

having to explore.

Giving Martin Gardner credit for the 1876 work of Henry Holiday is an example of the retarded or strong coupling Matthew effect, and as such it is roundly to be condemned. I must insist, however, that it was not my fault. I merely told the editors of PHYSICS TODAY where to find some good pictures—they then did the Matthew on poor Holiday. Having myself been a victim of the more common static or weak coupling Matthew effect, I applaud Gordon Freeman for his diligence in setting the record straight.

There are many kinds of neologism. Type I gives a new word an old meaning; type II gives an old word a new meaning; type III gives a new word a new meaning. Kenneth Sassen is confused about my title because his was a type I neologism, while mine was of type IIC, a less common variety in which the old word is itself the fruit of an earlier neologism, in this case (as the notation clearly reveals) of type III.

N. DAVID MERMIN
Cornell University
Ithaca, New York

6/81

More on mass versus weight

The letters on NBS and metrification in December (page 11) were interesting and have inspired me to offer suggestions to resolve the issue via compromise. I would also like to offer a few suggestions on the introduction of new unit terminology. I write on the basis of over 45 years of familiarity with (portions of) the metric system, and over 40 years as a physics teacher at Columbia University.

The confusion over mass and weight would be eased if the NBS and physics teachers included in discussions extra comments along the following lines. "In the metric system the unit of mass is the kilogram for which a primary standard exists in an international standards lab, with secondary standards in other standards laboratories. When comparing masses, or evaluating an unknown mass, in practice this is done by *weighing* using equal or unequal arm balances in a uniform non-zero gravitational field, usually that at the earth's surface. The term *weight* is then generally used in practice to mean that an object with a *weight* of X kilograms experiences the same gravitational force as a mass of X kilograms, or X times the gravitational force which the international standard kilogram would experience in the same gravitational field. It is believed that Einstein's equivalence principle applies so that such gravitational force is the same as the inertial force required

to accelerate the mass in the absence of gravity with acceleration $a = g$, where g is the free fall acceleration of the mass in the gravitational field. For weighing evaluations at the earth's surface, the gravity force, mg in Newtons per kilogram, varies slightly with position on the earth's surface due to the earth's rotation, non-uniform mass distribution, and height above sea level. The term *weight* is also frequently used to denote the gravity force on a mass, usually implying in some mean earth surface position, where $g \approx 9.8$ meters sec^{-2} . The magnitude of the force in Newtons is mg where m is mass."

I too have lived through teaching in non-metric units involving slugs or poundal and am unhappy with the various pound, ounce, penny-weight, grain, hands, stone, dram, and so on of the non-metric system. I am a strong believer in a "humane" introduction of the metric system. I have been very annoyed when international commissions decide on a change of naming to honor some historic scientist without adequate warning. Thus, the abrupt change by vacuum system manufacturers to the torr rather than mm Hg without explanation had me asking, "what is a torr?" Years-old libraries were no help. The sudden change from cps to "Hertz" for a while left me with a desire to substitute "Avis" in annoyance. Similarly, after preferring magnetic fields in non-rationalized cgs-emu units of Gauss (also metric), I finally became reconciled to Webers/ m^2 and then, suddenly I was confronted with a changed name where I could only guess at the meaning. When I first learned metric units, the cgs non-rationalized esu and emu defined quantities in terms of mass, length, and time with $E = D$ and $B = H$ in vacuum so $\epsilon_0 \equiv \mu_0 = 1$, with no real need for a confusing array of labels. The present trend seems to be away from that approach.

In view of the above considerations, I strongly recommend that when new labels are introduced for old concepts, there be a period of ~ 5 years where a footnote translates the new name into more familiar terms (for scientific publications and equipment specifications). Similarly, if we wish to introduce the metric system in the US, similar footnotes or parentheses should also give the value in customary units. This would possibly aid in public acceptance.

JAMES RAINWATER
Columbia University
New York, New York

1/81

I wish to record my strong support for the position of AAPT with respect to SI
continued on page 98

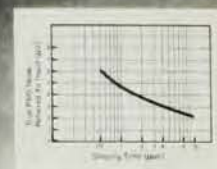
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letters

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units for mass and force as advanced by Albert Bartlett in December.

