ability. Rather, studies have shown that well before, and even in the absence of, any sign of lower math achievement, girls begin to exhibit waning confidence in their mathematical aptitude as compared with boys. Studies made on boys and girls of comparable mathematical background generally show little difference in their performance, and when they do indicate a difference they also indicate markedly lower levels of self-confidence in the girls, as well as growing sentiments that math is a male domain. In addition, by high school, girls increasingly perceive the attitudes of their teachers and parents (especially fathers) as negative and unsupportive. Fennema-Sherman, for example, reported these findings in the *Journal for Research in Math Education*, May 1978. To ignore societal influences in trying to account for sex differences in math achievement is improper, especially in light of the absence of biological evidence. Furthermore, it is irresponsible, given the effect that unsubstantiated claims of female inferiority have on each successive generation of school-age girls, who are subtly made to doubt their own natural talents.

Furthermore, Blake's analysis of his teaching experience leads him to draw conclusions that are somewhat less than scientific. He assumes his class was unmotivated due to the lack of interest exhibited by the girls. However, he ignores not only his own teaching style and personal attitudes as variables in this "experiment," but also the male students' attitudes during that semester. Were they unmotivated as well, and if so, why? In another instance, Blake claims that even the girls who do well need to memorize more. However, he fails to acknowledge how qualitative the interpretation of language can be. Personal discussions with students leave room for biased questions and unscientific interpretations of responses. Perhaps while a boy felt he "reasoned" out a solution, his female counterpart considered that she simply applied a technique that she had "memorized," when in fact they understood the physics equally well. Trusting the outcome of Blake's classroom "experiment" becomes even more difficult upon closer inspection. He used only one year's results to form a "pattern," and "was not disappointed" to discontinue the effort the very next year. The point is that Blake is drawing conclusions that are not obvious solely from his classroom experiences.

Blake's letter is typical of many arguments used against the advancement of women in the sciences. Supposedly, women would achieve success and go forward in science if they had the ability. That few women have pursued physics, either now or throughout history, is supposedly sufficient proof that women simply do not possess the required talent. Of course, women have made great contributions to science throughout the ages, in spite of the lack of formal scientific education that has hindered them until the more recent decades. Blake's style of psychological argument puts women on the defensive. Women must devote energy to trying to prove themselves to those like Blake, which can be a tiring and often futile undertaking. For example, Blake blames the girls themselves for being victims of a society that must certainly mold their attitudes. In noting that "many of the females were unashamed that they foresaw themselves as housewives," he first of all suggests that they should be ashamed, and secondly that society truly does offer them, as females, a full realm of alternative opportunities. Remember, we do not even have an equal-rights amendment yet!

Before Blake and others indict women as not fit for the pursuit of math and science, perhaps they could investigate the additional negative forces women must confront in attempting this goal. Alienating teaching, the existence of academic and social double standards,

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sexist jokes, family conflicts and lack of role models are a few examples of gender-specific obstacles women must deal with. As women come to make up a larger and larger percentage of the scientific establishment, we trust that letters like Blake's will not even find their way into magazines like PHYSICS TODAY. Women make up a larger percentage of Chinese, French and Indian graduate students than they do of graduate students from Germany and the US, for example, which appear to have chosen not to encourage their own young women. This is a tragic waste of talent for our own country as well as the world as a whole. However, innovative educational programs designed to reduce math anxiety and remotivate students, such as those described by Sheila Tobias (PHYSICS TODAY, June 1985, page 60), are a good start toward changing the attitudes that both women and men have toward math and physics.

JANE YATER
Cornell University
12/85 *Ithaca, New York*

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I think I have calmed down enough to respond to the three letters on math anxiety and physics in the September issue (page 15). I am female. I am a graduate student in physics. I have had, and on occasion still have, physics anxiety. I also know that this affects me from outside and not from inside (the cause is societal and not due to my femaleness). Sexism is real. The walls of the potential well are higher for women in our society. It takes more energy to be a free particle (barring the brilliant few who tunnel through).

