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Algebra-based high school physics FREE

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each burned (in 1996 and 2019, respectively) inspired the name of the Past Has Ears (PHE, for the constellation Phoenix) project.

These days, other measurable quantities are often preferable to energy-ratio metrics and more reliable as refined design criteria, especially regarding natural room acoustics. For example, temporal and spatial energy-repartition measures, such as interaural cross correlation and lateral energy fraction, and the sound strength, or gain, are of growing importance in representing the quality of experience and preference among audience members, musicians, and actors alike.

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Life and signs of the Casimir effect

We would like to offer a few comments in connection with the article "Science and technology of the Casimir effect" by Alex Stange, David Campbell, and David Bishop (PHYSICS TODAY, January 2021, page 42). First, as Steve Lamoreaux mentioned in another excellent article on the Casimir effect (PHYSICS TODAY, February 2007, page 40), Niels Bohr played a brief but seminal role in Hendrik Casimir's thinking. With Dirk Polder, Casimir calculated the large-distance van der Waals interaction without reference to zero-point energy.

In a 1992 letter to one of us (Milonni), Casimir recalled mentioning his results to Bohr during a walk sometime around 1947. When Casimir said that he was "puzzled by the extremely simple form of the expressions for the interaction at very large distance," Bohr mumbled something about zero-point energy. "That was all," Casimir wrote, "but it put me on a new track." That track led Casimir to use the zero-point electromagnetic energy of the modes of a resonant cavity to calculate the force between conducting plates. In his letter, Casimir said that he was "somewhat familiar with the theory of modes of resonant cavities and their perturbations" because of his position at the Philips Research Laboratories in the Netherlands.

Casimir remarked in a 1948 paper that the force between the plates "may be interpreted as a zero point pressure of electromagnetic waves,"[1] an interpretation fully supported by a calculation of the vacuum stress tensor.[2] That perspective might suggest, as do Stange and his coauthors, that the net inward pressure results from a "higher density of modes outside the plates" than inside. But such an argument is superficial in that the calculated inward and outward forces on the plates both diverge. In fact, the spectral mode density of the field between the plates can be greater at some frequencies than it is outside the plates. And it depends, of course, on the boundary conditions for the electric and magnetic fields.[3]

Stange and his coauthors highlight the major role Casimir forces play in microelectromechanical systems (MEMS) today. Interestingly, when one of us (Maclay) and two coauthors tried in 1994 to publish the first paper on the potential role of quantum forces in MEMS,[4] the reviewers initially rejected it on the grounds that the dimensions of MEMS, typically in the tens or hundreds of microns, made the discussion irrelevant.

Stange and his coauthors describe how repulsive Casimir forces can result from different dielectric properties of the interacting objects. Repulsive Casimir forces can also arise from combinations of dielectric and permeable materials, as shown in 1974 by Timothy Boyer. When one of two parallel plates is a perfect conductor and the other is infinitely permeable, for example, the force between them is repulsive. And whether the Casimir force is attractive or repulsive generally depends on the geometrical configuration of the interacting bodies. The Casimir force on a perfectly conducting sphere, for example, is repulsive, in contrast to Casimir's assumption that it should be attractive. More recently, researchers have focused on the possibility of realizing repulsive Casimir forces with metamaterials and chiral media. Qing-Dong Jiang and Frank Wilczek, for instance, have shown that chirality can be employed to obtain Casimir forces that are "repulsive," "enhanced," and "tunable."[5]

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Algebra-based high school physics

About 60% of all physics majors chose the field because of their positive experience in high school physics courses, according to a study by the American Institute of Physics presented at the 2018 summer meeting of the American Association of Physics Teachers. In most US public high schools, only the upper 35% of the student body is allowed or encouraged to enroll in algebra-based physics classes. Such restrictions often exclude many otherwise bright and capable youngsters—of all races and ethnicities—from that formative first step toward a future in physics.

At one time, weakness in elementary mathematics, including fractions, decimals, and long division, and in basic algebra prevented even higher-level students from being successful in algebra- and trigonometry-based high school physics courses. Those mathematics deficiencies also have prompted a number of public high schools to discontinue entire physics programs. As a certified high school physics and chemistry teacher who taught mostly in Chicago inner-city high schools, where a majority of students were Black or Hispanic, from 1975 to 2001, I initially found a severe deficiency in elementary arithmetic skills. However, inexpensive electronic hand calculators have made it possible for many students to properly solve basic algebra problems that are common in physics and chemistry.

Drills and practice with standard physics formulas helped my physics students remember their first-year algebra, if not learn those algebra skills in the first place. Many high school algebra-based physics texts have only a few problems of the same type, which often does not provide good learning experiences for students of any level. To enhance their learning, I would have students do about 10 physics problems per formula; I would go around the room and show the students how to do the first problem and then allow them to solve three more of the same type using the same formula. By solving for all the formula's variables in the same manner, students learn or reinforce their algebra skills as they master their scientific problem-solving. After I retired I learned that Black students I had taught at Carver Area High School and Paul Robeson High School who entered nearby Chicago State University passed their university chemistry courses, and some even graduated with degrees in chemistry.

I believe that inner-city Black and Hispanic students have great potential for majoring in physics and chemistry in higher education. About two-thirds of US high schools do not have a teacher who majored in physics or physics education.[1] Also, collegiate physics programs are being eliminated because of low enrollments. If high schools open algebra-based physics to all students and provide extra physics help—including mathematics remediation, which is done everywhere in the world except in the US—not only will many student lives be enhanced, but more students will major in physics, thereby helping rescue higher-education programs at risk of discontinuation, and there will be many more competent, certified high school physics and chemistry teachers.

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