It would indeed be distressing if NBS does not seize upon this opportunity to once and for all straighten out the mess with respect to the application of these two basic units. Surely, we can not afford to be different from the rest. We must begin to correctly relate mass to kilograms and weight to newtons.

L. J. GIACOLETTA

Michigan State University

East Lansing, Michigan

2/81

I take issue with many of the statements made by David Goldman of NBS in his letter in December.

► While the SI is a system of measurement units, they are dependent on the physical quantity which each unit represents. For this reason one cannot ignore physical quantities when discussing the SI and say they are not a part of it.

► The multiple use of the word "weight" has been a universal problem since antiquity, although within the last several years a number of industrial countries in the "Western" as well as the "Communist" worlds have taken steps to officially discourage the use of weight as a meaning for mass. The European Community and the Council for Mutual Economic Assistance have directives on the use of SI units in their respective countries' economies in which all reference to the kilogram, gram, milligram, and tonne is only mass. In some of the countries, consumer packaging and commercial transactions now refer to those units as mass instead of weight as was done previously. For instance, in November 1979 I observed a cargo container on the French ship, *LeSuroit*, in San Diego harbor; it had the following inscription stenciled on its side:

MASSE BRUTE 10 160 kg

TARE 1 650 kg

The statement is correct even to the extent that number groups are separated by spaces and the kilogram symbol is in lower case letters without a following period.

Most international organizations whose activities include the frequent use of measurement units have within the last few years changed all references to the "kilogram as weight" to "mass." Typical of these is the International Civil Aviation Organization.

► Is an authoritative body such as NBS supposed to promulgate what is correct but not necessarily popular, or is it supposed to recognize present incorrect usage and support it because it is popular?

► A dictionary is not the source for

correct technical usage, because it only follows and reflects popular usage. New ideas and words including their spelling are not initiated by dictionaries.

► The philosophy of not recommending the use of the word weight for technical audiences is specious, because it artificially divides society into two groups. Is not the unskilled laborer entitled to read what is correct even though he is not a technical person?

► Goldman says that an agreement among English-speaking peoples to restrict the use of "weight" to mean the "force due to gravity" is not likely to be reached in the foreseeable future. The Australians, Canadians, and South Africans are doing this, so the responsibility for not reaching such an agreement falls on NBS and the British Standards Institution who publishes PD 5686, to which Goldman refers.

► Goldman errs when he says, "The meaning of the word 'weight' is a problem also at the international level, and methods of handling the problem are analogous to those recommended for use in the US by NBS." Factually, the problem is being faced by many major industrial countries by referring to the kilogram as only mass to all sectors of their respective societies. When the issue was raised at the 1980 May 28-30 meeting of the international Consultative Committee on Units, CCU Chairman J. de Boer stated, "We do not have a problem, only the United States has a problem."

► Goldman states that NBS does not recommend "that in the US 'weight' should mean mass." Then why do several of the most widely distributed NBS metric publications refer to the kilogram only as weight as well as do all of the technical publications NBS publishes for the National Conference on Weights and Measures?

It is unfortunate that the present spokespersons for the Department of Commerce continually turn a deaf ear to the pleadings of those persons and organizations who do not see the necessity of "modifying the SI" unilaterally on a national level.

To the best of my knowledge, no other country undertaking a metrication program has found it necessary to include a "modification of SI" clause in its metric legislation.

LOUIS F. SOKOL

President Emeritus & Editor

US Metric Association

Northridge, California

1/81

Strictly speaking, grams and kilograms are units of mass. Often, it is convenient and also relatively accurate (about 10^{-3} uncertainty) to equate mass and weight because weight may be readily measured and the variation of the gravitational constant is not

large.

It is surprising how much effort can be spent to rewrite these two simple sentences into discussions of many pages. In these days of energy crisis and innovation crisis, there are far more important tasks for physicists. It is perhaps time for us to emphasize more physics and less government bureaucracy.

T. TSANG

Howard University

Washington, D. C.