The first thing in physics that I really felt comfortable with was wave–particle duality. It was so obvious to me because of an analogy that I am well aware of—that men have female (and male) characteristics and women have male (and female) characteristics—but which much of our society still ignores. B. Dudley, James F. Blake and H. J. Hunter (the authors of the three letters) probably still have trouble with this concept.

Many individuals in particular, and our society as a whole, have made it quite clear to me that I cannot do physics because I am female. I have spent much of my life fighting this attitude. Thank goodness there are exceptions. I will never forget one of my undergraduate professors, who at one point responded to my anxiety by saying, "You can do that." And I did. No one had ever said that to me before; none has since. But I say it to myself and it has pulled me through on numerous occasions. The same professor had another line that helped me: "I know you don't know how to do it. I'm going to show you how."

I'd like to thank all the men and women like him who have helped me out and treated me as an equal. Please help me educate our peers and colleagues. Help me make it clear to people like Dudley, Blake and Hunter that sexism and racism are alive and well in the physics community and that it would be a loss to physics not to destroy these barriers.

I for one am going to be a physicist (a damn good one, I hope) in spite of society's theories. I am not an exception; there are many women like me.

Also, thanks to Sheila Tobias for the great article (June 1985, page 60).

BETH THACKER
Cornell University
11/85 *Ithaca, New York*

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I wish to offer the following comments in response to James F. Blake's letter (September, page 108):

> I am reminded of my efforts in the late 1970s to increase the black enrollment in high-school physics. After the junior year, in which about half of the chemistry students are black, the overall fraction of black students drops to one-quarter. A similarly sharp drop occurs between eleventh- and twelfth-grade mathematics.
>
> Together with a black science teacher, I tried to elicit reasons from the junior-class blacks for their possible avoidance of senior math or physics. We met with the young blacks in their chemistry classes and found that avoidance was generally based on their perception of advanced math and science as being career-oriented courses for students, usually described as whites, who would be embarking upon rigorous professional training.
>
> My colleagues and I were evidently rather successful in encouraging the black students to explore their motives, because the black enrollments in the next year's physics sections were significantly increased. The effect, however, was not all I had hoped for. The physics classes that year were difficult to motivate and the students frequently expressed distaste for the subject. Not surprisingly, an unusually large number dropped the course during the first semester. Consequently, I was not disappointed that we didn't repeat our efforts in subsequent years.
>
> The evidence is that blacks dislike the rigorous, formal thinking of higher math and physics. Whites are more often uncomfortable in the more emotive disciplines of language and art, although the pattern is not as obviously one-sided. Until someone points out an advanced civilization in which the above pattern has not occurred, I shall be obliged to suspect that it is an outgrowth of mental differences between the races. Indeed, recent studies in prenatal brain development have vaguely indicated race-specific processes. Why do so many civil-rights people persist in the face of such evidence to hold environmental influences responsible for the math–science anxiety so prevalent in blacks?

Do you get my message? No publication should ever print a letter that so blatantly maligns a group of people. Yet this letter appeared in the September issue of PHYSICS TODAY: All I did was substitute "white" for "male" and "black" for "female," omit a few paragraphs and change fewer than ten words. Can you imagine the uproar if you dared to print the letter as I rewrote it? Your magazine would surely be censured. You could substitute "Hispanic," "Arab," "Jew," "Indian" or any other minority and I'm certain that the outcry would be enormous.

Blake should practice his profession in an all-male school because his attitude that females are genetically inferior must certainly affect his teaching. Letters such as his can only serve to further the aims of those in academia who believe that females should not pursue careers in science or math and who do their best to humiliate and belittle female students. Capable women are being effectively eliminated from these programs, and your magazine, by publishing these idiotic ramblings, will only encourage bigoted professors to discriminate further against female students. Or do you really believe that women are genetically inferior?

ELIZABETH K. HORVATH
10/85 *Fort Lauderdale, Florida*

BLAKE REPLIES: I took very little pleasure from writing my response to Sheila Tobias's article in PHYSICS TODAY, but I felt it necessary to relate my experience. I regret that mine was not a scientific experiment as Jane Yater would have preferred. However, my intent was merely to increase the female enrollments in physics, and this objective was achieved. Because the reported observations were confusing to me, I asked the students their reasons for dropping out of physics. The prevalent reason was that the course was not interesting. No males ever offered a similar explanation.