1/81

Two little words! What a surprise that an argument over their usage should squeeze out the discussions of economically and politically significant matters like unemployed physicists, persecuted physicists abroad, billion-dollar research projects, and presidential science advice, which usually are featured. It is heartening to see that rigorous definitions and precise language still are valued.

As a long-time habitué and, more briefly, staff member of NBS, I developed great respect—even reverence—for the diligence and precision of the NBS editorial staff. Perhaps their authority has been diluted in more recent years, but I doubt that there is any disagreement with the aim of the AAPT to discriminate between mass, an inherent property of a body of matter, and weight, a force exerted by the body on account of gravitational attraction.

The main disagreement is with NBS permissiveness. Like some modern editions of once-reliable dictionaries, NBS states a practice of the ignorant but doesn't seize the opportunity to dispel that ignorance by teaching the correct version. While "consensus standardization" is a legitimate NBS objective, it doesn't extend to accepting errors in English. Otherwise the Bureau's publications would be full of phrases like "the media says," "it looked like it was," "the data is recorded," and all the other popular mistakes. NBS is not always compromising with popular taste. The Bureau was holding to "aline," when the consensus, I believe, was strongly for "align."

The examples quoted by AAPT could easily be reworded to put NBS and the government clearly on the side of the angels. All that requires is to include a suitable notice and disclaimer. Instead of "'Weight' is the commonly used term for 'mass,'" the footnote might read "'Weight' is often mistakenly used for 'mass'; the distinction between the two should be carefully observed."

Admittedly it takes more care, and more words, to teach the difference between the two words than to ignore



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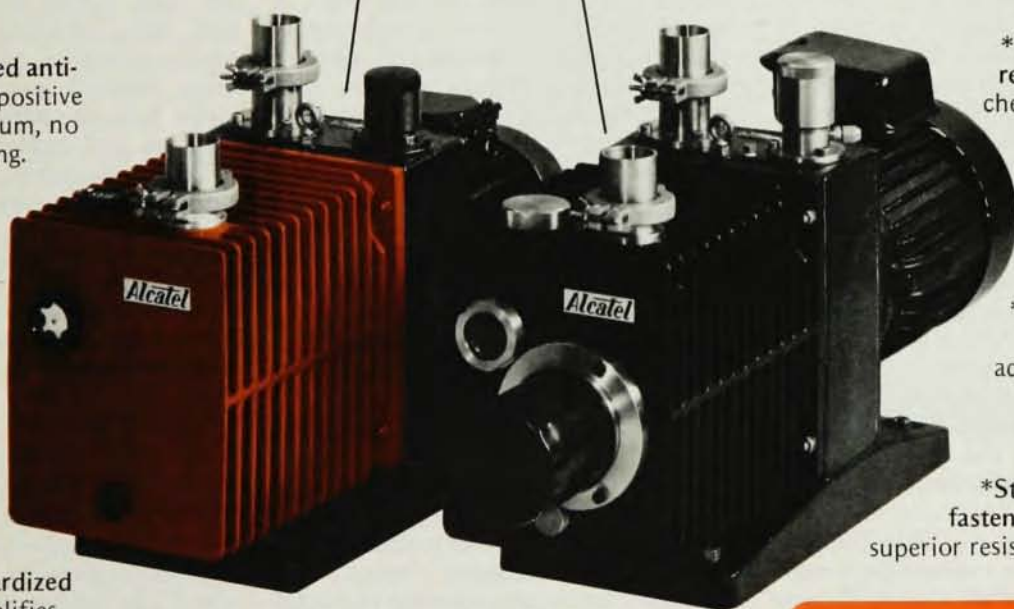
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letters

it. Proper usage is affected by the context. Blind substitution gives us jokes in the spirit of "A miss is as good as 2.2 kilometers," or "The chairperson is a member of the huperson race," or "He went on a diet and joined Mass Watchers." The writer's duty with respect to "mass" and "weight" deserves a good paragraph in his style book.

The mass and weight of a body are distinguished in the statement "A mass of 50 kg exerted its weight on the end of the lever," but I think the meaning of "weight" as an object such as "a standard weight" in "a set of weights" permits the statement "A 50-kg weight was placed on the end of the lever." An elementary text might make it "A weight having a mass of 50 kg..." while the more advanced reader would be expected to interpret the shorthand expression. Of course the job of AAPT members would be simpler if we forbade the use of "weight" to mean an object of known mass. That would be difficult, however, even in the New-speak environment of one of our great present-day tyrannies, and impossible here. We can only teach and practice that which is right, attempting to persuade the ignorant and indifferent that it is desirable to do likewise. I hope NBS will have the self-confidence to perform its role of leadership in precision, as I think AAPT is asking. The Bureau's reply suggests it will.

One question on the AAPT letter (page 11): Is my image of NBS editors to be shattered by the news that they actually allowed "concensus" and "supplimentary"?

FRED ORDWAY

Artech Corporation

1/81 Falls Church, Virginia

I wish to add my voice to those of the many physics teachers across the land whose opinion on the mass-weight controversy is represented by the AAPT position. It seems to me that, after all the dust has settled, we will be discussing whether we wish to be correct or to allow common errors to dictate our behavior. The custom of many to publish—and encourage the publishing of—materials which either imply or explicitly state that mass and weight are synonymous is a source of much unnecessary confusion.

At the risk of redundancy I would like to point out two examples. The first exemplifies the confusion and error that can result when mass-weight equivalency is implied in official documents. I have before me an unpublished copy of a workbook constructed by some teachers. On one page it is clearly stated that the kilogram is a

unit of mass, not weight, and that weight is a force. Several pages later, in a quiz, students are asked to give the most commonly used unit of weight in the metric system. The only choices offered are: the pound, the gram, the liter and the ounce. The second example comes from a teachers' guide ("The Metric System," Addison-Wesley 1974, no author listed) apparently intended for grade school use. In this book mass and weight are handled quite well and with quite clear explanations for the teacher. I cite this second example only to show that some (many?) of our youngsters have been and are being taught these concepts correctly. In spite of this we are told that common usage requires that we treat mass and weight as being interchangeable except for technical audiences. I contend that doing so will only confuse those children who are correct and solidify the error of those who are already confused. Even if we stipulate that most adults are confused on this topic it would seem that we will not reduce their confusion by aiding and abetting that confusion. In my opinion, some NBS publications have done just that.

In closing I would like to comment that David Goldman of NBS has exhibited generosity and patience during the meetings I have attended in which he participated. I disagree with his conclusions on this topic and the bases used for them but I am grateful for his willingness to search for solutions.

HOWARD VOSS

Arizona State University

2/81

Tempe, Arizona

I read with interest the letter about AAPT's censure of NBS for the latter's defining of the terms "mass" and "weight" to be synonymous, contrary to defined usage in the SI system of units. I also read the reply from NBS. Though the mass (*amount*) of argument presented by each was comparable, the weight (*force*) of argument was strongly in the AAPT's favor. So much so, that I think the APS should take an official stand in support of the AAPT.

There is an additional argument in favor of the AAPT position that carries considerable weight with me. Our government originated the idea of mass public education but it has never left education entirely in the hands of the school system. The US Government Printing Office churns out countless pamphlets for the purpose of public education from every federal agency, including NBS. Why then should NBS on this issue decide to abandon education and adopt the position of the least educated person who cannot distinguish between "mass" and "weight"? It is particularly puzzling after decades of educational effort on these concepts

here and abroad and a continuing education effort throughout the rest of the developed countries, all of which have adopted the complete SI system.

DONALD F. NELSON

Bell Laboratories

2/81

Murray Hill, New Jersey

The following point of view was represented in your fine coverage of the controversy about the use of the words "mass" and "weight."

However, it was hidden in the wealth of detailed information and not stressed sufficiently as the base for consensus. You may want to print this for benefit of those who would not read all the details.

The AAPT Metrication Committee correctly describes the problems and difficulties. However, their implicit assumption—that adherence to the particular interpretation will eliminate or diminish these problems—is not valid. Other people, who, like myself, were educated in traditionally metric countries, can confirm that the same problem persists, and that it stems from the difference between the common and technical usage.