More often than not, the top physics students in my school are females, but

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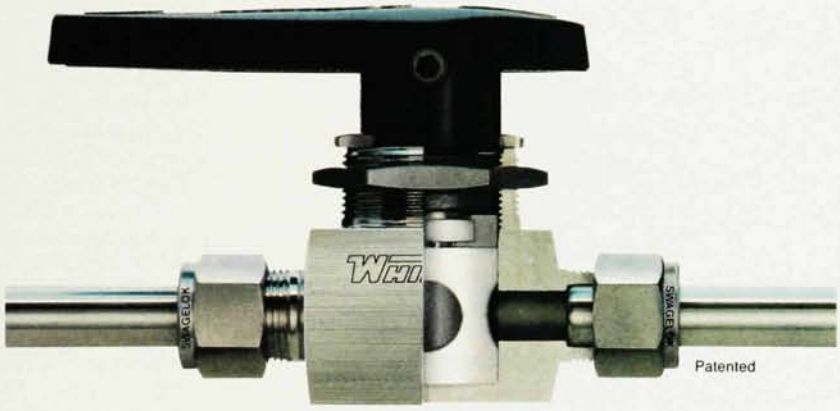

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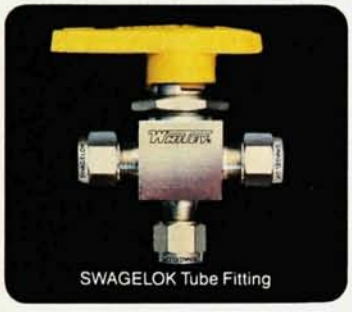
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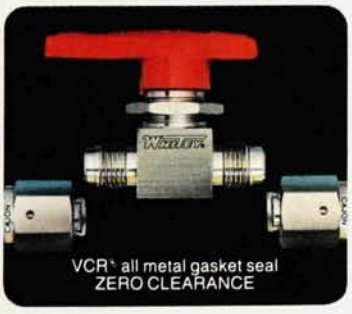
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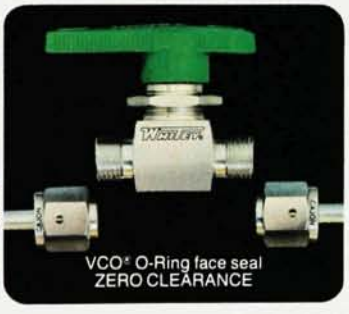
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the young women consistently constitute a far lower percentage of the physics enrollment than in preceding science courses. So I object to any inference that women as a group cannot succeed in physics. Indeed, the respondents representing the female students at Cornell University show evidence of the necessary fortitude and intelligence to become practicing physicists. There is little danger of their dropping out because of lack of interest.

While reading the first few paragraphs of Elizabeth K. Horvath's letter, I was saddened to think that blacks in Fort Lauderdale were following the same discouraging trends as the female population I had observed. Then I saw that the letter was a clever fiction designed to discredit the notion that any group, especially a racial or religious minority, should be singled out for its behavior patterns. Certainly this is an emotion-laden issue. The original article was by a woman. The first set of critical responses came from three men. This latest volley of counter responses emanates from three females.

Rather than encouraging another salvo from male readers, I would prefer to spur a scientific study of motives for enrolling in high-school or college physics courses, to learn how to improve the performance of all the students.

JAMES F. BLAKE

7/86 *New Hyde Park, New York*

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I found Sheila Tobias's article "Math anxiety and physics" (June 1985, page 60) most interesting and provocative. I recommend it to all physics teachers. But I found the "learning bill of rights" that it incorporated (after adaptation[1]) to be a dangerous document. As examples:

- ▶ "I have the right to view myself as capable of learning any subject."
- ▶ "I have the right to define success in my own terms."
- ▶ "I have the right to learn at my own pace and not feel put down or stupid if I am slower than someone else."
- ▶ "I have the right to be treated as a competent adult."