The implications for physics are clear: Let's drop the word weight—the word contaminated by ambiguity and controversy—from our dictionary. We can talk about the mass of the object or about the force of gravity and acceleration. The word billion is a precedent, which shows how well such a treatment works.

PETER MIKES

1/81

San Leandro, California

THE AUTHOR COMMENTS: T. Tsang and the NBS may find it "convenient... to equate mass and weight" but to do so is clearly contrary to the 1901 International Declaration which identifies the kilogram as the unit of mass (symbol *m*) and which says that "the word weight denotes a quantity of the same nature as a force." The goal of the AAPT in seeking acceptance by NBS of the 1901 International Declaration is to do exactly what Tsang advocates in his closing sentence, "... to emphasize more physics and less government bureaucracy". Peter Mikes adopts the NBS suggestion that we drop the use of the word weight (meaning force) from our dictionary and use instead "force of gravity." This probably has less chance of being widely accepted than the AAPT proposal that we try to use the present terms properly.

Rainwater makes "suggestions to resolve the issue via compromise" and then goes on to say that "... an object with a weight of *X* kilograms experiences the same gravitational force as a mass of *X* kilograms..." Later he speaks of "the gravity force *mg*" (the units would be Newtons, not Newtons

per kilogram) "which varies slightly with position on the earth's surface..." This does not appear to be a compromise, rather, it seems to be the NBS position. The NBS people have advocated that "weight" be synonymous with "mass" and that "gravity force" or some similar term be used for mg . The AAPT position is that the US should adhere to the 1901 International Declaration so that if we express a quantity in kilograms the quantity is called "mass" (symbol m) and that if we mean weight (a force; symbol mg) we express it in Newtons. "Weighing" is then an act of comparing or measuring masses. "I weighed myself and thereby determined that my mass is X kilograms." "The sack contains Y kilograms of beans."

I too have been frustrated by actions that change names of units without adequate warning. Let me make two suggestions in this regard:

► We should bring into the open the domestic and international metric discussions so that the physics community knows what bodies make these decisions, who represents us on these bodies, what questions are on coming agendas, who establishes the American position on these questions, the outcomes of the meetings and how the US representatives voted on these questions. This is what is meant by the AAPT's request for "full accountability."

► We should act to have all AIP publications move quickly to the exclusive use of SI (including the 1901 International Declaration). If the authors and editors agree that in a given case it would be helpful to have other units, then other units in parentheses could follow the SI units. When the names of units are changed, the old units could follow in parentheses after the new for a period of time.

In summary, it is difficult to see what all the fight is about because, having devoted a long letter to the defense of the NBS position that "weight" should be regarded as a synonym for "mass," Goldman says, "NBS certainly accepts the 1901 CGPM declaration of weight as a quantity of the same nature of a force." The only action that is consistent with this clear and unequivocal statement of acceptance is for the NBS to delete the footnotes in future publications and for the NBS personnel to end their active advocacy of the idea that "weight" is a synonym for "mass." Goldman's authoritative statement of acceptance by NBS of the 1901 International Declaration is the major step toward resolving the problem. If the NBS will implement this acceptance by deleting the footnotes then the issue is resolved.

ALBERT A. BARTLETT

3/81 University of Colorado at Boulder

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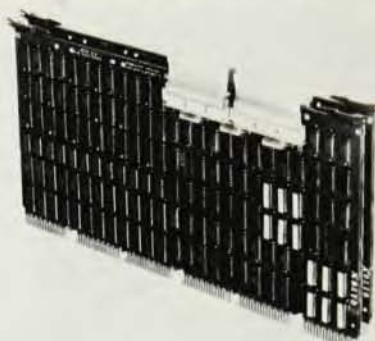
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letters

THE AUTHOR COMMENTS: Several of the respondents have restated their endorsement of the position taken by the American Association of Physics Teachers upon which I commented in detail in December (page 69). It might be worth summarizing the NBS position as follows:

The International System of Units (SI) is a coherent system of units based on seven base units. The base unit, kilogram is the unit for the quantity, mass. The derived unit, Newton ($\text{kg}\cdot\text{m}\cdot\text{s}^{-2}$), is the unit for the quantity, force. NBS publications, when using SI units, reflect this fundamental usage. The source of the present controversy is the use of the term weight. In 1901, the General Conference on Weights and Measures declared that: "1. The kilogram is the unit of mass; . . . 2. The word *weight* denotes a quantity of the same nature as a *force*; the weight of a body is the product of its mass and the acceleration due to gravity." NBS is considering wording as follows for a footnote to the declaration in the 4th Edition of "The International System of Units (SI)" SP-330 (to be published): "In the USA, ambiguity exists in the use of the term weight as a quantity to mean either force or mass. In science and technology this declaration (CGPM (1901)), is usually followed, [weight denotes a quantity of the same nature as force], with the Newton the corresponding unit. In commercial and everyday use, weight is usually used in the sense of mass for which the SI unit is the kilogram." NBS' use of the term weight is in accordance with these statements, with the additional premise that when the term weight is used, the proper SI unit will be used according to the intended meaning of the word. In disseminating information regarding the International System of Units, NBS would not be serving the purpose of either communication or education by totally neglecting the common meaning of weight. The most recent International Civil Aviation Organization Standard; "Units of Measurement to be Used in Air and Ground Operations," Annex 5 to the Convention on International Civil Aviation, 4th edition, July 1979, does not use the term weight in the body of the Standard which deals primarily with units. This is probably what Louis Sokol is referring to. On the other hand, Attachment B of the Standard, "Guidance on the Application of the SI" includes the recommendation that, "Because of the dual use of the term weight as a quantity, the term weight should be avoided in technical practice except under circumstances in which its meaning is perfectly clear. When the term is used it is important to know

whether mass or force is intended and to use SI units properly by using kilogram for mass or Newtons for force." Furthermore, European Economic Community (EEC) Council Directive 80/232/EEC, dated 15 January 1980, includes, "products sold by weight or volume..."; (Article 2 (a)) and "Food Products Sold by Weight (quantity in g)" (Annex 1). Thus, we see that even in Europe the ambiguity in the use of the word weight persists, as pointed out by Peter Mikes in his letter.

I can sympathize with Fred Ordway's concern over a matter which may appear Swiftian to an outside observer. I would reiterate, however, that there is not a single "correct" meaning for weight and that it is not a mistake to use it to mean mass in common parlance. I agree with Mr. Worrell that precise meaning of words is necessary for science and technology. That is what the American Standard for Metric Practice (Z210.1) recommends avoidance of the ambiguous term *weight*. Although it is possible for an international conference to recommend that for a specific purpose a certain definition of a word is preferred, usage then determines whether this recommendation is followed.

I agree completely with James Rainwater's sentiments that in teaching mass and weight, it becomes appropriate to discuss all the different meanings of the word weight. It is also desirable, as Rainwater points out, to introduce new units, or special names for SI units over a period of time with sufficient opportunity for comment by interested persons. For a proposed new definition of the base unit meter, exactly such comments were solicited, (*J. Opt. Soc. Am.* **20**, (December 1980)).

I cannot agree with L. J. Giacometti that NBS or any government organization should be in the forefront of straightening out the meaning of words.

Finally, I would like to thank Howard Voss and the others who have communicated to me their kind expressions of appreciation for my efforts in attempting to reach a solution to this particular problem.

DAVID T. GOLDMAN
National Bureau of Standards
Washington, D. C.

3/81

Organic superconductivity

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And we supply gaseous and liquid helium in Grade 4.5 (99.995% He) to Airco Grade 6 (99.9999% He). Or certified grades and mixtures with less than 1-ppm impurities.

If you want to know more about us, ask for our helium brochure and our specialty gases catalog. We'll also send you a litre of free helium. Write Airco Helium, 575 Mountain Ave., Murray Hill, New Jersey 07974. Phone (201) 464-8100. Or TWX 710-984-7970.

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