This bill of rights nowhere refers to a concomitant set of student responsibilities. Any student has the right to be treated with respect, and to seek out and receive extra help if available. But the student has the responsibility to study diligently, to read (sometimes in advance), to attempt homework, to seek all available help and to absorb the basic ideas and techniques—in summary, to make a diligent attempt to be prepared for class.

I will treat such a student with respect, even if he or she is having

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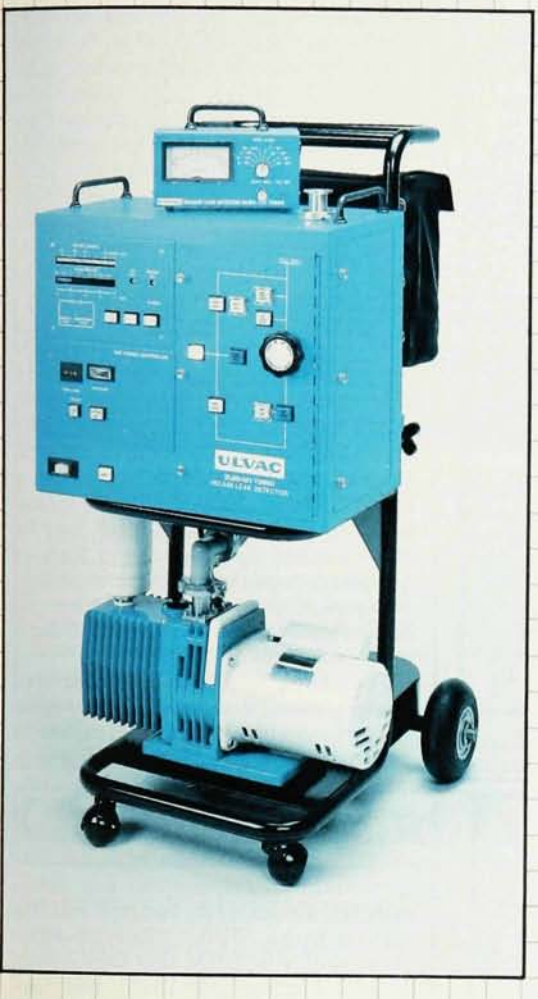

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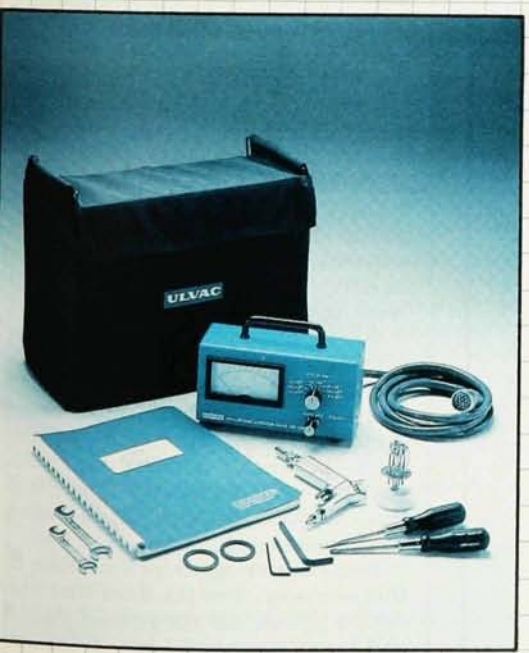

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difficulty with the subject.

A student who fails to meet his or her responsibilities, as outlined above, loses his or her rights. Such a student does *not* deserve my respect and yet may well cause many difficulties in class. He or she may ask inappropriate questions that slow everyone down, may delay us by not being able to answer my questions or those of other students, may put other burdens on the staff, may complain about the course's difficulty—or worse yet, may complain about my lack of respect for students, of my being too demanding and of my general "ineptness" as a teacher.

The teaching–learning process is a joint one. I cannot teach successfully unless the student is willing to work responsibly. It is a *mutual endeavor.*

Not every student has equal or adequate aptitude or potential, or the well-learned prerequisites, to succeed in a specific course. Even if all prior indicators are positive, the student may be overextended in total course load, in additional part-time work or in personal issues. (I once took a course in social dance, and was "lucky" to pass under a pass–fail grading option.)

I currently teach physics to university sophomore pre-engineers. I routinely start my class with a brief review in which I ask a straightforward review question of a *randomly selected* student. (Some examples: "What's an important difference between general oscillatory motion and simple harmonic motion?" "Tell me *any* key definition or property or requirement for motion to be SHM." "Tell me *something* involving SHM that uses energy ideas." I stress that I only seek "approximately correct" answers, of which there can be several different ones. For example, for the last question: $U = \frac{1}{2}kx^2$ or KE + PE = const.)

If the whom I ask cannot answer, I rapidly move on to other randomly selected students. I go through a series of review questions in this way. I publicly give significant bonus course points for nontrivial satisfactory answers. (Sometimes I also use this technique to develop new results using "old" ideas and methods.)

When I find that several students in turn cannot contribute anything at all useful to this steered review, I publicly assert that *those* sampled students on average have not met their responsibilities. I probably do make some such students feel put down. I will not grant those students the "right" to be treated as competent adults.

Today I gave my third such class of this semester. For the third time, the review process did not go well. At the end I was concerned—how is this semester going to continue? Later in the

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corridor an (unknown) student stopped me, shook my hand and said: "Dr. Kacser, you are the only one of my teachers this semester who is going to make me learn something. Thank you." He understands his responsibilities, and I am reassured that I understand mine.

In conclusion: All rights entail responsibilities, both for the professor and for the student. Most certainly, a student has a responsibility to strive to learn.

Reference

1. From S. L. Davis, in S. Tobias, *Overcoming Math Anxiety*, Norton, New York (1978), and Houghton Mifflin, Boston (1980).

CLAUDE KACSER
University of Maryland
9/85 *College Park, Maryland*

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I teach physics and math in an inner-city school. This year I am teaching math, and I can see why there is little physics in the inner-city school. The students cannot do the mathematics. Each year I get approximately 120 students in some form of high-school math class, and most of them have come out of elementary school not knowing fractions and decimals, let alone other basic math skills and facts such as short division, dividing a number into zero or even knowing how to divide. The other teachers have told me that this situation has existed for years. Extrapolating to other situations in our system I would estimate that we have now probably over 100 000 high-school students who do not know fractions and decimals well enough to do high-school physics successfully, let alone go on to college and pass a physics course. At one time, say 20 years ago, almost every student in high school in our system took a physics course, and physics was offered in every school. I was told by a long-time physics teacher that he is lucky to have a position teaching physical science. I was told by another teacher of physics that the students cannot hack the math in physics and now it is no longer offered at his high school. Sheila Tobias mentioned that there are even some possible racial explanations. I blame the math problems in our situation on the elementary schools. Without basic skills in math, students in the high schools cannot do high-school or college physics.

At our school we have an all-black student body. I would say that I have had many students with good minds who will go nowhere because of their poor math background; who will not pass employment tests, ACTs or SATs; and who will score low on IQ tests just because of a lack of skills in elementary-school mathematics. Many of my current and former students can understand the procedure for passing a physics course by doing problems—mainly apply formulas. But when it comes to a decimal or a fraction in the calculations they give up, saying that they do not know how to do the problem—when in reality they do know how; it is just that they cannot use decimals and fractions. I would venture that this situation exists in all the major cities in the US. This is in part where the high-school physics students and positions went, at least in our system. If they are not successful in high-school math and physics, students will not take college physics unless required to do so. I therefore trace the decline in high-school and college physics in part to a math anxiety generated by the elementary schools in the cities.

STEWART E. BREKKE
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Correction

June, page 71—In the article by Beverly F. Porter and Roman Czujko, "Becoming a professional physicist: A statistical overview," the flow diagram depicting the physics education pipeline was incorrect as drawn. The correct figure appears below. □